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Use of Low-Level Laser Therapy in**Temporomandibular Joint Disorders: A Review**

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Abstract

Temporomandibular joint (TMJ) disorders are common musculoskeletal conditions characterized by pain and loss of function, negatively affecting the quality of daily life. In recent years, low-level laser therapy (LLLT) has emerged as a promising modality in TMJ treatment due to its biostimulatory, anti-inflammatory, and analgesic effects. This review examines the mechanisms of action, application protocols, effectiveness, and current evidence in the literature regarding the use of LLLT in TMJ disorders.

Introduction

Temporomandibular joint (TMJ) disorders are one of the most common causes of musculoskeletal pain in the head and neck region and represent a significant source of morbidity in the population. Temporomandibular disorders (TMD) encompass a broad spectrum of clinical conditions affecting the TMJ, masticatory muscles, and associated structures. Symptoms of TMD are reported in 5–12% of the adult population worldwide, with a 2–3-fold higher prevalence in women than in men (1,2). The most common clinical manifestations include preauricular pain, joint sounds (crepitus or clicking), restricted mouth opening, and difficulty during mastication (3).

The etiology of TMD is multifactorial, with identified risk factors including parafunctional habits (bruxism, clenching), malocclusion, trauma, psychological stress, hormonal influences, and degenerative joint diseases. Pathophysiological mechanisms involve impaired local microcirculation, inflammation, neuromuscular dysfunction, and central sensitization. TMD treatment primarily relies on conservative methods, and as recommended by the American Academy of Orofacial Pain (AAOP), first-line interventions should be noninvasive and reversible (4,5). Common approaches include occlusal splints, exercises, medications, heat/cold therapy, and physical modalities. However, limitations in efficacy and potential side effects of current treatments have increased the demand for new, safe, and noninvasive options.

In recent years, low-level laser therapy (LLLT) has gained increasing attention as a treatment option for TMD. LLLT elicits a biological response in tissues using low-intensity (typically <500 mW) laser light through a nonthermal photobiomodulation mechanism (2,6). This mechanism allows for suppression of the inflammatory response, analgesia, and accelerated healing (3). Furthermore, LLLT is noninvasive, well-tolerated, and has a minimal side-effect profile, making it a valuable alternative for patients who do not respond to or prefer to avoid pharmacological therapy (5).

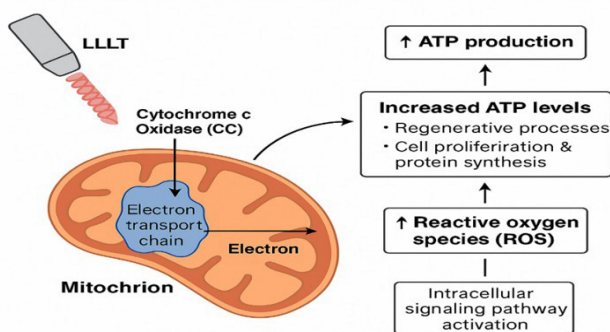
There is an increasing number of randomized controlled trials and systematic reviews supporting the effectiveness of LLLT in reducing TMD symptoms. However, substantial variability in application parameters and protocols limits the ability to evaluate its efficacy (1),(2). Therefore, more evidence-based research and standardized treatment protocols are necessary to clarify the role of LLLT in managing TMD.

Mechanisms of Action: Low-level laser therapy (LLLT), also known as

photobiomodulation (PBM), induces biological responses through non-thermal light-tissue interactions. Its main biological effects are mediated via enhanced mitochondrial activity, modulation of inflammatory mediators, altered nerve conduction, and improved microcirculation (1,7).

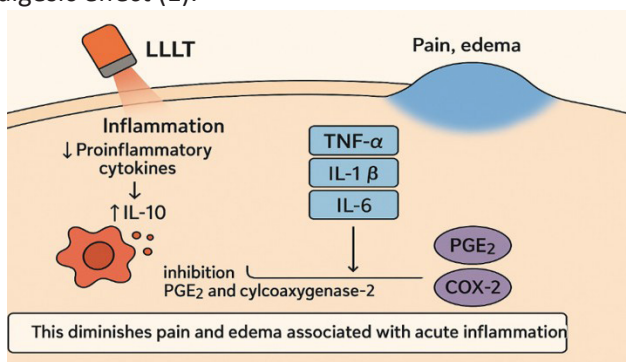
Mitochondrial Activation and ATP Production

A key biochemical target of LLLT is cytochrome c oxidase (CCO) in mitochondria. Laser irradiation enhances CCO activity in the electron transport chain, increasing adenosine triphosphate (ATP) production. Elevated ATP levels support regenerative processes, promote cell proliferation, and to improve protein synthesis in damaged tissues (8). A transient increase in reactive oxygen species (ROS) also activates intracellular signaling pathways, facilitating healing (7).



