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REVIEW ARTICLE

Low-Level Laser Therapy (LLLT) and Its Application in Dentistry: A Review

Manish Goyal [1], ,Sunita R Melwani[1 2] *, Rupinder Singh Dhall[3], M K Sunil[4], Nishant Bali[5], Rajnish K Jain [6]

1. Professor & Head, Department of Orthodontics and Dentofacial Orthopedics, Teerthanker Mahaveer Dental College and Research Centre, Teerthanker Mahaveer University, Moradabad, India
2. *Department of Periodontology and Implantology, Teerthanker Mahaveer Dental College and Research Centre, Teerthanker Mahaveer University, Moradabad, India
3. Department of Prosthodontics and Implantology, Himachal Institute of Dental Sciences, Himachal Pradesh University, Shimla, India
4. Professor & Head, Department of Oral Medicine and Radiology, Teerthanker Mahaveer Dental College and Research Centre, Teerthanker Mahaveer University, Moradabad, India
5. Nishant Bali, MDS, Reader, Department of Prosthodontics and Implantology, Himachal Institute of Dental Sciences, Himachal Pradesh University, Shimla, India.
6. Department of conservative Dentistry and endodontics, PDM Dental College & Research Institute, PDM University, Bahadurgarh, Jhajjar(Haryana), India

* **Corresponding author :**Dr Sunita R Melwani*,
E-mail Address- melwanisunita27@gmail.com

ABSTRACT

Low-level laser therapy (LLLT) is used as an auxiliary in various therapeutic modalities in medical and dental field. Its application in dentistry is slowly, but steadily gaining acceptance. Numerous studies have shown its effect in improved wound healing and tissue repair, accelerating tooth movement in orthodontics and as a tool for treating various dental disorders. This paper provides an overview of the application of LLLT in various procedures in the dental field.

Keywords*: low-level laser therapy(LLLT), dentistry, lasers, wound healing, tissue repair; accelerated orthodontic tooth movement*

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INTRODUCTION

The word LASER comes from the acronym "Light Amplification by Stimulated Emission of Radiation" as it generates light by stimulated emission of electromagnetic radiation through optical amplification [1].

Low-level laser therapy (LLLT) or phototherapy, sometimes also referred as Low-energy laser therapy, cold/soft laser, low-level laser irradiation, or even photobiomodulation is a low-intensity light therapy that alters biological activity at cellular level by way of photons at a non-thermal irradiance spectrum. The effect is photochemical, wherein biochemical changes are triggered within the cells and cellular photoreceptors known as chromophores absorb these photons which trigger chemical changes within the cell [1]. An optimal dose of radiation (wavelength range from 300-1,100 nm) either in continuous or pulsed mode for any suitable application exists to be called "low-level" laser therapy [2].It usually uses low fluence (dosage of 0.01-100 J/cm^2) and a low power output (< 0.1 Watts, intensity of 0.01-10 W/cm^2). Doses larger than this optimum dose, can result in a diminished therapeutic or even a negative outcome [2].

The most striking feature of animal and laboratory studies conducted by Mester demonstrated that experimental wounds healed better when irradiated with laser [3]. In an experimental study, 875 patients

with open wounds responded better to LLLT [4]. These early studies confirmed that the dose for LLLT follows the so-called Arndt-Schultz law: doses below and above the therapeutic window have no effect and can produce a negative consequence respectively [5].

