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REVIEW ARTICLE

Illuminating Relief: The Efficacy of Low-Level Laser Therapy (LLLT) in Managing Orofacial Pain Disorders – A Comprehensive Review

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ABSTRACT
Low-Level Laser Therapy (LLLT) has emerged as a promising non-invasive modality for managing orofacial pain disorders by modulating inflammation, enhancing tissue repair, and promoting neural regeneration. This comprehensive review explores the classification, mechanisms, and therapeutic applications of LLLT in treating conditions such as trigeminal neuralgia, myofascial pain dysfunction syndrome, and temporomandibular joint disorders. The mechanism of LLLT follows the Arndt–Schulz principle, where optimal energy doses stimulate biological processes while excessive exposure diminishes efficacy. Clinical studies suggest that LLLT significantly reduces pain intensity and improves functional outcomes, with minimal adverse effects. By examining laser-tissue interactions and the evidence supporting its efficacy, this review highlights LLLT as an effective adjunct in pain management. However, further large-scale trials are required to standardize treatment protocols and optimize therapeutic outcomes.
Keywords: Low-Level Laser Therapy, Orofacial Pain, Trigeminal Neuralgia, Myofascial Pain, Temporomandibular Joint Disorder, Photobiomodulation, Laser Therapy.
Abbreviation : **LLLT**- Low-Level Laser Therapy, **LASER** – Light Amplification by Stimulated Emission of Radiation, **TN** – Trigeminal Neuralgia, **ISAP** – International Association for the Study of Pain, **PDT** – Photodynamic Therapy, **PHN** – Postherpetic Neuralgia, **VZV** – Varicella-Zoster Virus, **HHV-3** – Human Herpesvirus-3, **UV** – Ultraviolet, **IR** – Infrared, **ATP** – Adenosine Triphosphate.

INTRODUCTION
LASER, which stands for **Light Amplification by Stimulated Emission of Radiation .[1]**Over time, LASER technology has advanced, with diode lasers and fiber-optic systems improving precision and safety. **[2]**The evolution of LASER technology has significantly impacted oral medicine, providing a minimally invasive and highly precise alternative for treating various oral conditions.**[3]** The foundation for LASER development was laid by **Albert Einstein in 1917** with the concept of stimulated emission, which led to the invention of the MASER and later the LASER.**[4],[5],[6]**The first functioning laser, developed by **Theodore Maiman in 1960**, used a ruby crystal. **[1], [5],[7]**Their non-ionizing nature makes them suitable for treating various benign and potentially malignant oral lesions. **[2]**This focused review aims to provide an overview of the effects of LLLT on orofacial disorders.

CLASSIFICATION OF LASERS[7],[8],[9],[10]
1. **Based on Gain Medium**
- Solid-state Lasers
- Gas Lasers
2. **Semiconductor Lasers (Laser Diodes)**
- Liquid Lasers (Dye Lasers)
- Fiber Lasers

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3. **Based on Power**
- High-power Lasers (Hard, Hot)
- Intermediate-power Lasers
- Low-power Lasers (Soft, Cold)

4. **Based on Wavelength**
- Ultraviolet Lasers (140-350 nm)
- Visible Lasers (350-750 nm)
- Infrared Lasers (750 nm and above)

5. **Based on Penetration Power**
- Hard Lasers
- Soft Lasers

6. **Based on Pulsing**
- Pulsed Lasers
- Non-pulsed Lasers

7. **Based on Clinical Use**

a) Surgical
- Hard Tissue Lasers (Er:YAG, Er:YSGG, CO_2)
- Soft Tissue Lasers (Diode, Nd:YAG, CO_2)

b) Non-Surgical
- Diagnostic (KaVo Diagnodent, Laser Doppler Flowmetry)
- Low-Level Laser Therapy
- Miscellaneous (Photoactivated Disinfection, Laser-based Curing Light)

MECHANISM OF ACTION

Lasers function by delivering controlled energy to target tissues through fiberoptic cables, waveguides, and lenses. Their mechanism follows the Arndt–Schulz principle, where optimal stimulation enhances biological effects while excessive or insufficient energy reduces efficacy. LLLT provides sub-thermal energy that penetrates tissues, activating immune cells, reducing inflammation, minimizing edema, and promoting collagen synthesis and cell regeneration. Surgical lasers, such as Er:YAG and CO_2 lasers, operate at specific wavelengths to achieve coagulation, vaporization, and healing. Laser wavelengths fall into ultraviolet (UV) (<400 nm), visible (400–700 nm), and infrared (IR) (>700 nm) ranges, influencing their interaction with tissues.**[10],[11],[12]**

