

Low Level Laser Therapy in Dentistry

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ABSTRACT

Soon after the discovery of lasers in the 1960s it was realized that laser therapy had the potential to improve wound healing and reduce pain, inflammation and swelling. Today, dentists have a variety of wavelengths to choose from the growing industry of lasers. Also, the field has broadened to include light-emitting diodes and other light sources, and the range of wavelengths used now includes many in the red and near infrared. Each wavelength has a unique interaction with the target tissues of the oral cavity. Laser dentistry, formerly embraced only by the speciality of oral and maxillofacial surgery, now, is positively affecting every field of dentistry. From pediatric and operative dentistry to periodontics, prosthetics to cosmetics and implantology, lasers have made a tremendous impact on the delivery of dental care in the 21st century and will continue to do so as the technology continues to improve and evolve. As low level lasers are more biocompatible than hard lasers, they are evolving rapidly. This article discusses low level laser therapy technology, its dosage, their application in every field of dentistry and risks associated with them, so that they can be used in delivery of superior dental care.

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INTRODUCTION AND HISTORY

*'On the other side of darkness, far away there shines a light
A light which bathes mans mind
In the wisdom of eternal flame
That which will redeem mankind
And make the highest truths plain.'*

The sound of dental drills, which made visits at the dentist so uneasy are now a history, as lasers add new dimensions to dental treatment for both the dentist and the patient. Invented in 1967, LASER stands for Light Amplification and Stimulated Emission Radiation. This is a device which produces light which is in-phase (have the same frequency) called coherent light.

Lasers can be categorized as hard tissue lasers and soft tissue lasers, not according to the type of tissue exposed, but depending upon the type of laser-tissue interaction. Laser-tissue interaction is dependent upon wavelength, tissue type, power (incident energy), and time. Wheresoever's, the effect is ablative (essentially photothermic), direct and primary, such lasers are termed 'hard.' Alternatively, where tissue effects are nondirect and through secondary (essential

biostimulatory), intermediate action, such lasers are termed 'soft'. This group also can be termed low-level lasers, low level laser therapy (LLLT), low power laser therapy (LPLT), cold laser, biostimulation laser, bioregulation laser, photobiomodulation, photomedicine, medical laser, therapeutic laser, healing laser, nonthermal laser, low-intensity laser, low-reactive laser. The latest name is laser-phototherapy and has been widely accepted.

The use of low intensity laser radiation for therapy was pioneered by Endre Master in Hungary in the late 1960s and independently by Fredrich Plog in Canada. Along with the primary benefit of being nonsurgical, it promotes tissue healing and reduces edema, inflammation and pain. For more than 35 years, LLLT has been an interesting but not well-defined field among the medical, dental, physiotherapy and veterinary professions.

THE MECHANISMS

The two major areas of action of LLLT are in biostimulation and photodynamic therapy (Fig. 1).

