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Research Article

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A comparative Efficacy of 635 nm and 980 nm Low-Level Laser Therapy in Treating Temporomandibular Disorders

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Abstract:

Background: Temporomandibular disorders (TMDs) are a complex group of conditions impacting the temporomandibular joint (TMJ) and masticatory muscles, leading to pain, reduced jaw mobility, and other debilitating symptoms. These conditions often result from multifactorial causes, including malocclusion, trauma, stress, and parafunctional habits. Effective treatment is challenging, necessitating innovative therapeutic approaches.
Aim: This study compares the efficacy of two low-level laser therapy (LLLT) modalities with wavelengths of 635 nm and 980 nm in managing TMD symptoms. The goal is to determine which wavelength provides superior short-term and long-term therapeutic outcomes in pain relief, improved mouth function, and reduction of tender points.
Materials and methods: Fifty patients with diagnosed temporomandibular disorder (TMD) were randomized into two groups. Group 1 received 635 nm low-level laser therapy (LLLT) , while Group 2 was treated with 980 nm low-level laser therapy(LLLT). Pain levels, mouth opening range, and the number of tender points were measured before each treatment and at a one-month follow-up. The treatment was administered in continuous mode, with a power output of 0.3 Watts (W). Irradiation time was 30 seconds per tender point, with a total of four treatment sessions (two sessions per week). A follow-up assessment was conducted one month after the completion of the treatment protocol. Data was analyzed using appropriate statistical methods to evaluate the efficacy of the treatments.
Result: The 635 nm laser group experienced significantly greater reductions in pain intensity ($p = 0.025$) and fewer tender points in the masseter muscle ($p = 0.048$) compared to the 980 nm laser group during the short-term evaluation. However, no significant differences were observed between the two groups at the one-month follow-up.
Conclusion: The 635 nm laser demonstrated superior short-term efficacy in reducing pain and masseter tender points, whereas both wavelengths were equally effective in the long term. These findings highlight the importance of wavelength selection in optimizing low-level laser therapy (LLLT) protocols for temporomandibular joint disorder (TMD) management. Further research is needed to explore the mechanisms underlying these differences and to identify the optimal parameters for sustained therapeutic outcomes.

Keywords: (Laser635nm), (Laser980 nm), Temporomandibular disorders (TMDs), pain, mouth opening.

1. Introduction

Temporomandibular disorders (TMDs) represent a diverse group of conditions affecting the temporomandibular joint (TMJ) and associated masticatory muscles, significantly impairing jaw function and causing pain. Common symptoms include headaches, limited jaw mobility, joint clicking, and tenderness in the facial muscles [1]. These conditions are often linked to factors such as malocclusion, trauma, emotional stress, and parafunctional habits [2]. TMDs predominantly affect women aged 20-40 years, with studies showing a 2:1 female-to-male ratio [3]. Diagnosis often involves imaging, physical examinations, and patient history [4]. According to the diagnostic criteria for temporomandibular disorder (DC/TMD), TMD patients are categorized into three groups: Group I includes muscle disorders (e.g., myofascial pain with and without limitation of mouth opening (Group II involves disc displacement with or without reduction and mouth opening limitation), and Group III: arthralgia, arthritis, and osteoarthritis [5]. Despite advancements in diagnostic techniques, including imaging and clinical evaluations, effective treatment remains challenging due to the multifactorial nature of TMDs. Treatments range from conservative approaches (medication, splints, physical therapy) to advanced methods like low-level laser therapy (LLLT) [6]. Recent studies have highlighted the potential of low-level laser therapy (LLLT) as a non-invasive treatment modality for managing TMD symptoms. LLLT operates through photobiomodulation, a process that stimulates cellular activity, promoting pain relief, reducing inflammation, and enhancing tissue repair. Different wavelengths, particularly 635 nm and 980 nm, have demonstrated therapeutic benefits, yet their comparative efficacy remains underexplored [7]. The optical properties of different wavelengths of light significantly influence their interaction with human tissues, affecting absorption, penetration depth, and therapeutic outcomes. To evaluate the effectiveness of light-based treatments, it is essential to measure the path length and absorption coefficients of the masseter and temporalis muscles at two distinct wavelengths (980 nm and 635 nm). The path length (x) (0.4-0.5 cm) and adsorption coefficients (α) for masseter and temporalis muscle, respectively, were (0.24-0.43 cm^-1) and (0.27-0.51 cm^-1) at 980 nm, and the path length (x) (0.2-0.3 cm) and absorption coefficients (α) for masseter and temporalis muscle, respectively, were (1.13-1.67 cm^-1) and (1.23-1.83 cm^-1) at 635 nm [8,9,10,11,12]. This study aims to address this gap by comparing the short-term and long-term efficacy of 635 nm and 980 nm LLLT in reducing pain, improving mouth opening, and alleviating tender points in the masseter and temporalis muscles of TMD patients. By evaluating the outcomes of these two wavelengths, this research seeks to optimize treatment protocols and contribute to evidence-based advancements in TMD management.

