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Efficacy of Two Diode Laser Wavelenghts in the Management of Masticatory Disorders and Myofascial Pain

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Abstract

Objective: This study aimed to evaluate the effect of photobiomodulation on restricted mouth opening and pain relief in painful temporomandibular patients by using two wavelengths of diode laser. **Material and Methods**: In this study, thirty-six participants—ages 18 to 45 yeas—who suffered from restricted mouth opening, pain in the temporomandibular joint area and tenderness in the temporal and masseter muscles were divided into two groups: Group A (n = 15) received 980 nm laser therapy, and Group B (n = 15) received 635 nm laser therapy. Six participants were excluded. Over the course of two weeks, each group had six therapy sessions. The maximal mouth opening was measured by digital caliper and the pain severity was evaluated using the Visual Analog Scale. The mouth opening and pain scale of the groups were then evaluated statistically using Multiple Wilcoxon sign rank adjusted by Dunn-Bonferroni method, and Tukey's HSD tests. The significance level was set to 0.05. **Results**: The outcomes demonstrated that there were notable improvements in mouth opening and discomfort reductions in both groups. The 980 nm treatment displayed a consistent reduction from baseline, with statistically significant differences between all-time points. The 635 nm treatment showed a more pronounced reduction, especially between baseline and six weeks or one month, but no significant difference between six weeks and one month. **Conclusion**: This study demonstrated the significant impact of the therapeutic efficacy of diode laser wavelengths on the management of masticatory disorders and myofascial pain.

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Introduction

Temporomandibular disorder (TMD)
TMD refers to conditions affecting musculoskeletal system structures, such as the joints (TMJ), masticatory muscles and other related structures. Tenderness in the joints and/or muscles, sounds from the joints, and restricted jaw movement and limitation of mouth opening are the common conditions [1-3]. TMD occur due to injury due, neuropsychological stress, malocclusion, and stroke-related parafunctional activity [4]. Intense pain felt in chewing muscles is quite common in temporomandibular disorders. This pain can often be debilitating. Problems with chewing can arise for a variety of causes that affect the muscles of the jaw, which is felt in the pre-auricular area and masticatory muscles [5,6].

PBM and Arndt- Schulz law
Photobiomodulation is an application that relies on the use of certain wavelengths in low and sub-ablative power settings that produce minimal and accepted thermal effects on tissues to stimulate cellular responses. Many experiments show high compliance with PBM, with no invasiveness, atraumaticity, and no collateral effects [7,8]. The wavelengths shorter than 600 nm tend to be absorbed excessively by pigmental proteins of the cell, while water serves as an effective absorber of the bands longer than 1150 nm [9]. The therapeutic window is the range of suitable wavelengths appropriated for Photobiomodulation. This range lies between 600 and 1150 nm [10].
The phrase "Arndt-Schulz law" refers to a law of treatment effect by medication. It guides the optimal dosing of a therapeutic stimulus.
The Arndt-Schulz curve expresses the optimum response of a living organism between 0.1 to 10 joules/ cm² [11].
The curve suggests that:
1. Low doses (low energy densities) < 2 joule/cm2 insufficient for effect or may be weak stimulatory, promoting cellular function and healing.

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2. Moderate doses (1- 10 joules/cm²) lead to an optimal therapeutic effect.
3. At 10 joules/ cm² indicate the analgesic effect
4. High doses (high energy densities) > 10 joules / cm² can be inhibitory or even harmful.

Pain relief and muscle relaxing
Low level lasers can improve and restore muscle function and alleviate pain threshold, ultimately leading to the restoration of normal cell and tissue functions. As inhibiting of the pain signals that nerve cells send to the brain, laser treatment affects these cells. The brain and adrenal gland produce large amounts of painkillers including endorphins and encephalin, which is a representation of the pain blocking mechanism [12, 13]. Using a non-invasive approach, laser therapy targets muscle trigger points to relieve musculoskeletal discomfort and accelerating angiogenesis, which results in transient vasodilatation, provides an additional advantage [14]. This study aimed to evaluate the effect of Photobiomodulation on districted mouth opening and pain relief on painful temporomandibular patients by use two wavelengths of diode laser.