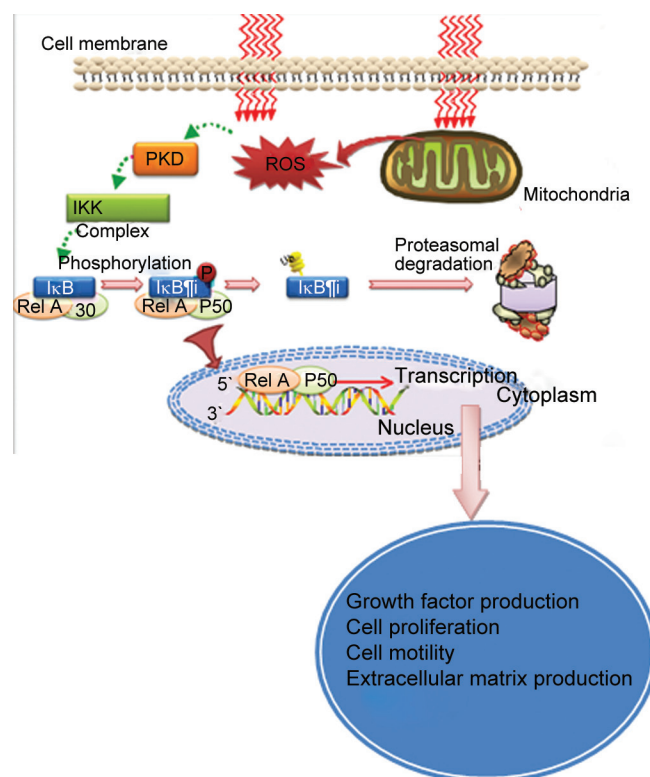


Fig. 1: LLLT mechanism and application: Incoming red and near infrared photons are absorbed in cell mitochondria, producing reactive oxygen species (ROS) and releasing nitric oxide (NO), which leads to gene transcription via activation of transcription factors (NF-κB and AP-1)

1. **Biostimulation:** LLLT uses smaller energies over greater areas. The tissue effects are essentially photochemical and photobiological and seen through selective increase in cellular activity.
2. **Photodynamic therapy (PDT):** It is based on a cytotoxic photochemical reaction. This reaction requires molecular oxygen, dihematoporphyrin ether (DHE), which is administered intravenously, and laser light. This produces singlet oxygen, a highly reactive free radical, which ultimately leads to tissue necrosis. Through the use of PDT, many malignancies can be treated nonsurgically, or as a result of tumor shrinkage, allow surgical excision with greater success.

LOW LEVEL LASER THERAPY TECHNOLOGY

The major components of an LLLT system are the laser device itself, a delivery system, and a controller (Fig. 2). All common commercially available LLLT systems use semiconductor diode lasers. These are generally variants of either Gallium-aluminum-arsenide (GaAlAs) which emit in the near infrared spectrum (wavelength: 700-940 nm), or indium-gallium-arsenide-phosphorus (InGaAsP) devices which emit in the red portion of the visible spectrum range (wavelength: 600-680 nm). Power outputs are typically 10 to 50 mW, when measured at the level of the diode laser itself, although the final useable output (from the handpiece) would be less because of losses in the delivery system. For this reason, calibration of the laser system using an external power meter is an important quality assurance measure.

DOSAGE AND CALCULATION

Although there is a wide therapeutic window in laser therapy, it is essential to apply a reasonable dose. To calculate the dose (energy density), the given energy is calculated as product of power and time ($\text{mW} \times \text{seconds}$). The dose is

calculated by dividing the energy with the irradiated area. A reasonable power density (mW per cm^2) is necessary to trigger biologic effects, so low output cannot be fully compensated by longer exposure, and the depth of the treatment target site must be considered.

The following are some suggested treatment dosages: 2 to 3 J/cm^2 two or three times a week on gingival tissues; 4 to 6 J/cm^2 two or three times a week on muscles; 6 to 10 J/cm^2 once or twice a week on a temporomandibular joint (TMJ); and 2 to 4 J/cm^2 directly on the tooth or indirectly above the apex or osseous structure.

CONTROVERSY SURROUNDING LLLT

More than 30 years of research into LLLT has yielded thousands of journal articles, hundreds of them with specific dental implications. However, there is still considerable skepticism regarding LLLT's legitimacy within the broad scientific community. Due to lack of complete knowledge of principles of photobiology, the field of LLLT is shunned by the core scientific community.

SAFETY REGARDING LLLT

The nonionizing laser radiation contains minimal risk at low levels as they do not increase the temperature of tissues. The principle risks with laser use are associated with eye damage. Destruction of retinal photoreceptors may occur after a transient increase of 10°C to the cells; due to the lens' focusing ability on the retina, even low power laser settings, once concentrated, could very rapidly produce this effect. Low level lasers receive class III hazard ratings because their therapeutic use poses the potential for retinal damage.

CLINICAL APPLICATIONS

Alveolar Osteitis

The treatment of alveolar osteitis (AO) is palliative, given that healing occurs eventually within 1 to 4 weeks postoperatively. Goskel Simsek Kaya et al¹ reported that there was no statistically significant difference in the pain scores among the patients treated with alvogyl (eugenol) and SaliCept (Acemannan) during the 7-day treatment course. However, LLLT resulted in the quickest decrease in the VAS scores after treatment as it provides relief within 3 days as compared to 6 days with other two groups.