New research shows that low-level laser therapy (LLLT) can help people with temporomandibular muscle disorders (TMDs) feel less pain and improve their ability to function. Researchers Da Silva et al. (2023) found that combining low-level laser therapy (LLLT) with exercise helped people with temporomandibular disorders (TMD) feel less pain and be able to do more things than exercise alone. In addition, Kim et al. 2024 [14] found that low-level laser therapy (LLLT) using a 635nm wavelength was better than a 980nm wavelength at reducing pain and improving function in people with temporomandibular disorder (TMD).

2. Materials and methods

2.1 Study design

This randomized clinical trial was conducted at the Department of Oral and Maxillofacial Surgery, AL Imam Ali Hospital, and the oral medicine clinic at a specialized center in Baghdad from January to August 2024. Ethical approval for the study was obtained from the Research Scientific Committee of the Laser Institute (Ref. No. 1329, 23/09/2024). Informed consent was acquired from all participants prior to their inclusion.

2.2 Participant Selection

Fifty patients (43 females and 7 males) aged 20-29 years with a clinical diagnosis of muscular temporomandibular disorder (TMD) were recruited for the study. Inclusion criteria encompassed patients presenting with pain, restricted mouth opening, and tender points in the masseter and temporalis muscles. Exclusion criteria encompassed congenital temporomandibular joint (TMJ) abnormalities, recent trauma, occlusal disturbance, neoplastic conditions, and previous treatments within the last month.

2.3 Laser components

The following are the laser device accessories as shown in Figure 1:
1. Wireless footswitch
2. Front view of the base unit
3. Laser-protective eyewear
4. Therapy hand piece
5. Patient’s goggle

Fig. 1: Solase Pro dental laser

2.4 Laser System and Application

The laser system utilized was a Solase Pro diode dental laser device, equipped with wavelengths of 635 nm and 980 nm.
Parameters included:
Power output: 0.3 W
Spot size: 3.14 cm^2
Power density: 0.0955 W/cm^2.
We applied each laser wavelength in continuous mode. We used the therapy handpiece to deliver laser energy to the affected sites, which included the TMJ and tender points in the masseter and temporalis muscles. We administered the treatment in four sessions, two per week, one-month follow-up. Each tender point received 30 seconds of laser application per session. As shown in figures (2b), (2c).

(a)

(b)

Fig.2: (a) Application of laser 980 nm on masseter tender points (b) Application of laser 635 nm on temporalis tender points.

2.5 Outcome Measure

Pain Intensity: Assessed using the Visual Analog Scale (VAS)before and after each session, and at one-month follow-up.
Mouth Opening Range: Measured using a digital caliper before and after each session, and at one-month follow-up.
Number of Tender Points: Evaluated through palpation of the masseter and temporalis muscles before and after each session and at a one-month follow-up.

