Photobiomodulation: Laser-Assisted Dentistry

Dr. Gaurav Setya
Senior Lecturer
Dept. of Conservative Dentistry
S.G.T. Dental College, Gurgaon

Dr. Jyoti Sachdeva
Senior Lecturer
Dept. of Conservative Dentistry
S.G.T. Dental College, Gurgaon

Dr. Shveta Arora Setya
Private Practitioner
New Delhi

Abstract

Many laser instruments are available for treating oral disease. Some treatments involve removal of hard and/or soft dental tissue. However, other beneficial therapeutic results can occur without a photo thermal event, and these effects are known as photo-biomodulating or low-level laser effects. They can be produced by all lasers; however, specific photo bio-modulating laser instruments are available that operate at levels below 500 mW and can be used to provide a wide range of benefits. This article describe the many uses for these devices used in the dental practice.

Key Words: Laser, Dental hard tissue, Photo bio-modulation.

Introduction

Although low-level lasers are being used successfully in many dental clinics, the wide range of applications is still largely unknown to many practitioners, especially dental specialists. In these fields, there is the potential to see the most definitive results of what laser therapy can do to improve clinicaloutcomes and patient satisfaction.

Photo bio-modulation (PBM), also commonly referred to as low-level laser therapy (LLLT) or cold laser therapy, uses light energy to elicit biological responses from the cell and normalize cell function Numerous studies have shown that PBM affects the mitochondria of the cell, primarily cytochrome-c oxidase in the electron transfer chain and porphyrins on the cell membrane.[1-2] It has been proposed that when light photons are absorbed by these receptors, three events occur: stimulation of adenosine triphosphate (ATP) synthesis by activation of the electron transport chain; transient stimulation of reactive oxygen species, which increases the conversion of adenosine diphosphate (ADP) to ATP; and a temporary release of nitricoxide from its binding site oncyto-chrome-c oxidase. These factors contribute to the clinical effects seen with PBM, including tissue repair, relief of inflammation andpain, and repair of nerve damage.[3]

Determining the Appropriate Dose

Treatment dose is probably the most important variable in laser treatment. Dose is measured in joules per square centimeter (J/cm2) and is a measure of the amount of energy that is conducted into the tissue. Clinical effects of the laser, such as wound healing, pain relief, or muscle relaxation, are all sensitive to different irradiances or doses. An example of this is the stimulation of fibroblasts; a dose o5 J/cm2 will stimulate the cellular activity of fibroblasts, where as higher doses inhibit cell viability and proliferation.[8]

Thus, for wound healing, the clinician should ideally use a dose lower than 5 J/cm2.The bio-stimulatory and inhibitory effects of lasers are governed by the Arndt-Schultz Law, which indicates that weak stimuli will increase physiological processes and strong stimuli will inhibit physiological activity. A therapeutic window, which includes both bio-stimulatory and bio-inhibitory effects, is evident and is the intended target for PBM treatments.

Acute vs. Chronic Pain

Treatment dose and duration will largely be governed by the status of the injury. PBM can effectively speed the resolution of acute inflammation and pain, conditions that should be treated frequently (daily). The reverse applies to chronic pain; treatments should be done using lower doses over a longer period of time (e.g., treat 2 to 3 times per week for 3 to 4 weeks).

Clinical Applications of Photo bio-modulation in Dental Specialties

Oral Surgery

Dental surgeons can utilize PBM in almost every facet of their practice. Many procedures a dental surgeon performs, especially extraction of molars, create an acute inflammatory response that can result in edema, bruising, and pain. Currently, the primary method of dealing with the pain and discomfort of the surgical procedures is prescription of pain analgesics, many of which carry side effects or decreased mental alertness. Healing is also accelerated by stimulation of fibroblasts and osteoblast, which produce soft tissue and bone, respectively, as noted in an animal study conducted by Gerbiet al.[11]

Post-Extraction

Following any surgical extraction, laser irradiation is applied into the socket immediately after the surgery for reduction of pain and inflammation and then after suturing for soft tissue healing.