Laser-Tissue Interaction

Laser-tissue interaction depends on wavelength, power, and exposure duration, leading to **photothermal, photomechanical, photochemical, and photoablation effects**. **Photothermal interaction** converts laser energy into heat, causing hyperthermia (40–45°C) for therapy, coagulation (60–100°C) for tissue ablation, and vaporization (>100°C) for precise cutting.**[13],[14]Photomechanical interaction** uses pulsed energy to create shock waves (photoacoustic effect) or plasma-induced tissue fragmentation (optical breakdown). **Photochemical interaction** includes **photodynamic therapy (PDT)**, which destroys cells via reactive oxygen species, and **LLLT**, which promotes healing and reduces inflammation. **Photoablation** breaks molecular bonds, allowing precise tissue removal with minimal thermal damage.**[13],[14]**

LASER in management of Orofacial Pain Disorders

Definition

"According to ISAP Pain is defined as an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of suchdamage". Orofacial pain is a frequent form of pain perceived in the face and/or oral cavity. It may be caused by diseases or disorders of regional structures, nervous system dysfunction, or through referral from distant sources.

1. **Neuralgic Pain[15],[16],[17]**

A. Trigeminal Neuralgia

B. Post Herpetic Neuralgia

2. **Myofascial pain dysfunction syndrome**
3. **Temporomandibular joint disorder**

1. **Neuralgic Pain**

A. Trigeminal Neuralgia [15],[16],[17]

TN or Tic douloureux is defined by the International Association for the Study of Pain(IASP) as " a sudden, usually unilateral, severe, brief, stabbing, recurrent pain in thedistribution of one or more branches of the fifth cranial nerve". **[15],[17]**

Clinical appearance

TN pain is usually described as sudden, sharp, and electric shock-like, often triggeredby everyday activities such as talking, chewing, or brushing teeth. These painfulepisodes last from a few seconds up to two minutes, with frequency varying widelyamong individuals, which can severely impact one's quality of life. The maxillary andmandibular branches of the trigeminal nerve are most commonly involved, while theophthalmic branch is less frequently affected.**[15],[17],[18],[19]**The exact cause and mechanism of TN are not fully understood. Some theoriessuggest that both peripheral and central mechanisms play a role. Peripheral theoriesfocus on changes in the peripheral axons and myelin, altering the threshold forstimuli. Central theories liken TN to focal epilepsy, where pressure on the nervebranches or ganglia leads to pain. Factors such as nerve compression by tumorsorvascular anomalies, demyelinating conditions like multiple sclerosis, infections, andnerve trauma can trigger TN.

Management of Trigeminal Neuralgia [19],[20]

Treatment of TN varies depending on whether a specific cause can be identified. If acause is known, addressing it directly is preferred. The management of TN is asfollows:

1. **Non-Surgical Management**
- Pharmacological management
- Surgical Management

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- Peripheral Nerve Procedures
- Open Surgical Procedures

2. Management of Neuralgic Pain with Lasers:

In idiopathic cases, management includes medications like carbamazepine, phenytoinand gabapentin, though these can have significant side effects. Surgical options rangefrom peripheral nerve procedures to more invasive surgeries like microvasculardecompression. However, Low-Level Laser Therapy (LLLT) can effectively treatchronic pain and nerve injuries, by promoting nerve function and myelin production.The mechanism behind LLLT's effectiveness in pain relief includes modulation ofinflammatory responses, increased ATP production, and enhanced localmicrocirculation.**[19]**

Mann et al. (1995) found that combi-laser therapy provided substantial pain reliefafter 15 sessions. They suggested that LLLT is effective in reducing TN pain.**[18]**

Haghighat et al. (2020) conducted a systematic review to assess the efficacy of laser therapy in trigeminal neuralgia. Databases- PubMed, Scopus, Web of Science, Science Direct, and Embase were searched from December 1983 to August 2020 using the keywords "trigeminal neuralgia" and "laser."Out of 269 records, 13 studies met the eligibility criteria. Results indicated that low-level laser therapy, i.e. diode lasers, effectively reduced pain in trigeminal neuralgi**a. [19]**