The mechanism of pain relief is not well understood, although some studies have suggested that LLLT helps to reduce inflammation by inhibiting the production of cyclooxygenase-2 and prostaglandin-2, potent mediators of inflammation.²⁻⁴ LLLTs effect on wound healing has been attributed to an increased mobility of keratinocytes, the promotion of early epithelization, increased fibroblast



Fig. 2: Dental LLLT unit

proliferation, matrix synthesis and the enhancement of neovascularization.⁵

Dental Infections

In any case of a dental infection, the laser can be applied to the submandibular lymph nodes (Fig. 3) to increase the lymphatic flow of the infected area, reduce the inflammatory cells and bring neutrophils to the site of infection for faster healing. Laser therapy will not preclude the use of antibiotics in most cases but will help to potentiate the uptake of the antibiotic into the blood stream.⁶ It was demonstrated by Lopes et al⁷ that laser therapy was effective for treating acute infected procedures like pericoronitis, endodontic abscess and alveolitis. Herpes simplex can be treated by 4 to 6 J per blister (Fig. 4) in the prodromal stage or slightly later. It promotes healing as well as reduces the number of relapses.⁸ HSV1 attacks can be treated in the silent periods.⁹

Lasers kill bacteria by mechanism known as lethal laser photosensitization (LLP). Laser radiation emitted from a low power laser device activates a dye like toluidine

blue O, which in turn exerts a lethal effect on particular cells, such as bacteria. Burns T et al¹⁰ found that the cariogenic bacteria-*Streptococcus mutans*, *S. sobrinus*, *Lactobacillus casei* and *Actinomyces viscosus* can be killed via LLP using toluidine blue O.

Analgesia

LLLT is being used by many dentists and pedodontists for analgesia of primary tooth restorations (Fig. 5). When operated at pulse rates between 15 and 20 Hz, at pulse energies below the ablation threshold of tooth structure, the erbium laser energy penetrates into the tooth, and is directed along hydroxyapatite crystals (which function like waveguides) toward the dental pulp.

Laser irradiation decreases the conduction of C-fibers from the pulp and stimulates the release of endorphins and serotonin, and increases oxygenation and lymphatic drainage, which results in decreased pain sensation (analgesia).^{11,12}

The laser is applied over the apex of each tooth for analgesia. The duration of this effect is approximately 15 minutes. Another application is after the tooth has been prepared for reduction of pain and inflammation. Dental analgesia is not as effective in permanent tooth because of the increased size of the dental pulp; however, it will allow for comfortable air abrasion treatments and crown and bridge cementations.

Nausea and Gagging

Application of the laser to the P6 acupuncture point of the wrist will decrease the gagging and nausea sensations felt by many patients during dental treatments, impressions and X-rays.¹³ The P6 acupuncture point is one of a triad of points (Fig. 6) that calms the parasympathetic nervous system. Application of these points is also effective for patients who are anxious and nervous.