MECHANISM OF LLLT

The commonly used light source for LLLT are inert gas and semiconductor diode laserse.g.; gallium-aluminium-arsenide(GaAlAs 612-870 nm), krypton (521, 530, 568,647 nm), argon (Ar 488 & 514 nm), gallium-arsenide (GaAs 904 nm), ruby (694 nm),helium-neon (HeNe 633 nm)and indium-gallium-aluminium-phosphide (InGaAlP 630–700 nm). To create an effect on a biologic system, the photon of low-energy visible or near-infrared light (NIR) are taken up by electronic absorption bands present in a chromophore which is the "photon acceptor"[6]. This is considered as the first law of photobiology. Chromophores are molecules (or a portion of it) which gives a colour to a compound like chlorophyll, haemoglobin, melanin, myoglobin, cytochrome c oxidase, other cytochromes, porphyrins flavin, flavoproteins [2].The optical properties of the tissues are the next important consideration since light can either be absorbed or scattered in tissues and depends on the (1) wavelength which is maximum at 650-1100 nm and (2) principle chromophores in the tissues (haemoglobin and melanin) [2]. Since water has maximum absorption from infrared light and wavelength greater than 1100 nm and tissue chromophores at short wavelength, most LLLT utilise red to NIR having wavelength range from 600 to 1100 nm. This "optical window" covers the red and NIR wavelengths and it is in this "optical window" where light penetrates the tissue greatest. (Figure-1)

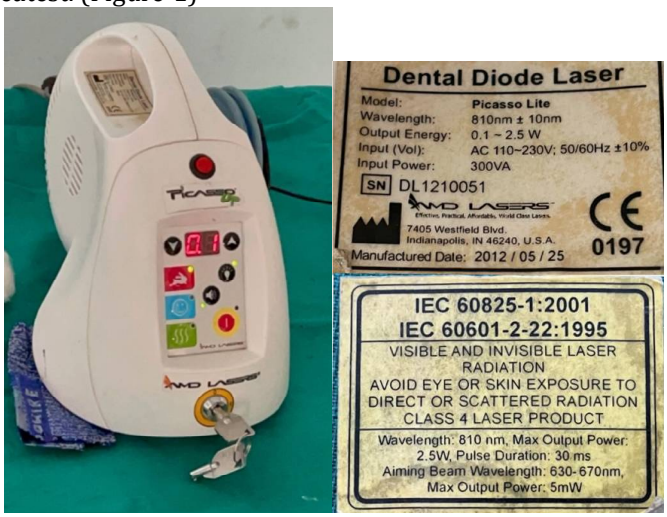

FIGURE-1: DIODE LASER (810nm, Power output:0.1W-2.5W)

LLLT in dentistry

The use of LLLT in dentistry can be enumerated into the following: promotion of faster wound healing and tissue repair, relief of inflammation and edema, restoring normal neural function after nerve injury, as analgesia for pain reduction and for enhanced speed of orthodontic tooth movement.

Wound healing

Mester et al used HeNe lasers as a cure for skin ulcers, and was among one of the first applications of LLLT for wound healing [3]. In these studies, electron microscopy examination demonstrated accumulation of collagen fibrils and electron dense vesicles within cytoplasm of laser-stimulated fibroblasts of the treated area as compared with the untreated areas [3].

There are three phases of wound healing and it has been suggested that LLLT influences all these three phases: the phase of inflammation –where immune cells move to the site to the wound, phase of proliferation – enhanced production of fibroblasts and macrophages, and remodelling phase – collagen is deposited at the wound site and extracellular matrix is remodeled [7]. LLLT induces the expression of cytokines, chemokines and other biological response modifiers locally and hence hastens wound closure and increases the mean breaking strength of the wound [8-10].

In a split-mouth controlled clinical trial, significant differences in the mean healing scores in test group who received LLLT (InGaAsP) after scalpel gingivectomy when compared to their control on days 7 and 30 was seen [11]. Another investigation by Ozcelik et al to assess the healing of gingiva after gingivectomy and gingivoplasty,complete wound healing was observed in 21 days on LLLT-applied areas and for controls it was around 24 days [12]. It was concluded that LLLT enhanced wound healing and

epithelialization after these two procedures. Madi et al in their study to evaluate the effectiveness of LLLT on healing following gingivectomy stated that LLLT can be used as an adjunct to gingivectomy procedure which not only reduced patients' pain perception but also enhanced healing during the early phases [13].

