

Low Level Laser Therapy

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Abstract—Low Level Laser Therapy (LLLT) has emerged as an important non-invasive treatment modality in dentistry, particularly in periodontal therapy. It utilizes low-intensity laser energy to stimulate biological processes without causing thermal damage to tissues. The therapeutic effects of LLLT are mainly based on photobiomodulation, which enhances cellular metabolism, increases adenosine triphosphate (ATP) production, and promotes cell proliferation and tissue repair. This mechanism helps in reducing inflammation, pain, and postoperative edema while accelerating wound healing. LLLT has been widely applied in the management of various oral conditions such as aphthous ulcers, oral mucositis, dentinal hypersensitivity, temporomandibular disorders, and periodontal diseases. Commonly used lasers for this therapy include gallium–aluminium–arsenide (GaAlAs) lasers operating within the near-infrared wavelength range. Due to its ability to enhance healing, reduce discomfort, and improve clinical outcomes, LLLT has gained significant importance as an adjunctive therapeutic approach in modern dental practice.

Index Terms—Low Level Laser Therapy (LLLT), Photobiomodulation, Periodontal Therapy, Tissue Healing, Dental Lasers, GaAlAs Laser.

I. INTRODUCTION

Lasers have been widely utilised in the field of periodontology due to their ability to deliver precisely controlled energy with high spatial and temporal accuracy[1]. One of its major advantages in periodontology is the maintenance of a relatively bloodless field. Low-Level Laser Therapy (LLLT), also known as soft laser therapy or low-intensity laser therapy, is a non-ablative therapeutic modality which promotes tissue healing and also helps to reduce post-operative oedema, inflammation, and pain[2]. Clinically, LLLT has been extensively used in the management of temporomandibular disorders, dentinal hypersensitivity, oral mucositis, aphthous ulcers, and periodontitis, and it plays a significant role

in contemporary periodontal therapeutics. In our review article we are going to elaborate the application of LLLT in periodontal therapy[3].

MECHANISM OF ACTION

The therapeutic effects of low-level laser therapy (LLLT) are primarily mediated through photobiomodulation. The biostimulatory effects of laser irradiation acts on the antenna pigments of the mitochondrial respiratory chain, resulting in increased adenosine triphosphate (ATP) production[4]. This leads to intracellular metabolic modulation, enhanced cell proliferation, increased fibroblast migration, and accelerated extracellular matrix synthesis. This modality enhances cellular metabolism, promotes tissue repair, and supports regenerative processes without producing thermal damage[5].

LASERS USED FOR LLLT

The most commonly used laser system for LLLT is the gallium–aluminium–arsenide (GaAlAs) laser, which operates within a wavelength range of 780–830 nm and delivers an output power between 10 and 500 mW[6]. These lasers are compact and typically operate in continuous mode, with the capability of electronic or mechanical pulsing. Experimental and clinical studies have demonstrated its potential role in neural tissue repair, including recovery following spinal cord injury[2].

II. APPLICATION OF LLLT

APHTHOUS ULCER

LLLT is regarded as an effective supportive treatment for aphthous ulcers. A commonly recommended energy density for treatment is around 2 J/cm². [6] Red and near-infrared wavelength lasers are widely utilized for oral ulcerative and mucositis lesions. The therapy helps by lowering inflammatory mediators and regulating the inflammatory process in affected tissues[7]It boosts cellular metabolism and

mitochondrial function, resulting in quicker tissue repair. Immediate pain relief occurs due to reduced nerve conduction and increased endorphin release. LLLT enhances fibroblast activity and collagen production, aiding epithelial regeneration. It improves local blood flow and oxygenation, thereby speeding up wound healing^[8]. Patients experience reduced pain and discomfort while eating, drinking, or maintaining oral hygiene. Research indicates that LLLT can reduce healing duration compared to conventional or placebo treatments^[9]. Diode laser therapy has also been shown to decrease ulcer size and promote faster lesion resolution.