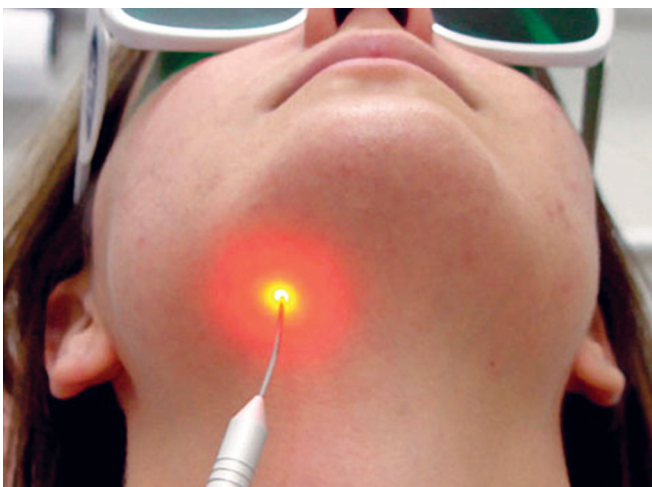


Fig. 3: Application of laser to submandibular lymph node

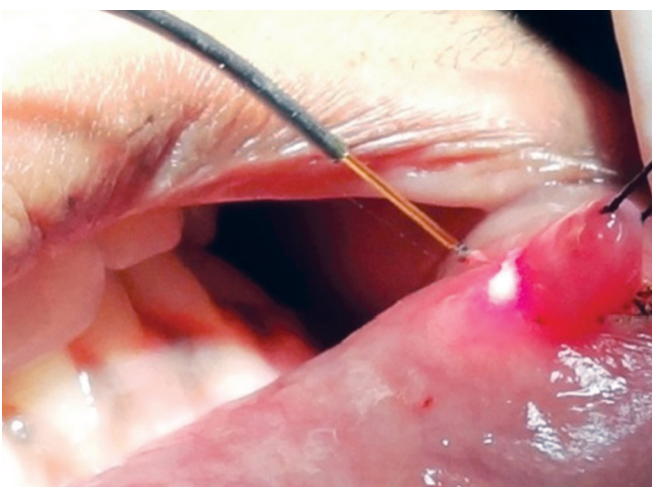


Fig. 4: Laser treatment of a soft tissue lesion



Fig. 5: Promotion of analgesia by laser for primary tooth restoration



Fig. 6: Suppression of nausea and gagging

A 1998 report¹⁴ in the British Journal of Anesthesia investigated the effectiveness of laser irradiation to the P6 acupuncture point on postoperative vomiting. In the laser stimulation group, the incidence of vomiting was significantly lower (25%) than in the placebo group (85%), and the patients were quite receptive to the painless procedure.

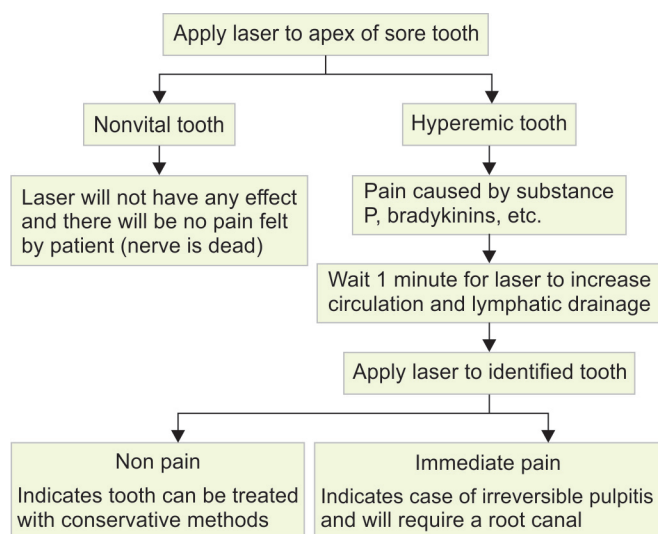
Endodontics

It is effective for reducing pain and inflammation after endodontic treatments, but can also be used as a diagnostic tool for pulp hyperemia.¹⁵ Laser irradiation increases circulation, thus a patient will feel a sharp pain when the laser is applied to a tooth with a hyperemic pulp (Flow Chart 1).⁶

Endodontic Surgery

Postoperative pain relief after apicectomies can be achieved by irradiating the operation site subsequent to suturing

Flow Chart 1: Endodontic diagnosis



(Fig. 7). MB Keslier et al¹⁶ conducted a study to find efficacy of LLLT in reducing postoperative pain after surgery and concluded that the pain level in the active laser group with an 809 nm GaAlAs laser (oralaser voxx, Oralial GmbH, Konstanz, Germany) at a power output of 50 mW and an irradiation time of 150 seconds, was lower throughout the 7-day follow-up period.

Dentin Hypersensitivity

LLLT is efficacious when either the tooth crown or the root apex is irradiated. It might be a direct result of effects of LLLT on neural networks within dental pulp, rather than any accompanying thermal effects.¹⁷ However, the mechanism at cellular level is not fully known, but it is likely that inhibition of nociceptive signals arising from peripheral nerves is a major component of the therapeutic effect.¹⁸ Fabrizio Syolastia et al¹⁹ conducted a study and concluded that effectiveness rate of GaAlAs laser at a 1 month follow-up ranges from 53.3 to 94.2%. A hypersensitive tooth that does not respond to 4 to 6 J per root in two or three sessions is indicated for endodontic treatment.²⁰ Figure 8 illustrates low level laser toothbrush that is used to treat dentin hypersensitivity.