Dry Socket

Tunér and Hode describe the benefits of PBM in helping to prevent alveolitis after a tooth extraction.[14] The following case study illustrates PBM treatment for a painful 'dry socket.'

Oral Mucositis

Oral mucositis, presenting as an open sore over the oral soft tissue, is a life-altering condition that is a side effect of chemotherapy and radiation therapy. Laser therapy has been investigated as a preventative application to mucositis and as a treatment modality for healing erupted sores, with positive results.[15] Often, oral mucositis can be so debilitating for patients that they cannot continue their cancer treatments, so a tool that can treat or prevent the sores will have considerable clinical importance. Consultation with the oncologist should always be done prior to commencing laser treatments.

Fractures and Orthognathic Surgery

PBM accelerates healing of bone after fractures or orthognathic surgery through the stimulation of osteoblasts. A 2005 study in rats demonstrated that laser irradiation resulted in an increase in bone neo-formation, with better quality bone on the irradiated groups when compared to the control group, who received no radiation.[11]

Soft Tissue Lesions

Soft tissue lesions, such as herpessimplex, denture sores, and angularcheilitis respond positively to low level laser irradiation. Schindl and Further, the author has clinically observed that laser irradiation of herpes simplex decreases the incidence of lesion recurrence. Mareietal. examined the effect of laser irradiation on denture sores and noted that LLLT eased the pain caused by denture lesions, while at 4 weeks post-treatment the laser irradiated areas showed clinically superior healing, and histological epithelialization and vascularization of the lesion.[18] Tunér and Hode report successful treatment of angular chelitis with PBM, but warn of its recurrence if the fundamental cause is not dealt with.19 Itis advantageous to treat any soft tissue lesion in its most acute stage. For example, herpetic lesions are most susceptible to LLLT during their prodromal stage.

Dental Infections

For infections and edema, PBM has been reported to dilate lymphatic vessels and reduce the permeability of blood vessels.[20]

Primary Tooth Restorations

A variety of factors contribute to the analgesic effect produced by PBM which allows dental practitioners to perform many primary tooth restorations without anesthesia. Small animal studies show that laser irradiation promotes are lease of endor-phins and serotonin; inhibits the conduction of C fibers, the fibers that carry-pulpal pain; and increases oxygenation and lymphatic drainage, which are responsible for pain relief after the first minutes of tissue irradiation.[6, 21,22]

Laser irradiation is applied to the apex of each root for analgesia and again after the tooth has been prepared for reduction of pain and inflammation.

Distraction techniques are recommended to help the patient deal with the mental fears or anxiety surrounding the dental

appointment. Dental analgesia does not seem to be as effective in permanent teeth because of the increased size and sensitivity of the dental pulp; however, it has been shown clinically to be effective for pain relief during crown cementations and decreased sensitivity during scaling appointments.

Nausea and Gagging

Application of the laser to the P6 (Pericard 6) acupuncture point on the wrist can decrease or eliminate the nausea and gagging some patients feel during impression taking or X-ray procedures. The P6 is located on the underside of the wrist, approximately 1 inch from the distal palmar crease (approximately the width of the distal thumb phalanx).[23] For patients who are extremely nauseous or anxious, application to three acupuncture points in the wrist can be effective; H7, LU9, and P6 are the parasympathetic calming points and stimulation of these points can be very effective in reducing anxiety.

A 1998 report in the British Journal of Anaesthesia 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.[24]

Uptake and Elimination of Anesthesia

Based on the mechanisms of PB Mtherapy's ability to increase bloodcirculation,[4] the author has found that there is an increase in uptake and elimination of anesthesia. PB Mis applied to the sub-mandibularlymph nodes and the site of injection after the injection and upon completion of the dental appointment, for uptake and elimination, respectively.

