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Cold Lasers in Dentistry - An Update

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ABSTRACT *Low-level laser therapy (LLLT) is an evolving technology. It is noninvasive and has been used for many conditions in various fields of medicine. Various uses of LLLT are being discovered with increased patient compliance. Although low-level lasers are being used successfully in many dental clinics, the wide range of applications is still largely unfamiliar to many practitioners, especially in dentistry. In our hands is a tool that can reduce pain, stimulate wound healing, and modulate the inflammatory response along with numerous other applications to help the patients in the treatment of a range of diseases. There is clearly a need to investigate the effectiveness of LLLT with the help of new trials on LLLT.*

Introduction

The use of LASERs first began in the field of medicine in early 1960s, Opthalmology being the main branch, using Lasers for precise photocoagulation of retina.[1] Since then, Lasers have been used in various industrial and scientific fields spurring various new innovations in the field.

The word LASER, an acronym for Light Amplification by Stimulated Emission of Radiation, is the name of a device projecting intense radiation of light. This light can be either the visible, ultraviolet or infrared portions of the light spectrum. The laser instrument produces a very thin beam of light in which energies are concentrated. The energies can either be high or low. The laser light, when reduced in its energy output to a low level, may be utilized for tissue healing and repair and a lot of other therapeutic applications. For bringing about health enhancement, the application of these amazing beams of light is called "Low Level Laser Therapy.[2]

Based on power, lasers can be classified into the following three categories.[3,4,5]

High-power lasers (hard, hot)- output power of more than 500 mW

Intermediate-power lasers - output power ranges from 250 - 500 mW

Low-power lasers (soft, cold) - output power less than 250 mW

The U.S. Food and Drug Administration (FDA) categorizes photobiomodulating lasers as posing no significant risk (NSR) and therefore these devices are considered safe.[5,6,7]

An assortment of names for Low level laser

therapy (LLLT) include "Cold laser", "Soft laser", "Photobiomodulation"(PBM), "Low-power laser therapy" (LPLT), "Healing laser" and "Laser biostimulation". LLLT uses low-level lasers (LLL) or light-emitting diodes to stimulate or inhibit cellular function. LLLT uses red-beam or near-infrared lasers with a wavelength between 600-1,000 nanometers (nm) and from 5- 500 milliwatts. LLLT emits no heat, sound, or vibration. LLLT acts by photochemical reactions in the cells i.e, photobiomodulation instead of producing a thermal effect.[8] Low-level Laser Therapy (LLLT) can have both a photobiostimulative effect and a photobioinhibitive effect within the irradiated tissue - each of which can be used in a number of therapeutic applications.[9] Low-power lasers produce light-dependent chemical reactions in tissues.[3,5,10]

LLLT is gaining increasing acceptance in conventional medical, physiotherapy, acupuncture, dental, and veterinary practice.[9] Although LLLT has been available to health care professionals since the 1960s, they were not popular until the 1980s when more studies began to be published.[11,12] The use of LLLT in the field of dentistry is a relatively new one as many of the dental surgeons are yet to know the benefits of LLLT, for its usage on a large scale.

LLLT effectiveness is affected by four important factors: wavelength, treatment duration of LLLT, dosage and site of application.

There are 2 kinds of LLLT devices: [8]

1. Point Lasers – with a treatment area of approximately 0.5 cm^2.

2. Clusters (shower type lasers) with generally 3 – 8 diodes covering larger areas, irradiating an area of 0.5 cm^2 times the number of laser diodes

Mechanism of action

The physiological repair effects of low level laser therapy

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are achieved by the light's reenergizing (repolarizing) injured and malfunctioning cell membranes.[2] LLLT works on the principle of inducing a biological response through energy transfer, in that the photonic energy delivered into the tissue by the laser, modulates the biological processes within that tissue, and those within the biological system of which that tissue is a part. [9]

The Arndt-Schultz Law of Biomodulation infers that low dosages of photonic energy will stimulate those biological processes, and higher dosages will inhibit them.

The critical point that differentiates low-power lasers from high-power ones is photochemical reactions with or without heat. It lacks thermal effect because the power used is low and there is more surface action; hence, the heat dissipates, producing further biostimulant effect on cells.[2] LLLT affect damaged cells and do not produce harmful or negative effects on healthy cells. Stimulation of any point of the body creates neural impulses that are transmitted to upper nervous centers by neurons that have different features. These impulses finally reach the CNS leaving their effects in different parts of the body.[4,5]

The wavelength at which the laser emits light determines the effective depth of penetration, within the tissue, of the laser energy delivered. Red to infra-red wavelengths (longer than 800nm) will penetrate deeper, and so are indicated for deeper acupuncture points and trigger points, and deeper tissue injuries. Photons emitted at shorter wavelengths do, however, have greater energy/mass which is measured in electron-volts (eV).[9]

According to Baxter who conducted studies using LLLT, "For a given wavelength of light, energy density is the most important factor in determining the tissue reaction". Energy densities in the range 0.5 to 4 Joules/cm^2 are most effective in triggering a photobiological response.