2.6 Statistical analysis

Data analysis was performed using the statistical package for social science SPSS software, version 26). Descriptive statistics were expressed as mean, standard deviation, and minimum/maximum values. The Mann-Whitney U test was used to compare continuous variables (non-normally distributed data), while Fisher's exact test was applied to categorical data. Statistical significance was set at $p \leq 0.05$.

3. Result

Participant Characteristics: Most participants were female (86%), with a mean age of 27.5±9.3 years. As shown in Figures 3 and 4. No significant difference between both groups regarding age (P=0.316) and gender (P=1.000) as shown in Table 1.

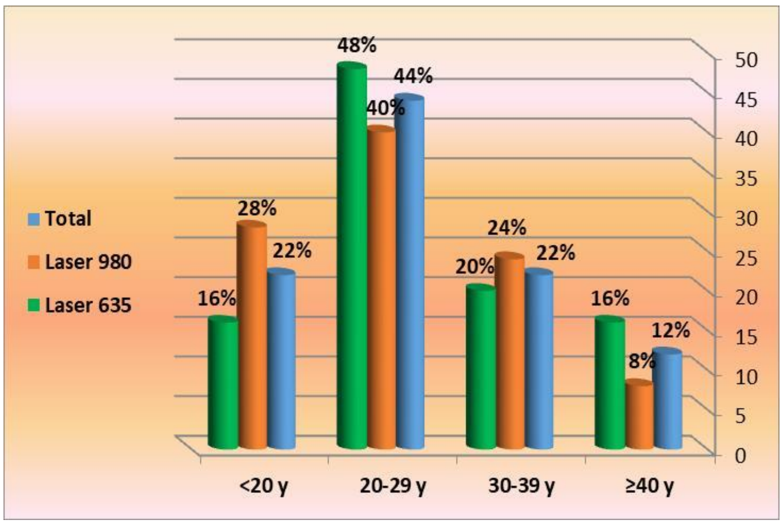

Fig. 3: Distribution of participants according to age groups, Baghdad, 2024.

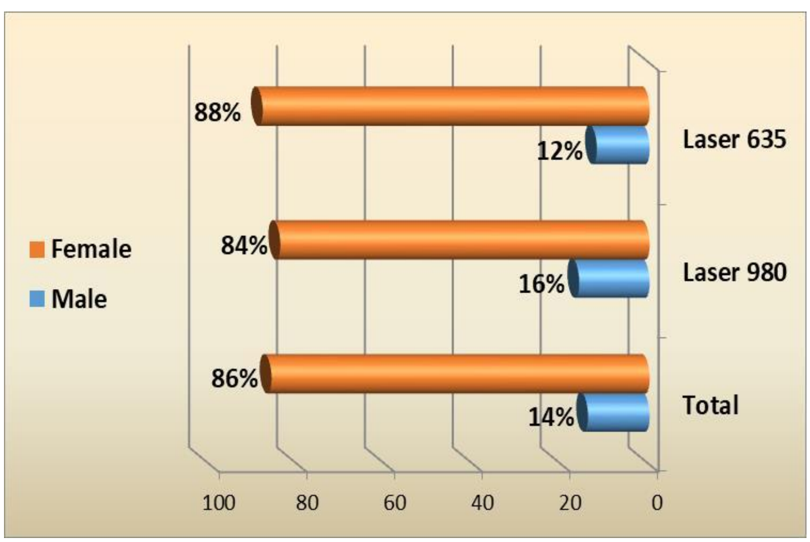

Fig. 4: Distribution of participants according to gender, Baghdad, 2024.

Table 1. Comparison of age and gender of both groups, Baghdad, 2024.