Musculoskeletal pain and TMJ disorders

Musculoskeletal pain disorders are the one of the most common complaints worldwide and have increased by 45% from 1990 to 2010 [14]. Temporomandibular disorders (TMDs) is a collective term that includes the temporomandibular joint (TMJ) derangements, and disorders of the masticatory muscles and their associated structures. Patient demonstrates joint sounds (crepitus and clicking), pain and, altered & restricted mandibular movements [15, 16].The treatment of TMDs generally include NSAIDs, antidepressants, splint therapy, and/or physiotherapy. Some may include complex occlusal therapies and surgeries, which are irreversible and aggressive in nature and should be avoided. LLLT can be employed for the treatment of musculoskeletal disorders. With minimum contraindications and limited treatment time, it is easy to apply and has analgesic, anti-inflammatory and regenerative effects [17, 18] Several possible processes have been attributed to LLLT. These include: elevated production of endogenous opioid neurotransmitter,19increased threshold to thermal pain and improved local blood circulation [20, 21], raised oxygen consumption by facilitating the redox reaction rate of the electron respiratory chain of mitochondria [22],scalated adenosine triphosphate (ATP) production at cellular level [23-25], and elevated production of anti-inflammatory cytokines [26-28].

A review of the available literature by Herranz-Aparicio J et al [29] in 2013, concluded a scientific evidence level B for treating TMDs using LLLT.Ayyildiz Set al[30] in 2015 used a 685 nm diode laser thrice a week for one month for a patient complaining of pain in the TMJ region accompanied with limited mouth opening. Absence of pain and an increase in mouth opening which remained stable even after a follow up of one year was noted. Carrasco et al [31] conducted a random, placebo-controlled study to assess the efficacy of LLLT in pain control and on masticatory efficiency in patients suffering from TMD. Aninfrared laser (780 nm) was employed for the intervention group and at the end of the study period it was seen that LLLT enhanced masticatory function and reduced TMD symptoms in the experimental group.

Trigeminal neuralgia

Trigeminal neuralgia (TN) presents as a unilateral, periodic, sharp, and electric shock-like pain felt in the eyes, lips, nose, scalp, forehead, and jaw passing through branches of the trigeminal nerve, which in majority of the cases (95%) is limited to one side of the face [32].It is one of the most painful conditions that may last up to two minutes, occurring spontaneously or triggered by day-to-day activities (brushing teeth, washing face, shaving, talking, eating and drinking). Patients may experience a single attack during the day to more than one attack per minute that can affect their quality of life [32]. To relieve this pain; various medicinal and surgical modalities have been employed.

Results of clinical studies on injured nerves treated by LLLT have shown an increase in nerve function and enhanced capacity for myelin production [33]. In a clinical study by Walker [34], twenty-six patients with trigeminal neuralgia, post-herpetic neuralgia, sciatica and osteoarthritis were irradiated with low power HeNe laser (power: 1 mW, wavelength: 632.5 nm, pulse frequency: 20 Hz, and time: 30-90 secs three times a week for 10 consecutive weeks). A significant decrease in frequency and pain intensity were noted in nineteen patients. Iijima K et al [35] in 1989 demonstrated that for post-herpetic neuralgia repeated exposure with low power He-Ne laser is an effective and safe modality in reduction of pain & accelerated healing.

Acceleration of orthodontic tooth movement

Both experimental and human investigations indicate that LLLT hastens orthodontic tooth movement (OTM) and hence shortens treatment duration. Its application therefore can be used to an advantage especially for the adult patient. Experimental studies by Kawasaki et al [36], Fujita et al [37] and Shirazi et al [38] found greater tooth movement in the laser irradiated tooth. Cruz et al [39] irradiated maxillary canines with a semiconductor diode laser and found that lased group retracted 34% more than control group. Investigations by Doshi-Mehta [40] and Kochar [41] found highly significant reduction in treatment duration in groups that received the laser irradiation than the controls. These investigations did not report any adverse effects on the lased tooth and surrounding structures seen on radiographs taken after the facilitated tooth movement. (Figure-2)

FIGURE-2:LLLT used for accelerated orthodontic tooth movement for rapid canine distalization for space closure.