Material and Methods

Participants
The experimental in vivo trials of this study were approved by Research Ethics committee at Faculty of Dentistry, University of Almaarif, Ramadi, Iraq. (Ref. No. 2, 2024). In this study, thirty-six participants—ages 18 to 45 years—who suffered from restricted mouth opening, pain in the temporomandibular joint area and tenderness in the temporal and masseter muscles presented to the dental clinic at The University of Almaarif. The established guidelines were used to conduct a clinical evaluation of the relevant subjects. A digital measuring instrument was used to measure the participants' mouth opening, and the Visual Analog Scale was employed to gauge the patients' subjective pain level [15]. Participants were chosen according to predefined inclusion criteria. To ensure excluding unwanted instances and maintain other dental and surgical aspects of the research unaware of it, an MRI was taken. Inclusion participants have been divided into two groups, with Group B receiving laser therapy at 635 nm and Group A receiving laser therapy at 980 nm.

Diagnosis
Extraoral and intraoral examinations are achieved in the counselling dental clinic: Palpation, percussion, x- ray, MRI, and the history case of each patient had taken.

2.1 Inclusion and exclusion subjects
The study included patients with pain in the temporomandibular joint region, tenderness in the masticatory muscles, and reduced mouth opening. The excluded cases include complicated conditions such as dislocated joint capsules, trauma, tumors, dental pain, and oral lesions, vascular diseases, arthritis, any known neuropsychological or hormonal problems [16]. Six participants were excluded.

Laser Equipment
1. The laser system used was a Medency triplo laser device, production date 08/2024.
2. Therapy handpiece (DIRECTO HAT-TOP). Directo is a special collimated handpiece developed to increase therapy's reliability with no energy dispersion.

Laser parameters
each patient received irradiance per session as the following equations: [17]
Power density = Power / Area of laser beam
Energy Density = E /Area of laser beam
Peak Power = E/ duration of each treatment session in seconds.
a. 980 nm wavelength
Power 0.8 W, Beam spot diameter 2.2 cm, power density 0.2105 W/cm² exposure time 30 seconds per trigger points in continuous mode, energy density per session 6.32 J/cm2
b. 635 nm wavelength
power 0.5 W, beam spot diameter 2.2 cm, power density per point 0.1315 W/cm² exposure time 30 seconds per trigger points in continuous mode. Energy density of each exposure 3.95 J/cm2

Treatment Approach
Participants in the treatment groups received laser therapy sessions, during which the Directo Hat-Top handpiece was placed over the trigger points, with each exposure time for 30 seconds. Each participant underwent a total of six treatment sessions, which included three laser therapy sessions per week over a duration of two weeks. Subjects in Group A were treated with a 980 nm wavelength at a power setting of 800 mw and an energy density of 6.32 J/cm2. Meanwhile, Group B was administered 635 nm laser therapy at a power setting of 300 mw and an energy density of 3.95 J/cm2 [18].
For every participant, the maximal mouth opening and baseline VAS pain scores were documented. A mean value of pain and MO during function was to be recorded by the patients over two days in between each treatment session. The laser beam was applied in a contact delivery with continuous mode. The contributors monitored patients pain intensity using the Visual Analog Scale before, during, and after the therapy. Mouth opening was measured using a digital caliper. IBM SPSS software version 22 was used for the statistical analysis (SPSS Inc., Chicago, IL, USA). For the categorical and nominal variables, descriptive statistics included to characterize the study variables, while means and standard deviations were used to present the continuous variables.

Results

After completion of laser treatment, the drop in pain intensity and development of mouth opening has been recorded for one month (Tables 1 through 7 and Figures 1 and 2).

Discussion

The values of laser parameters and usable settings were included in therapeutic range of photobiomodulation curve.
Laser therapy is a treatment that is effective in alleviating pain and discomfort. It is also useful for relaxing muscle spasms and increasing circulation to speed up inflammation healing. When the measurements were obtained after treatment period, there was a significant drop in the levels of pain. Those receiving treatment from the 635 nm laser had better results when it comes to mouth opening compared to those receiving treatment from the 980 nm laser. It was helpful that laser light's anti-inflammatory and pain-relieving impact took place in the target tissues. The differing results of 980 and 635 nm laser treatments were possibly due to the varying depth of penetration and biological effects of these two laser wavelengths. Normality test of Maximal mouth opening among periods and groups.
PBM transfers energy to intracellular light-absorbing molecules. Chromophores are present as porphyrins and the mitochondrial e- transport chain. The result is a metabolic energy through the respiratory chain direct to redox change of photons and production of adenosine triphosphate (ATP), and release of nitric oxide (NO) may act as a potent extracellular vasodilator [19,20]. Photoreceptors are present as two complementary groups inside mitochondria. The respiratory chain enzymes at the mitochondrial level act as the main photoreceiver for Photobiomodulation outcomes within wavelengths of the visible band. ion channels embedded on the cell membrane act as the primary photoreceiver for PBM outcomes at infrared wavelength bands [21-23]. Laser-tissue interaction determines the absorption and scattering nature of light, especially the wavelength and its chromophores inside the tissues
Both laser treatments show significant reductions in maximal mouth opening over time. The 980nm treatment displays a consistent reduction from baseline, with statistically significant differences between all-

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time points. The 635 nm treatment shows a more pronounced reduction, especially between baseline and six weeks

The study's findings concur with those of other researchers, such as Mortazavi and Martins-Júnior. The most prevalent age for the development of this condition is between 20 and 40 years old, according to another research conducted by Lipton and Glass & Glaros [24, 25]. This study supports Minghella's findings that 68% of patients with these diseases were young adults [26].