Postextraction and Bone Healing Therapy

It is useful to irradiate the area before and after an extraction. Before extraction it aids in faster onset of local analgesia and reduced bleeding while after extraction, it aids in control of the swelling and inflammation. Thus, less postoperative pain and better healing can be expected. GaAlAs diode devices (Fig. 9) produce nonthermal bioactive reaction in the irradiated bone defect and underlying marrow. This resulted in earlier osteogenesis. It also has stimulating action on the bone morphogenetic proteins and also stimulates

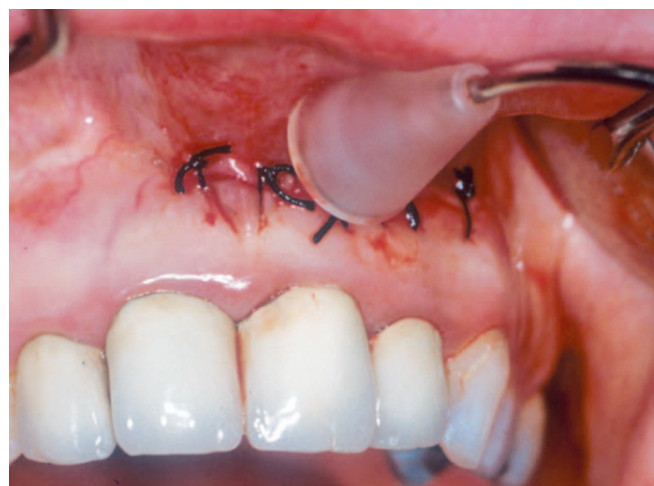


Fig. 7: Laser irradiation of surgical site after suturing using an applicator tip



Fig. 8: Low level laser toothbrush that treats dentin hypersensitivity by hindering the delivery of stimulant through the dentinal tubules or by blocking the delivery of painful stimuli by closing the matrix region of the tubules

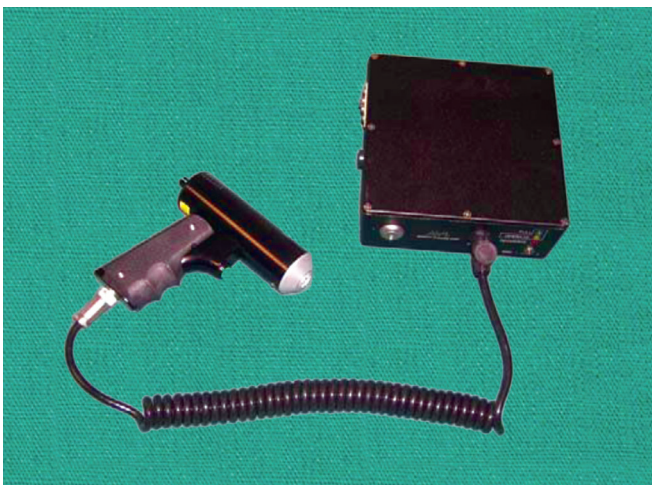


Fig. 9: A typical Ga:Al:As low-level laser (OpusDent Lasers, Santa Clara, California)

undifferentiated mesenchymal cells into osteoblasts; thus further enhancing the mechanism of osteogenesis. The increased blood circulation after LLLT might also bring a better supply of inorganic salts, promoting better bone formation.²⁰

Oral Mucositis

It is used as a preventive application to mucositis and as a treatment mechanism for healing erupted sores (Fig. 10). A 2006 study by Corti et al²¹ demonstrated that LLLT accelerated the healing rate of oral mucositis by 117 to 164% and was able to control inflammation, maintain the mucosa integrity and improve the quality of life cancer patients.

Implant

LLLT can effectively decrease pain sensations during the implant placement (Fig. 11), help speed the integration of



Fig. 10: Treatment of oral mucositis with low level He He-Ne unit

the implant into the bone and improve the quality of the bone around the implant. A study²² investigating the effect on infrared light on the loading time of dental implants found a significantly greater amount of mature bone, a bone with better distribution and organization after laser irradiation, when compared to the control group.