Tissue repair

LLLT causes biomodulatory effects on various types of cells, such as keratinocytes, fibroblasts, osteoblasts, odontoblasts, cardiomyocytes and endothelial cells [42]. Photostimulatory effect by LLLTin mitochondria processes, promotes the release of growth factors thus improving healing. A study by Parihar AS and Pathak R demonstrated the beneficial effects of LLLT (irradiated after 1 hour, frequency-80 mW, energy output-4 J/cm^2, time-4 mins)in post-extraction wound healing [43]. In this investigative study, LLLT was found to reduce the post-extraction pain, swelling and trismus which are usually seen after surgical third molar extraction. A prospective randomised controlled split mouth trial showed that LLLT (808 nm GaAlAs) was an effective tool after tooth extraction with accelerated repair, by improving tissue colour and reducing pain [44]. The irradiations were performed in three sessions and found that the degree of repair was higher in the irradiated side. Weber et al [45] in 2017 carried out an experimental study on rats to determine the effectiveness of LLLT after dental extraction. Zoledronic acid and dexamethasone were given together to induce osteonecrosis and thus delay healing. In this study LLLT in the red (685 nm) and infrared (830 nm) ranges of lasers application showed positive effects on repair of both hard and soft tissue.

Recurrent aphthous ulcers (RAU, canker sores)

LLLT modifies inflammatory reaction with a reduction in pain and edema alongwith cellular biostimulation, which can therefore be used as a replacement therapy for canker sores [46]. Albrekston et al [47] incorporated LLLT of wavelength of 809 nm, output power 60 mW, pulse frequency 1800 Hz, and dose 6.3 J/cm^2 for duration of 80s per treatment for three days separated by 24 hours, to cure minor RAUs and reported that LLLT had a highly significant analgesic effect when compared to the placebo group.A decrease in pain encountered during eating, drinking and brushing teeth was also noted. Another split-mouth study by Aggarwal *et al* revealed a highly significant decline in pain with a decrease incomplete healing time for the group receiving LLLT in comparison with the control group [48]. Post-LLLT irradiation, complete relief from pain was noted in 28 of the 30 patients of the experimental group, and complete resolution of the aphthous ulcers in the experimental group was observed in 3.05 ± 1.10 days as compared to the control group which took 8.90 ± 2.45 days. In another series of case studies, it was found that LLLT can hasten healing and decrease intensity of pain, size and recurrence of lesions in recurrent aphthous stomatitis [49].

Analgesia

Various studiesindicatethat LLLT may have significant neuropharmacologic consequences on the synthesis, release and metabolism of neurochemical molecules both at central (e.g., Serotonin and acetylcholine) and peripheral (eg. histamine and prostaglandin) levels [50]. The enhanced analgesic effect of LLLT is said to increase synthesis of β-endorphin, reduced c-fiber activity, bradykinin and altered pain threshold.[51,52]A study on paediatric patients by Tanboga I et al to as certain if LLLT has any reduction in pain threshold during cavity preparation found that use of LLLT prior to the procedure made the patients more comfortable [53]. Gelder NV in 2019 compared the efficacy of LLLT and nitrous oxide sedation analgesia for pain control in children and found them both to be equally effective [54].

CONCLUSION

LLLT has multiple applications in dentistry and can be used as an adjunct to various treatment modalities and is well accepted by patients worldwide. Its use should be explored further since it acts locally and does not cause any adverse effect or damage to the surrounding structures. The acceptance of LLLT as a

treatment modality is gaining wide acceptance amongst the health professionals and in order to maximise its acceptance and benefits, long term studies specifying the various laser parameters used for each application need to be carried out.

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Competing interest
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Consent for publication
"Not Applicable"

Ethics approval and consent to participate
"Not Applicable"

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