Implant Placement

Three papers indicate that PBM can reduce inflammation following implant placement, help speed the integration of the implant into the bone, and improve the quality of the bone around the implant. A study using rabbits utilized Ramans-pectroscopy and electronic microscopy to investigate the effect of infrared light on the loading time of dental implants, and found a significantly greater amount of mature bone, a better distribution of bone, and more organization of bone after laser irradiation, when compared to the control group that received no laser irradiation.[25]

Orthodontics

Orthodontic treatments are lengthy and often painful for many patients. As mentioned previously, Gerbietal. have shown that PBM irradiationon bone increases osteo-blastic proliferation, collagen deposition. and bone neo-formation when compared to non-irradiated bone.[11]

Periodontics

The use of PBM as a treatment modality in periodontics is effective,either as a treatment method on its own or as an adjunct to the increasingly popular surgical lasers. A recent study investigated the gingival inflammatory responseand dental plaque reduction following scaling and root planning combined with PBM in 60 patients.

Periodontal Surgery

Healing after periodontal surgery is often a lengthy and painful process. PBM has been shown tostimulate fibroblasts for faster regeneration of soft tissue, while providing analgesia and a modulation of the inflammatory chemicals that cause pain and discomfort.

Endodontics

PBM is effective for reducing pain and inflammation after endodontic treatments, for dentin hypersensitivity, and as a diagnostic tool for pulp hyperemia.[34]

Laser Therapy as a Diagnostic Tool

Occasionally, a patient will present to a dental practitioner with excessive tooth pain, the source of which cannot be accurately identified. Traditional diagnostic methods such as thermal or electrical stimuli often do not show any indication of the problem, making the diagnosis and treatment stressful for both the patient and the doctor. As stated previously, PBM irradiation increases circulation, thus a patient with a hyperemic pulp will feel a sharp pain when the laser is applied to a tooth.[35]

Dentin Hypersensitivity

A study by Marsilioet al. demonstrated that LLLT treatment of dentin hyper-sensitivity in two different groups of patients was effective for 86% to 88% of all the participants.[36] Another study compared LLLT to topical fluoride varnish application for treatment of dentinal hypersensitivity and found that 86% of the laser irradiation group achieved absence of pain compared to 27% of the fluoride.

TMJ and Facial Pain

When treating temporomandibular joint (TMJ) or facial pain, PBM is a useful tool to add to the therapeutic arsenal. From simple acute cases like facial pain after long appointments to chronic TMJ cases, laser therapy will help reduce pain and inflammation, and significantly resolve muscle trismus. In a systematic review of postoperative pain relief in patients after undergoing third molar extraction, a PBM irradiation was shown to be beneficial in reducing acute inflammatory pain.[13]

Neuropathic Pain

Neuropathic facial pain is a debilitating condition for a patient that results in their living with excruciating pain or with a continuous dose of prescription analgesics. As stated above in the study by Bjordal et al.[13] PBM permits many patients to live a life free from discomfort or with less pain.

Conclusion

Although PBM has been available to health care professionals since the 1960s, low-level laser therapy did not really begin to gain popularity until the 1980s when controlled and randomized studies began to be published.

However, there are precautions all laser users should take and areas to avoid treating when using PBM. Specifically, those include avoiding exposure to the thyroid gland, to pregnant women, and to radiation therapy patients.[40] Also important to note is that the laser will be ineffective if the patient has had a steroid injection in the last six months.[41] All laser users should consult their regarding contraindications and appropriate treatment doses, as well as for instructions about safety eye wear for everyone within the nominal hazard zone of the beam.

Photo bio-modulation 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. At our hands is atool that can reduce pain, stimulate wound healing, and modulate the inflammatory response.

Photo bio-modulation can be used effectively in dental specialties to better manage treatments that are often deemed

painful by patients, without prescribing pharmaceuticals that often have a number of side effects. All healthcare professionals, including dentists and dental specialists, should further investigate photo bio-modulation to enhance their clinical treatments and outcomes.

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