Kim et al.(2003) conducted a study in which He-Ne, GaAlAs, and CO_2 lasers were used to treat patients with trigeminal neuralgia. 25 patients were divided into two groups, one with low-level laser therapy and the other, a combination of laser therapy and medication. Results from the Visual Analog Scale indicated that laser therapy alone provided greater pain relief compared to the combined treatment. **[20]**

B. Postherpetic Neuralgia

Postherpetic neuralgia (PHN) is the most prevalent chronic complication resulting from the reactivation of the varicella-zoster virus (VZV), also referred to as human herpesvirus-3 (HHV-3). This reactivation, commonly known as herpes zoster or shingles, occurs when the dormant VZV is triggered. VZV is the virus responsible for varicella, more commonly known as chickenpox in children.**[21],[22]**

Clinical Features

The clinical features of postherpetic neuralgia (PHN) are distinct and typically follow an episode of herpes zoster (shingles), marked by a dermatomal rash with blisters. A rash may be absent (zoster sine herpete), complicating the diagnosis. The hallmark of PHN is persistent pain lasting three months or more after the rash resolves, characterized by sharp, burning sensations, allodynia (pain from non-painful stimuli like light touch), paresthesias, pruritus, dysesthesias, and hyperalgesia. Physical examination may reveal cutaneous scarring, altered sensation (either hypersensitivity or hypoesthesia), and signs of autonomic dysfunction, such as excessive sweating in the affected area**.[23],[24]**

Management of PHN [20],[25],[26],[27]

1. Early Treatment of HZ Infection

2. Symptom Management:

Multimodal medication regimens and interventional procedures.

3. Pharmacological management

a) First-line Medications:

- Tricyclic antidepressants (TCAs)
- Pregabalin
- Lidocaine 5% patch

b) Other Pharmacologic Options:

- Gabapentin
- Capsaicin cream/patch (requires pre-treatment for irritation)
- Serotonin-norepinephrine reuptake inhibitors (SNRIs)
- Selective serotonin reuptake inhibitors (SSRIs)
- NMDA antagonists (e.g., ketamine, lidocaine infusions)

4. Invasive Therapies:

- Botulinum toxin injections
- Sympathetic blockade with local anesthetics
- Epidural/intrathecal injections (e.g., methylprednisolone, lidocaine)
- CT-guided radiofrequency ablation of the dorsal root ganglion

Management of PHN with Lasers

Iijima et al. (1986) demonstrated significant pain reduction in patients with post-herpetic neuralgia after treatment with a helium-neon (He-Ne) laser. Walker's studies (1987) also showed that He-Ne laser therapy reduced pain intensity and frequency in TN and other chronic pain conditions.**[28]**

Moore et al. (1992) reported significant pain relief in PHN patients following LLLT.**[29]**

Kemmotsu et al. (1989) achieved good long-term results with similar laser parameters.**[30]**

Myofascial Pain Dysfunction Syndrome (MPDS)

Myofascial Pain Dysfunction Syndrome(MPDS) is a prevalent condition responsible for chronic facial pain, primarily affecting the muscles involved in mastication. The condition is multifactorial, with key contributors being psychological stress, occlusal imbalances, and para-functional behavior like bruxism, which cause muscle spasms.[**30],[31]**

Clinical Features

MPDS commonly experience facial pain, limited jaw movement, and tenderness in the jaw muscles. Clicking, popping, or grating sounds in the temporomandibular joint (TMJ).[**30]**

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Management of MPDS[30],[31]

1. Conservative Treatment:

Includes nonsteroidal anti-inflammatory drugs, muscle relaxants, and analgesics to manage pain and inflammation. Occlusal Splints help reduce stress on the TMJ and prevent teeth grinding. Biofeedback help patients become aware of and control muscle tension. Exercise and physical therapies to improve muscle function and reduce pain.

2. Management of MPDS with Laser:

Azizi et al.(2007)conducted a studyto assess the effects of low-level laser therapy (LLLT) in the treatment of Myofascial Pain Dysfunction Syndrome (MPDS). The study involved 22 MPDS patients who received LLLT over 4weeks, with follow-up evaluationconducted up to 3 months post-treatment. Results indicated significant improvements in pain severity, cheek pain, pain frequency, and tenderness of the masseter, temporalis, medial, and lateral pterygoid muscles. These improvements persisted throughout the 3-month follow-up period, demonstrating that LLLT is an effective treatment for alleviating pain and reducing muscle tenderness in MPDS patients.**[32]**