Reduction of Inflammation

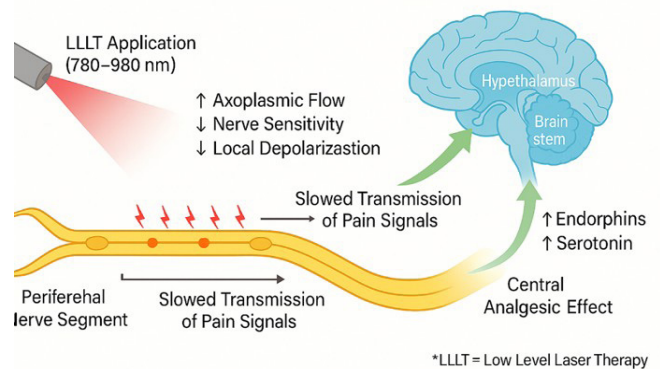
LLLT suppresses the local inflammatory response by reducing proinflammatory cytokines (TNF- α , IL-1 β , IL-6) and increasing the anti-inflammatory cytokine IL-10 (10). This diminishes pain and edema associated with acute and chronic inflammation. Inhibition of prostaglandin E2 (PGE2) and cyclooxygenase-2 (COX-2) also contributes to its analgesic effect (1).



Modulation of Nerve Conduction and Pain Control

LLLT enhances axoplasmic flow at nerve endings, promoting nerve healing and reducing sensitivity in neuropathic pain. It inhibits local depolarization in peripheral nerve fibers, thereby slowing the transmission of pain signals (1). Central analgesia is also achieved by increasing endogenous opioid-like neuropeptides such as endorphins and serotonin (5).

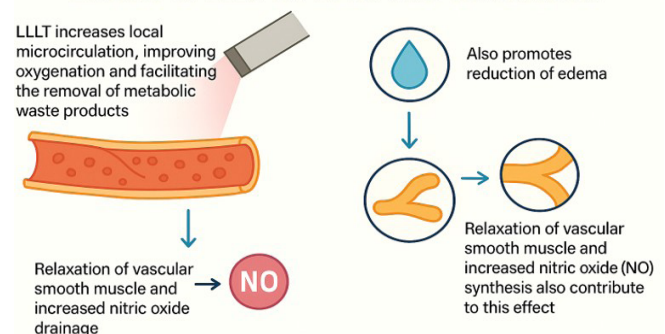
Modulation of Nerve Conduction and Pain Control



Improved Microcirculation and Edema Resolution

LLLT improves local microcirculation and oxygenation while facilitating the removal of metabolic waste. Lymphatic drainage is stimulated to reduce edema, and increased nitric oxide (NO) production, along with vascular smooth muscle relaxation, supports these effects (7).

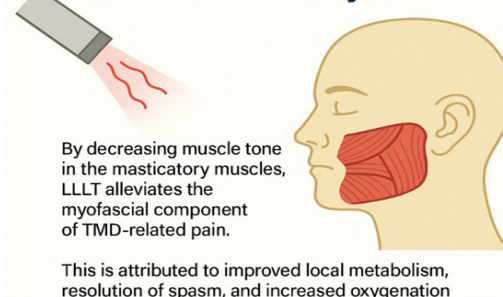
Effects of LLLT on Local Microcirculation



Reduction of Muscle Spasm

By decreasing muscle tone in the masticatory muscles, LLLT alleviates the myofascial component of TMD-related pain. This is attributed to improved local metabolism, resolution of spasm, and increased oxygenation (6).

Effect of LLLT on Myofascial TMD Pain



Thanks to its multifaceted biological effects, LLLT stands out as an effective treatment method for TMD, targeting both intra-articular TMJ inflammation and myofascial pain in the surrounding muscles. The combination of these mechanisms results in pain reduction, functional improvement, and an enhanced quality of life for patients.