Variable	Groups		P value
	Laser 635 nm	Laser 980 nm	
	N%	N%	
	Age		
Mean±SD	29.5±8.8	25.6±9.5	0.3161
	gender		
Male	3 (12%)	4 (16%)	1.0002
Female	22 (88%)	21 (84%)	

Table 2. Comparison between the variables studied among groups at different time periods

Variable	Laser 635 nm Mean±SD	Laser 980nm Mean±SD	P value
	Before first session		
Pain intensity	5.4±1.2	5.9±1.5	0.246
Mouth opening	39.1±7.4	37.6±4.4	0.454
No. of masseter tender points	4.1±1.5	4.3±1.3	0.623
No. of temporalis tender points	0.7±1	0.9±1.1	0.624
	Before second session		
Pain intensity	3.9±1.2	4.8±1.4	0.025*
Mouth opening	40.4±6.8	39.9±4.8	0.976
No. of masseter tender points	3.1±1.6	3.3±1.2	0.647
No. of temporalis tender points	0.5±0.9	0.6±0.8	0.616
	Before third session		
Pain intensity	3.0±1.1	3.7±1.2	0.021*
Mouth opening	42.0±6.1	40.8±5.8	0.686
No. of masseter tender points	2.8±1.2	2.7±1.3	0.968
No. of temporalis tender points	0.3±0.6	0.5±0.7	0.366
	Before fourth session		
Pain intensity	2.2±1.1	2.8±1.2	0.145
Mouth opening	57.8±71.4	42.8±3.9	0.419
No. of masseter tender points	1.7±1.4	2.3±1.2	0.048*
No. of temporalis tender points	0.3±0.7	0.4±0.7	0.37
	One month follow-up		
Pain intensity	1.3±1.3	1.1±0.9	0.754
Mouth opening	43.6±4.8	42.9±3.8	0.767
No. of masseter tender points	0.9±0.9	1.1±0.9	0.351
No. of temporalis tender points	0.1±0.3	0.2±0.4	0.127

The results of this randomized clinical trial revealed distinct differences in the short-term and long-term efficacy of the two laser wavelengths (635 nm and 980 nm) for the management of temporomandibular disorders (TMDs).As shown in Table2

Short-Term Outcomes Pain Intensity: Patients in the 635 nm laser group reported significantly lower pain levels compared to the 980 nm group by the second session ($p = 0.025$) and third session ($p = 0.021$). These findings highlight the superior analgesic effects of the 635 nm wavelength in the short term.

Tender Points: A significant reduction in the number of tender points in the masseter muscle was observed in the 635 nm laser group before the fourth session ($p = 0.048$). No significant differences were detected in temporalis muscle tender points during the short-term evaluation.

Mouth Opening: Both groups showed slight improvements in mouth opening range over the short-term, but the differences between the two wavelengths were not statistically significant ($p > 0.05$).

Long-Term Outcomes (One-Month Follow-Up) Pain Intensity: No significant differences in pain intensity were observed between the two groups after one month ($p = 0.754$), indicating comparable long-term efficacy.

Tender Points: Both groups demonstrated reductions in the number of tender points in the masseter and temporalis muscles, with no statistically significant differences between them ($p > 0.05$).

Mouth Opening: Improvements in the range of mouth opening were sustained in both groups, with no significant differences between the two wavelengths ($p = 0.767$).

Summary of Findings While the 635 nm laser provided superior short-term pain relief and reduction in masseter tender points, both wavelengths exhibited equivalent long-term outcomes in all measured parameters. These results underscore the potential of wavelength-specific laser therapy in tailoring TMD management strategies.

4. Discussion

This study highlights the potential of low-level laser therapy (LLLT) as an effective treatment for temporomandibular disorders (TMDs), with particular emphasis on the comparative efficacy of 635 nm and 980 nm wavelengths. The findings provide insights into the therapeutic advantages and limitations of each wavelength, offering a foundation for optimizing temporomandibular disorder (TMD) management protocols. Regarding age, the study found that the highest incidence of temporomandibular joint disorders (TMD) was in the 20-29 age group (44.0%). This aligns with previous research, such as Vales an et al.,2021 [15], which reported that 41% of TMD patients were over 18, and Al-Jew air et al., 2021 [16] which reported that 41% of TMD patients were over 18, and noted that TMD peaks between 20 and 40 years.