Chitnis et al. (2020) assessed laser therapy in management of MPDS using low-level laser therapy in reducing pain and improving muscle function in patients suffering from MPDS. Asignificant reduction in pain levels and range of motion, suggesting LLLT can be a beneficial treatment option for managing MPDS. The study supported the integration of laser therapy into MPDS treatment protocols for enhanced patient outcomes.**[33]**

Jagdhari et al.(2015) evaluated the effectiveness of laser therapy in conjunction with routine treatment modalities for MPDS. 60 patients, aged 15-60 years, were given TMJ exercises, laser therapy, or a combination of both. There wasa significant reduction in pain across all groups. Patients treated with laser therapy alone experienced an 81% reduction in pain, those who underwent a combination of laser therapy and exercises saw the most significant improvement, with an 88% reduction in pain.Thecombination treatment led to a complete elimination of muscle tenderness in 100% of the patients, while laser therapy alone achieved a 93% reduction, and exercise alone showed a 62.5% reduction. The study concluded that laser therapy, especially when combined with exercise, is an effective treatment modality for MPDS. However, the authors suggested that further long-term studies with larger sample sizes should be conducted to confirm these findings.**[34]**

Temporomandibular joint (TMJ) disorders

Temporomandibular joint disorders (TMDs) refer to conditions that affect the temporomandibular joint (TMJ), muscles of mastication and related structures.**[35]** These disorders often lead to pain, functional limitations and structural abnormalities in the jaw. The overall prevalence of TMDs ranges from 21.5% to 50.5% with a higher occurrence in females.**[35]**

Clinical Features of TMJ Pain Disorder

TMDs are commonly characterized by symptoms, like pain or tenderness in the jaw, restricted jaw movements, joint sounds such as clicking or popping, and muscle fatigue**[35], [36]**

Management of TMJ Pain Disorder[36],[37]

The management of TMJ disorders is multidisciplinary, involving conservative and in some cases, surgical approaches. Laser treatment is increasingly used for managing TMJ pain due to its therapeutic benefits, such as promoting tissue healing and improving localmicrocirculation.**[38]**

1. Conservative therapy[38]
- Physical therapy
- Pharmacological treatment (e.g., analgesics, muscle relaxants)
- Occlusal splint therapy.

2. Surgical intervention
- Arthrocentesis
- Arthroscopy

3. Management of TMJ Pain Disorder with Lasers

CarliBMet al. (2016) studied 15 participants (laser group: n=8, botulinum toxin A group: n=7) and found that while both laser and botulinum toxin treatments were effective in reducing pain, laser therapy showed faster pain reduction. However, neither treatment significantly improved mouth opening **[39]**

ShobhaR, Narayanan VS, Jagadish Pai B S, Jaishankar H P, Jijin M J. **(2017)** conducted a study with 40 participants aged 18–40 years, divided into a laser group (n=20) and a placebo group (n=20). They used a diode laser (810 nm, 0.1 W, 6 J/cm²) and observed a reduction in pain in both the laser and placebo groups. Improvement in temporomandibular clicking was also noted, but there was no statistically significant difference between the groups**[40]**

Chellappa D, Thirupathy M. **(2020)** compared LLLT (n=30) and TENS (n=30) in a group of 60 participants. LLLT was found more effective than TENS in reducing pain and improving the range of mandibular motion .**[41]**

Zwiri A. et. al. conducted a study in 2020 on the management of TMJ pain using laser therapy in 1172 patients, finding that majority of studies reported significant pain reduction with laser treatment. Two-thirds of the studies showed better outcomes compared to conventional treatments and 84.4% of studies were of high methodological quality with a low risk of bias**[42]**

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CONCLUSION

Low-Level Laser Therapy (LLLT) has emerged as a promising, non-invasive modality for managing various orofacial pain disorders, including trigeminal neuralgia, myofascial pain dysfunction syndrome (MPDS), and temporomandibular joint disorders (TMDs). By modulating inflammation, enhancing neural regeneration, and promoting tissue repair, LLLT offers significant pain relief with minimal adverse effects. The existing literature supports its efficacy in reducing pain intensity and improving functional outcomes. Studies demonstrate that LLLT, either alone or in combination with other therapeutic modalities, yields better results compared to conventional treatments. However, despite its potential, variations in laser parameters and treatment protocols necessitate further large-scale, standardized trials to establish optimal guidelines for clinical use. Future research should focus on refining LLLT application protocols to maximize its therapeutic benefits and broaden its adoption in routine pain management practices.

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