PERIODONTAL THERAPY

LLLT plays an important role in managing periodontitis by decreasing inflammation and accelerating periodontal tissue repair. As an adjunct to conventional periodontal procedures, it helps reduce gingival inflammation, bleeding on probing, and periodontal pocket depth^[10]. The therapy boosts cellular metabolism and stimulates mitochondrial activity, leading to faster healing. It encourages fibroblast growth and increases collagen production, both essential for periodontal regeneration^[11] LLLT improves blood circulation and oxygen delivery within periodontal tissues, promoting efficient wound healing. It is effective in minimizing postoperative pain and edema after periodontal surgery. Commonly used wavelengths in soft tissue therapy include 904 nm (continuous mode) and 820–830 nm applied for about 60 seconds^[12]. A wavelength near 670 nm may also be utilized to support tissue repair in periodontal treatment. Studies suggest that LLLT can enhance clinical attachment levels and contribute to regeneration of periodontal structures. It may also be useful in treating associated oral conditions such as trigeminal neuralgia, paresthesia, herpes labialis, and discomfort related to orthodontic treatment^[6]. Due to its non-invasive approach and minimal adverse effects, LLLT is regarded as a safe and beneficial adjunct in periodontal management.

POST OPERATIVE THERAPY

LLLT is routinely applied after tooth extractions, periodontal surgeries, implant placement, and other minor oral surgical procedures to improve wound healing. A laser energy dose of approximately 2 J is commonly recommended for standard postoperative

care.^[6] The therapy reduces pain and swelling by regulating inflammatory mediators and improving local blood circulation. It enhances cellular metabolism and mitochondrial function, thereby accelerating tissue repair and regeneration. LLLT stimulates fibroblast activity and collagen production, supporting rapid soft tissue healing. It promotes angiogenesis and increases local blood flow, ensuring better oxygen and nutrient delivery to the surgical area. For temporomandibular disorders (TMD), infrared laser therapy with doses between 6–10 J is often used to relieve joint pain and muscle inflammation. In cases of dentin hypersensitivity, energy doses of 4–6 J help decrease dentinal nerve excitability and reduce pain sensation^[6]. During post-extraction management, around 1 J may be applied pre-extraction at the injection site, followed by 2 J near the tooth apex to minimize inflammatory response. After extraction, approximately 2 J/cm² is delivered over the alveolar socket and adjacent gingiva to control edema and enhance healing¹³.

LLLT may also contribute to improved bone remodeling and faster osseous healing within the extraction socket. Since the procedure is non-invasive, painless, and associated with minimal adverse effects, it is considered a safe and effective adjunct in postoperative dental care^[14].

HARD TISSUE APPLICATION

LLLT is commonly utilized to enhance bone healing and regeneration after surgical interventions or bone trauma. Gallium–Aluminum–Arsenide (GaAlAs) diode lasers, usually operating at wavelengths around 820 nm, are frequently preferred for hard tissue applications^[6]. The therapy promotes osteoblast proliferation and differentiation, which are essential for new bone formation. It stimulates bone matrix synthesis and mineral deposition, thereby improving bone density and structural strength^[15]. By increasing cellular metabolism and mitochondrial activity, LLLT accelerates the bone repair process. Laser irradiation encourages angiogenesis and improves microcirculation, ensuring adequate oxygen and nutrient supply to regenerating bone^[16]. LLLT is often applied as an adjunct in bone grafting procedures to improve graft integration and healing outcomes. It may speed up bone remodeling and maturation during the recovery phase. In implant dentistry, LLLT supports osseointegration by enhancing bone

formation around dental implants^[17]. The therapy can also reduce postoperative inflammation and discomfort following bone-related surgical procedures. Additionally, LLLT may improve implant stability and long-term success by increasing bone-to-implant contact.