Regarding gender, our study revealed that the highest incidence of TMD was observed in females (86.0%) compared to males (14.0%). This finding was nearly consistent with most other studies, which also found a predominance of females to males in TMD, including the studies such as Lei et al., 2021[17]. The impact of sex steroid hormones, like estrogen, on condylar shape and health was recently reviewed by Stinson et al., 2019 [18]. Furthermore, the study of Nauru et al., 2024 demonstrated how low amounts of estradiol altered proteoglycan levels in the mandibular condyle cartilage [19].

Neurological, inflammatory, and psychosocial factors significantly impact pain in patients with Temporomandibular Joint Disorders (TMDs). Neurological mechanisms include central sensitivity, abnormal pain processing, peripheral sensitivity, and neuroimmune interactions. Inflammatory mediators like cytokines and prostaglandins contribute to pain, while stress and anxiety exacerbate it by causing muscle tension and altering perception [20,21].

Temporomandibular Joint Disorders (TMJDs) patients often experience limited mouth opening, often less than 40 mm, which affects their ability to eat, speak, and maintain oral hygiene. Joint inflammations, muscle spasms, neurotransmitter imbalance, stress, and anxiety contribute to this issue by affecting the masseter and temporalis muscles [22,23,24,25].

LLLT, a low-level laser therapy, can alleviate pain and mouth discomfort by increasing tissue adenosine triphosphate (ATP) production. This process, called photo biomodulation, raises nerve growth factors, balances neurotransmitters, and lowers substance P, which stops the transmission of pain [26, 27, 28]. The treatment also improves membrane permeability, reduces oxidative stress, accelerates tissue repair, offers pain relief, improves function, reduces inflammation, and increases mobility. The treatment's effects on cells include improved membrane permeability, reduced oxidative stress, faster tissue repair, and reduced inflammation [22, 23, 24].

The study compares the effects of two different laser wavelengths (635 nm and 980 nm) on pain intensity and tender points in the masseter and temporalis muscles. The results indicate that the 635 nm laser, which delivers higher transmitted intensities (0.7618–0.5786 W/cm² for the masseter and 0.7467–0.5515 W/cm² for the temporalis), is more effective in reducing pain and the number of tender points in the masseter muscle. In contrast, the 980 nm laser, with lower transmitted intensities (0.8676–0.7702 W/cm² for the masseter and 0.8572–0.7400 W/cm² for the temporalis), results in less energy delivery to the tissue, leading to diminished therapeutic outcomes. The superior short-term effects of the 635 nm laser can be attributed to its higher absorption in superficial tissues, enhancing photobiomodulation effects. These findings align with previous research, suggesting that shorter wavelengths are more effective in modulating inflammatory processes and reducing nociceptive signaling in superficial tissues [29,30].

In contrast, the 980 nm laser exhibited deeper tissue penetration due to its longer wavelength but showed comparatively less impact on superficial tissues. This limitation may explain the reduced efficacy in addressing masseter tender points in the short term, as the energy may have been dispersed beyond the target tissues[31,32].Long-Term Outcomes Interestingly, the long-term results revealed no significant differences between the two wavelengths in terms of pain intensity, tender points, or mouth opening[33,34,35].This finding suggests that while the 635 nm laser provides superior immediate relief, the 980 nm laser achieves comparable therapeutic outcomes over time. The deeper penetration of the 980 nm laser may contribute to sustained effects by targeting deeper structures, including the TMJ capsule and associated nerves [36,37].

Clinical ImplicationsThe findings underscore the importance of wavelength selection in tailoring LLLT protocols to individual patient needs. The 635 nm laser may offer a more effective short-term solution for patients with acute pain and localized tenderness. Conversely, the 980 nm laser may be preferable for patients requiring treatment of deeper tissue structures or those with chronic conditions. Combining both wavelengths or integrating LLLT with other modalities, such as physical therapy, could further enhance treatment efficacy [38].