Effectiveness: In recent years, studies investigating the effectiveness of low-level laser therapy (LLLT) in treating

temporomandibular joint (TMJ) disorders have increased significantly. Systematic reviews, meta-analyses, and randomized controlled trials (RCTs) support the positive effects of LLLT on pain management and functional improvement in TMJ patients.

Pain Reduction: Several studies have demonstrated that LLLT significantly reduces TMJ-related pain. In a comprehensive meta-analysis by Shen et al. (9), patients receiving LLLT showed statistically significant reductions in pain scores compared to the placebo group. Furthermore, this pain reduction persisted in both short- and medium-term follow-ups. Similarly, de Moraes et al. (1) reported that LLLT was effective in decreasing pain and increasing pain thresholds in myogenic TMJ disorders.

Functional Improvement: LLLT not only reduces pain but also leads to significant improvements in jaw range of motion. In a systematic review by Lomas-Vega et al. (10), maximum mouth opening was increased in patients receiving LLLT, indicating functional improvement. Likewise, a clinical study by Chang et al. (11) demonstrated that LLLT improved mandibular functions.

Suppression of Inflammation and Reduction of Edema: The inhibitory effects of LLLT on inflammatory mediators clinically translate into reduced inflammation in the TMJ (5). These effects help alleviate inflammation-related pain and decrease periarticular edema. Clinical studies have shown that edema around the joint significantly decreases with LLLT (12).

Variability of Protocols and Its Impact on Outcomes: Some studies report heterogeneity in outcomes due to the use of different wavelengths, energy doses, and treatment frequencies in LLLT protocols. Shen et al. (9) noted that wavelengths between 780 and 830 nm produced more consistent positive results in terms of pain and function. Additionally, energy doses of 6–12 J/cm² were reported to be optimal for effectiveness. This variability highlights the need for standardized protocols in clinical practice.

Safety and Side Effects: Current studies report that LLLT does not cause serious adverse effects in TMJ treatment and is generally well tolerated by patients (13). This makes LLLT a desirable alternative or adjunctive therapy to pharmacological treatments.

Application Parameters: The effectiveness of low-level laser therapy (LLLT) in temporomandibular joint (TMJ) disorders largely depends on the application parameters. Although there is heterogeneity in the literature regarding wavelength, power, energy density, application time, and number of sessions, recent studies propose more standardized protocols and optimal values.

Wavelength

- The most commonly preferred range is 780–980 nm (infrared spectrum), which ensures deep tissue penetration and supports mitochondrial activity (9,14).
- Although some studies use 660 nm (red light), infrared wavelengths are considered more effective in reaching intra-articular tissues (1).

Power Output

- The output power of laser devices usually ranges from 50 to 500 mW (5).
- Careful selection of low power is recommended to avoid thermal tissue damage.

Energy Density (Fluence)

- Typically applied in the range of 4–12 J/cm² (9).
- Meta-analyses suggest that doses of 6–8 J/cm² are optimal for reducing pain and inflammation (13).

Application Time and Points

- Each application point usually receives laser light for 30 seconds to 1 minute.
- Application points include the TMJ line in the preauricular area, as well as trigger points in the masseter, temporalis, and lateral pterygoid muscles.
- Typically, 4–6 points are treated (9).

Number and Frequency of Sessions

- Clinical protocols generally recommend 2–3 sessions per week, totaling 8–12 sessions (1,5).
- The overall treatment period averages 4–6 weeks and can be adjusted according to the patient's response.

Mode: Continuous or Pulsed

- Both continuous wave and pulsed modes are used; some studies suggest that the pulsed mode may produce less tissue heating and better outcomes (7). However, there is no consensus yet.

Parameter	Range/Value	Notes
Wavelength	780–980 nm	Infrared light, deep penetration
Power Output	50–500 mW	To avoid thermal damage
Energy Density	4–12 J/cm ²	Optimal: 6–8 J/cm ²
Application Time	30–60 sec/point	4–6 points recommended
Session Frequency	2–3/week	Total of 8–12 sessions
Treatment Duration	4–6 weeks	Can be adjusted
Mode	Continuous/Pulsed	Pulsed may be preferred

Example of Clinical Protocol (1,2)

The application parameters of LLLT should be carefully selected based on the patient's symptoms, response to treatment, and the characteristics of the device used. More controlled clinical studies are needed to standardize these parameters. Current evidence supports that applications using a wavelength of 780–980 nm and an energy dose of 6–8 J/cm², administered 2–3 times per week, are effective and safe in TMJ disorders (9,13).