LOW LEVEL LASER THERAPY IN ORAL TISSUE HEALING AND PAIN MANAGEMENT

In intraoral applications, an energy dose of about 4 J is commonly delivered to obtain therapeutic benefit^[18]. Extraoral probe applications generally require slightly higher energy levels, typically between 4–10 J, based on the treatment area and clinical indication. Intraoral probes are frequently used for managing oral mucosal lesions, aphthous ulcers, periodontal pockets, and post-surgical wounds^[19] and minor oral surgical procedures. Intraoral LLLT helps reduce gingival inflammation and accelerates epithelial regeneration. Extraoral probes are widely applied in the management of temporomandibular disorders (TMD) to relieve joint pain and muscle tenderness. This approach is also beneficial in treating facial pain, trigeminal neuralgia, and other neuromuscular conditions affecting the maxillofacial region^[20]. LLLT enhances local blood flow and lymphatic drainage, thereby minimizing edema and inflammatory response. The therapy increases cellular metabolism and ATP synthesis, leading to faster tissue repair and regeneration^[21]. It provides analgesic effects by decreasing nerve excitability and stimulating endorphin release. Because it is non-invasive, comfortable for patients, and associated with minimal side effects, probe-based LLLT is regarded as a safe and effective adjunct in dental care^[22].



Fig 1: PHOTOBIO-MODULATION TIPS



Fig 2: TEETH WHITENING HANDPIECE



Fig 3: TMJ THERAPY TIPS





Fig 4: GINGIVECTOMY TIPS

III. PERI IMPLANTITIS MANAGEMENT

LLLT is frequently used alongside conventional peri-implantitis treatments, including mechanical debridement and antiseptic measures. Different laser systems such as Nd:YAG, He-Ne, and GaAlAs diode lasers are commonly utilized in peri-implant therapy^[23]. Laser irradiation aids in lowering the microbial count and disrupting bacterial biofilm on implant surfaces. It reduces the release of inflammatory mediators, thereby controlling inflammation in peri-implant tissues. LLLT stimulates fibroblast growth and collagen production, promoting improved soft tissue healing around implants^[24]. The therapy enhances local blood circulation and oxygenation, supporting faster tissue repair. It has been shown to encourage osteoblastic activity and assist in bone regeneration in areas affected by peri-implant bone loss^[25]. LLLT may speed up healing after implant placement or surgical management of peri-implantitis. By stimulating bone remodeling, it can improve osseointegration and contribute to greater implant stability. The therapy also helps decrease postoperative pain, swelling, and discomfort related to peri-implant procedures. Since it is non-invasive and associated with minimal side effects, LLLT is regarded as a valuable adjunctive approach in implant dentistry^[26].

LASER BACTERIAL REDUCTION:

Laser bacterial reduction is a minimally invasive technique used to decrease the bacterial load within periodontal pockets before or during periodontal

therapy. In this procedure, a diode laser with an E4 surgical tip is commonly used^[27]. The laser is initiated and operated at approximately 1.5 W with a pulse duration of 30 ms on and 30 ms off, corresponding to a 50% duty cycle. The laser tip is directed into the gingival sulcus without deeply penetrating the periodontal pocket, usually limited to about 0.5 mm. The laser energy helps disrupt bacterial colonies and reduce periodontal pathogens, thereby improving periodontal healing and enhancing the effectiveness of conventional periodontal treatment^[28].

IV. SUMMARY AND CONCLUSION

Low Level Laser Therapy (LLLT) is a modern and promising therapeutic modality that promotes tissue repair, reduces pain, and enhances healing through the process of photobiomodulation. The therapy effectively reduces inflammation, edema, and discomfort while simultaneously improving microcirculation and promoting collagen synthesis in the affected tissues. One of the major advantages of LLLT is that it is a non-invasive, painless, and patient-friendly procedure with minimal or no side effects when used appropriately. It can significantly reduce postoperative complications, enhance wound healing, and shorten recovery time following dental procedures. LLLT also helps decrease the need for analgesics and anti-inflammatory medications, thereby minimizing the risk of drug-related adverse effects. Another important benefit is its ability to stimulate nerve regeneration and improve neurosensory recovery in certain clinical conditions.

With advancements in laser technology and increasing scientific evidence, LLLT has gained wider clinical acceptance as a valuable adjunctive therapy in both dentistry and medicine. Overall, Low Level Laser Therapy represents a highly effective and safe therapeutic approach that improves treatment outcomes, enhances patient comfort, and holds great potential for future applications in regenerative and minimally invasive healthcare.

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