The present study contradicts Emshoff and De Abreu Venancio, who found no alleviation of TMJ pain with LLLT treatment [27]. According to Petrucci, LLLT is insufficient for easing TMJ pain [28]. Numerous research concurs with this one since they found that LLLT application is a useful treatment for TMD sufferers. According to Mazzetto, Çetiner, and Venezian's investigations, patients were monitored for up to 30 days following their final laser application sessions. According to Çetiner and Bisson, the pain decrease remained statistically significant during this time [29-31]. Mazzetto stated that despite these outcomes, the last laser application session eliminated the minimal sensitivity to palpation. For a year, Lassemi monitored the patients and recorded pertinent results in terms of pain relief [32].

According to their research, Arani, Myer used lasers and trigger points to treat the afflicted area. The study reported a significant reduction in pain in all the patients with a laser beam at a wavelength of 980 nm and 635 nm. The corresponding outcomes of PBM with 980 nm were documented in previous studies [33-35]. The mean VAS between the two groups reached a significant difference ($P < 0.05$) after the fourth session which continued till the 6th session and one month follow-up period. According to Turky index, the procedure is considered successful if there is 50 % reduction in the VAS. It is recorded as 75 % reduction in 635 nm group.

The mean MMO between the two groups reached a significant difference ($p < 0.05$) after the sixth session which continued till month follow-up period. The result was in accordance with the study by Khalighi et al., in which results demonstrated 33.6% increase in mouth opening in the laser group which started from the eighth session [36]. The application of photobiomodulation lasers with different wavelengths become popular for pain reduction and healing acceleration after surgeries. Infrared lasers are the best because of their deeper penetration, according to the findings of last research and the laser's wavelength ranged from 635 to 980 nm [37-38].

Conclusions

This study has demonstrated the significant impact of the therapeutic efficacy of diode laser wavelengths on management of masticatory disorders and myofascial pain. By examining two diode laser wavelengths 980 nm, 635 nm, the research highlights relaxing muscle spasms and increasing circulation to speed up inflammation healing. When the measurements were obtained after treatment period, there was a significant drop in the levels of pain to use a 635 nm laser therapy as a biostimulaton aids with myogenic TMD. While the study determines key aspects of diode laser effect on soft tissue, further investigation is needed to explore as applying other laser wavelengths. However, since there were no further side effects of two wavelengths observed after laser session. It is possible to recommend the use of a 635 nm as a photo-biomodulation second option in treatment of masticatory disorders and myofascial pain patients.

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Table 1. Pain relief 1-10.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
980 nm	Pre	7	7	8	6	7	8	8	9	9	10	9	7	8	9	6
	Post 1st	5	3	5	2	5	4	5	5	6	7	7	7	5	6	2
	Post 6th	1	2	2	0	2	0	2	1	2	2	4	5	3	2	0
	1 month	1	2	1	0	2	2	3	4	2	5	7	7	5	2	0
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
635 nm	Pre	8	6	7	7	9	7	6	7	6	9	8	8	7	10	8
	Post 1st	5	4	3	3	6	5	3	4	4	6	5	6	3	6	5
	Post 6th	2	0	1	0	2	1	1	2	0	4	2	2	1	2	2
	1 month	0	0	1	0	2	2	0	4	0	4	0	0	0	2	2