5. Limitations and Future Directions

This study is limited by its relatively small sample size and short follow-up duration. Future research should explore the long-term effects of LLLT with larger, more diverse patient populations and investigate optimal treatment parameters, such as session frequency and duration. Additionally, mechanistic studies are needed to elucidate the cellular and molecular pathways underlying the differential effects of 635 nm and 980 nm lasers.

6. Conclusions

The 635 nm laser offers superior short-term benefits for TMD management, particularly in pain reduction and tender point alleviation. However, both wavelengths demonstrate equivalent long-term efficacy, emphasizing their role as viable options for LLLT in clinical practice. Tailoring treatment protocols based on individual patient characteristics and integrating multimodal approaches may maximize therapeutic outcomes.

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دراسة مقارنة بين استخدام جهاز (ليزر 635) وجهاز (ليزر 980) في علاج اضطرابات الصدغية الفكية

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الخلاصة: مقدمة: ان اضطرابات المفصل الصدغي الفكي هي مجموعة معقدة من الحالات التي تؤثر على المفصل الصدغي الفكي وعضلات المضغ مما يؤدي إلى الألم وانخفاض حركة الفك وأعراض أخرى منهكة. غالبًا ما تنشأ هذه الحالات عن أسباب متعددة العوامل بما في ذلك سوء الإطباق والصدمات والإجهاد والعادات غير الوظيفية. ان العلاج الفعال لهذه الاضطرابات من الامور الصعبة مما يستلزم اتباع أساليب علاجية مبتكرة.

الهدف: تهدف هذه الدراسة الى مقارنة وتقييم فعالية طريقتين من طرق العلاج بالليزر منخفض المستوى بطول موجي 635 نانومتر و980 نانومتر في علاج أعراض اضطراب المفصل الصدغي الفكي. والهدف هو تحديد الطول الموجي الذي يوفر نتائج علاجية قصيرة وطويلة الأمد متفوقة في تخفيف الألم وتحسين وظيفة الفم وتقليل النقاط المؤلمة.
المواد والطرق: تم تقسيم خمسين مريضًا تم تشخيصهم باضطراب المفصل الصدغي الفكي (TMD) بشكل عشوائي إلى مجموعتين. تلقت المجموعة الأولى علاجًا بالليزر منخفض المستوى 635 نانومتر بينما عولجت المجموعة الثانية بالليزر منخفض المستوى 980 نانومتر. تم قياس مستويات الألم ونطاق فتح الفم وعدد النقاط المؤلمة قبل كل علاج وفي متابعة بعد شهر واحدمن العلاج. تم تحليل البيانات باستخدام الأساليب الإحصائية المناسبة لتقييم فعالية العلاجات
النتائج: أظهرت النتائج أن مجموعة الليزر 635 نانومتر شهدت انخفاضًا أكبر بكثير في شدة الألم ($p = 0.025$) ونقاط أقل إيلامًا في العضلة الماضغة ($p = 0.048$) مقارنة بمجموعة الليزر 980 نانومتر أثناء التقييم قصير المدى. غير انه لم تلاحظ أي فروقات كبيرة بين المجموعتين في المتابعة بعد شهر واحد من المعالجة.
الاستنتاجات: أظهر الليزر بطول موجة 635 نانومتر فعالية فائقة على المدى القصير في تقليل الألم ونقاط الألم في العضلة الماضغة، في حين كان كلا الطولين الموجيين فعالين بنفس القدر على المدى الطويل. وتسلط هذه النتائج الضوء على أهمية اختيار الطول الموجي في تحسين بروتوكولات العلاج بالليزر منخفض المستوى لإدارة اضطراب المفصل الصدغي الفكي (TMD). وهناك حاجة إلى مزيد من البحث لاستكشاف الآليات الكامنة وراء هذه الاختلافات وتحديد المعايير المثلى لتحقيق نتائج علاجية مستدامة.

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