Periodontology

LLLT stimulates fibroblasts for faster regeneration of soft tissue, while providing analgesia and a modulation of the inflammatory chemicals that cause pain and discomfort. LLLT when used in conjunction with surgical lasers for treatment such as gingivectomies, periodontitis and periodontal surgery, have shown great promise in achieving improved clinical outcomes. A 2006 study²³ showed a statistically significant decrease in pocket depth at 21 and 28 days postsurgery. Moreover, the laser-treated wounds presented with factors suggestive of better healing, including color, contour, and mucosa healing when compared with nonlaser-treated area, which served as a control. Cell



Fig. 11: Application of laser during implant placement

proliferation as a result of stimulation by LLL irradiation might be associated with autocrine production of growth factors. Yu et al²⁴ found increased concentration of basic fibroblast growth factor (b-FGF) in the supernatant of lased fibroblast cultures.

Orthodontics

Orthodontic treatments are lengthy and often painful for many patients. LLLT (Fig. 12) stimulates osteoblasts which results in an increased velocity of tooth movement. It also decreases the inflammation and pain caused from the pressure on the teeth during orthodontic tooth movement. Kess et al²⁵ showed that PG level increased and peaked at 24 hours after application of orthodontic forces, whereas Kamogashira et al²⁶ showed that the level of substance P increased and peaked at 36 hours after separation of incisors by orthodontic forces.

No immediate therapeutic pain relief was noted after laser application in the orthodontic treated patient in the study conducted by Lim et al²⁷ and the treatment effect took about 24 to 48 hours to become apparent. The results tended to support the hypothesis that laser analgesia was due mainly to the effect of laser treatment on the inflammatory processes.

TMJ and Orofacial Pain

From simple and acute cases like facial pain after long appointments to chronic TMJ cases, laser therapy (Fig. 13) will help reduce pain and inflammation, and significantly resolve muscle trismus. A 2007 study²⁸ demonstrated that laser therapy softened overly tense and hard muscles by increasing circulation and removing noxious deposits associated with hypertension of the tissue. The authors postulated that an increase in microcirculatory flow and volume caused muscles to relax and thus normalized the intramuscular pressure on sensory nerve endings.



Fig. 12: Application of laser in orthodontics



Fig. 13: Application of laser in TMJ disorder

FUTURE PROSPECTUS

Look for the light in the new millennium, bringing a new wave of exciting dental procedures. Dental laser technology has been developed that can be used to generate both hard and soft tissue laser energy, depending upon the patient's needs. As more dentists practice laser dentistry, new procedures are tested and perfected. Patients appreciate the reduced risk and recovery time of laser procedures and as more and more demand that this technology be used in their dental offices, dentists around the world are complying. They are looking forward to greater comfort and precision care provided by laser technology. Lasers are certainly the future for dentistry as it makes it very easy to remove the decay. It is very helpful when reaching areas that were hard to treat with traditional treatments. There is low risk of infections in and around the treatment area. Laser dentistry has been a benchmark in dentistry and is truly the future of this field. It has boosted a trauma-free treatment yet increasing the confidence of the dentist as well as the patient. A new level of procedures, protocols and strategies have been adopted that not only surpasses the traditional treatment methods but also furthers the healing process. Lasers are the future of dentistry mainly because it far exceeds the bar that has been set by traditional drilling and other procedures. Most of all, lasers have changed the way patients and dentists think and operate.

CONCLUSION

Photobiomodulation is an evolving technology. With every passing day, more is being discovered about the mechanisms of laser therapy, doses, treatment locations and diseases in which a laser will have an effect. Improvements in the design of LLLT equipment are necessary to enable the various techniques to be accomplished within an adequate time frame and without breaching cross-infection

control requirements. Given the low-technology, low-cost characteristics of LLLT, the future for LLLT applications are promising. Efforts should be directed toward investigating the precise dosimetry required for therapeutic laser effects, in order to achieve standardization of treatment protocols. It is a benefit to the patient and dentist to investigate LLLT, an untapped resource in the dental industry.

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