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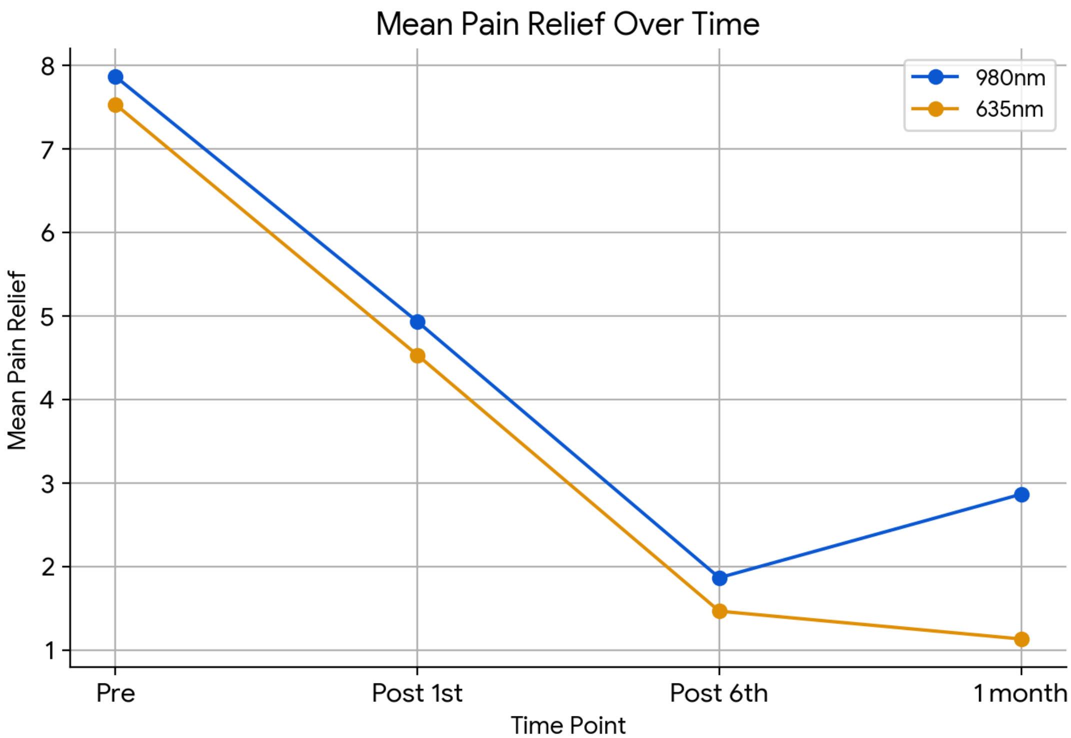

Figure 1. Mean pain relief over time.

Table 2. Maximum mouth opening (mm).

	No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
980 nm	Pre	25	27	24	31	27	24	23	21	21	21	25	27	25	24	30
	Post 1st	37	39	34	37	41	40	36	32	36	32	38	34	36	36	44
	Post 6th	42	44	40	41	42	49	46	41	48	40	45	40	44	40	52
	1 month	37	40	40	41	40	44	46	37	42	40	40	36	44	42	50
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
635 nm	Pre	22	32	23	25	20	26	30	25	33	22	24	22	27	20	22
	Post 1st	26	36	30	31	28	36	40	35	41	28	34	30	37	30	31
	Post 6th	40	52	42	42	40	51	55	52	53	41	47	43	54	41	44
	1 month	42	50	44	43	41	54	55	50	50	40	45	43	52	40	40

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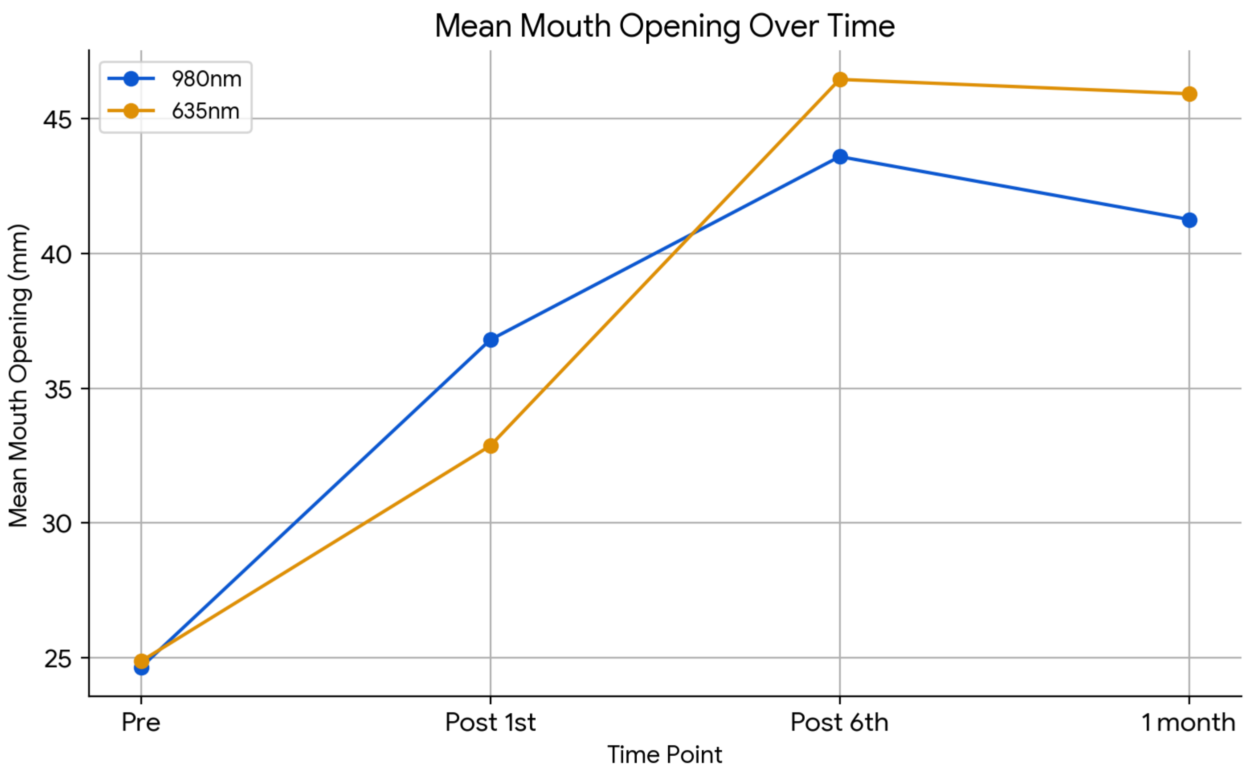