Safety and Side Effects: Low-level laser therapy (LLL) is considered a noninvasive, painless, and minimally risky modality for TMJ disorders. Recent studies have confirmed its safety profile, with serious adverse effects being rare (5,13).

Side Effect Profile

- Serious side effects of LLLT have rarely been reported. The most common effects are mild and transient, such as redness, warmth, or a mild burning sensation at the application site (6,11).
- No permanent skin or mucosal lesions, burns, or painful reactions have been observed (10).
- Systemic side effects have not been reported, as LLLT is a localized therapy without systemic pharmacological effects.

Safety Precautions

- Eye protection is mandatory during laser application, especially when working near the eyes (7).
- Caution should be exercised in special conditions such as pregnancy, malignancy, or photosensitivity, and treatment should always be under physician supervision (5).

Contraindications

- Active malignant tumors, infections, or acute inflammation at the treatment site, as well as pregnancy, are among the contraindications (13).
- Caution is also advised in patients taking photosensitizing drugs.

Clinical Reliability and Patient Compliance

- Patients are likely to accept LLLT due to its noninvasive and painless nature (9).
- As an alternative or adjunct to medication, it is particularly beneficial for patients who wish to avoid pharmacological side effects.

Recent studies have clarified the safety profile of LLLT in TMJ disorders, showing that serious side effects are infrequent and transient. With appropriate protocols and

protective measures, LLLT is recommended as an effective treatment that enhances patient comfort (5,13).

Discussion

Low-level laser therapy (LLL) has recently gained prominence as a noninvasive and biomodulatory treatment for temporomandibular joint (TMJ) disorders. Based on the current evidence presented in this review, LLLT appears to provide significant benefits in both pain control and functional improvement. However, heterogeneity in the literature and methodological differences make it challenging to interpret the results and underscore the need for greater standardization.

The majority of studies demonstrate that LLLT significantly reduces TMJ-related pain (1), (9). This is explained by LLLT's biological effects, including suppression of inflammation, modulation of nerve conduction, and improved local circulation (7). A meta-analysis by Lomas-Vega et al. (14) highlighted that LLLT was superior to placebo and conventional treatments, and its effects persisted for weeks after treatment. However, some studies did not report a significant difference compared to placebo (13), which may be due to differences in application parameters (wavelength, energy dose, session frequency, etc.).

The role of LLLT in improving mouth opening and jaw function is also supported in the literature (15). Nonetheless, the extent to which pain reduction contributes directly to functional improvement remains a matter of controversy. Some studies report significant pain reduction without corresponding improvements in mouth opening (9). This variability may be related to whether the disorder is of myogenic or articular origin.

A key limitation in LLLT studies is the lack of standardized protocols. There is significant variability in the wavelengths (660–980 nm), energy doses (4–12 J/cm²), and session frequencies used (5,9). However, meta-analyses suggest optimal parameters of 780–830 nm wavelength and 6–8 J/cm² energy density (14), but a definitive consensus has yet to be reached. Until standardized protocols are developed, variable outcomes in clinical practice are likely to persist.

LLL's most important advantages include its noninvasiveness, ability to be applied without pharmacologic therapy, high patient tolerance, and rare occurrence of serious side effects (5,13). It offers a valuable option, particularly for patients with drug intolerance or systemic conditions where pharmacotherapy should be avoided.

Many studies are limited by small sample sizes, short follow-up periods, and lack of double-blind designs, which restrict the generalizability of their findings (14). Furthermore, evidence suggests that LLLT may have different effects in myogenic versus articular TMJ disorders,

but more detailed studies are needed. In the future, larger, long-term, high-quality randomized controlled trials are required to understand the biological effects of LLLT better and to standardize clinical protocols.

Conclusion

Current evidence indicates that LLLT is a safe, well-tolerated, and effective treatment option for TMJ disorders. However, given the heterogeneity in application parameters and methodological limitations, developing standardized treatment guidelines is crucial. Clinical decisions should be tailored to individual patient characteristics and disease type.

- LLLT significantly reduces pain intensity in TMJ patients (1,9).
- Functional improvement is reflected by an increased range of jaw movement (10).
- Reduction in inflammation and edema supports treatment effectiveness (5).
- Standardization of application parameters is essential for reliable clinical outcomes.
- It is a safe and side-effect-free treatment option (13).

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