Figure 2. Mean mouth opening over time.

Table 3. Maximum mouth opening comparison using Shapiro Wilk test at p>0.05.

Period	Groups					
	980nm			635nm		
	Statistic	df	P value	Statistic	df	P value
Baseline	0.930	15	0.274	0.898	15	0.090
One	0.956	15	0.631	0.947	15	0.475
Six	0.885	15	0.054	0.886	15	0.055
1month	0.928	15	0.257	0.884	15	0.054

Table 4. Mean maximum mouth opening comparisons.

Period	Groups				T test	P-value
	980nm		635nm			
	Mean	±SD	Mean	±SD		
Baseline	25.000	3.024	24.867	4.086	0.102	0.920
One	36.800	3.278	32.867	4.518	2.729	0.011
Six	41.267	3.654	45.933	5.351	2.789	0.010
1 month	43.600	3.757	46.467	5.705	1.625	0.117
F	89.200		239.857			
P-value	0.000		0.000			
Effect size	0.957		0.984			

Table 5. Multiple pairwise comparison of Maximum mouth opening.

Groups	Period		Mean Difference	P value
980nm	Baseline	One	-11.800	0.000
		Six	-16.267	0.000
		1 month	-18.600	0.000
	one	Six	-4.467	0.000
		1 month	-6.800	0.000
	Six	1 month	-2.333	0.018
635nm	Baseline	One	-8.000	0.000
		Six	-21.067	0.000
		1 month	-21.600	0.000
	one	Six	-13.067	0.000
		1 month	-13.600	0.000
	Six	1 month	-0.533	1.000

Table 6. Mean pain scores comparisons.

	Groups						WSR	P-value
	980nm			635nm				
Period	Median	Mean rank1	Mean rank 2	Median	Mean rank1	Mean rank 2		
Baseline	8	16.77	3.93	7	14.23	4.00	0.812	0.436
One	5	16.83	2.93	5	14.17	2.97	0.852	0.412
Six	2	16.77	1.30	2	14.23	1.60	0.839	0.436
1 month	2	19.13	1.83	0	11.87	1.43	2.339	0.023
Friedman	40.664			42.277				
P-value	0.000			0.000				
Effect size	2.03			2.11				

WSR=Wilcoxon sum rank, Mean rank 1=between groups, Mean rank 2 between periods.

Table 7. Multiple pairwise comparisons of pain (multiple Wilcoxon sign rank adjusted by the Dunn-Bonferroni method).

Groups	Sample 1-Sample 2	Wilcoxon sign rank	P-value
980nm	Pain1-Pain0	2.121	0.034
	Pain6-Pain0	5.586	0.000
	Pain1month-Pain0	4.455	0.000
	Pain6-Pain1	3.465	0.001
	Pain1month-Pain1	2.333	0.020
	Pain6-Pain1month	1.131	0.258
635nm	Pain1-Pain0	2.192	0.028
	Pain6-Pain0	5.091	0.000
	Pain1month-Pain0	5.445	0.000
	Pain6-Pain1	2.899	0.004
	Pain1month-Pain1	3.253	0.001
	Pain1month-Pain6	0.354	0.724