The depth of the energy of this laser in bone tissue is 1cm, while in soft tissue it may vary from 2 to 5 cm. To maximise irradiance at the target tissue, the laser probe should be held in contact with, and perpendicular to, the tissue surface. When treating open wounds, the probe should be held slightly away from the tissue surface, whilst still maintaining a 90° angle. The probe tip may be covered with plastic cling film, in order to reduce the likelihood of cross-contamination. In treating musculoskeletal conditions, manipulative therapies should be completed prior to laser irradiation. Laser therapy should be carried out following cryotherapy, as the vasoconstriction caused by cooling the tissue will increase the penetration depth of the laser irradiation. Heat therapies and various creams and lotions can be applied after laser therapy.[9]

Laser treatments can be carried out by irradiating daily for the first week, then gradually increasing the interval between treatments over successive weeks, according to the progression of the condition being treated.

The effect of low-power laser on various oral tissues has been studied by several authors, thereby recognizing the beneficial effect on the oral mucosa and other tissues. Numerous studies have shown that LLLT affects the mitochondria of the cell, primarily cytochrome-c oxidase in the electron transfer chain and porphyrins on the cell membrane; Stimulates adenosine triphosphate (ATP) synthesis by activation of the electron transport chain; Causes transient stimulation of reactive oxygen species, which increases the conversion of adenosine diphosphate (ADP) to ATP and a temporary release of nitric oxide from its binding site on cytochrome-c oxidase.[2, 3,4,8,10] LLLT also increases the mitochondria's energy output within the cell by more than 150 percent. The extra energy becomes a repair and restoration mechanism so that the damaged cell begins to thrive once again. Increased singlet oxygen generates ATP increasing cellular energy. Short term increased cell membrane permeability initiates changes in cell activity. Light energy is converted into bio-chemical energy, restoring normal cell function. [2,13]

Physiologic effects of laser energy in the body are numerous. Theyinclude.[2,5,6,7,10,11,12,14]

- Stimulation of collagen and elastin production.
- Alteration of DNA synthesis.
- Improves the function of damaged neurological tissue.
- Increased serotonin and increased endorphins.
- Increased anti-inflammatory effects through reduced prostaglandin synthesis.
- Macrophages, lymphocytes, fibroblasts, endothelial cells and keratinocytes proliferation.
- Growth factors and other cytokines release.
- Change of fibroblasts to myofibroblasts.
- Changes in cell membrane potential and permeability.
- Vasodilation and angiogenesis (improve in tissue nutrition).
- Direct nerve regeneration, as well as an increase in the speed of regeneration.
- Stimulating action of the immune system, leading to increased production of antibodies
- Reduces oxidative stress.
- Increased ATP production by the mitochondria and increased oxygen consumption on the cellular level, which may result in muscle relaxation.
- Reduced blood pressure
- Improved capillary circulation
- Increased endogenous opiate production.
- Low level laser energy stimulates the sodium potassium pumps in cell membranes, which enables transport of essential nutrients into cells to allow healing.

Clinical Applications

While some studies reported on a positive laser effect with regard to the investigated parameters, others showed no or only negligible clinically relevant influence of LLLT.[12] In dentistry, the use of LLLT in various branches has led to the following:[12,13]

Pain reduction, swelling and trismus – before and after dental treatments

- Orofacial pain
- Mucositis
- Chronic sinusitis
- Gingivitis
- Healing of soft tissue lesions
- Temporomandibular joint disorders
- Periodontal surgical procedures
- Implant surgery
- Endodontic surgery
- Orthognathic surgery
- Better integration of implant into bone
- Faster movement of teeth during orthodontic procdures and reducing orthodontic post adjustment pain
- Treatment of fractures
- Crown lengthening
- Restorative treatment

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- Pulp therapy and root canal treatment
- Tooth hypersensitivity
- Sensory aberrations in the inferior alveolar nerve
- Gingival contouring
- Neuralgia
- Cellulitis
- Nerve regeneration
- Hematoma - Prevention of inflammation and Pain
- Crown Preparation – Less irritation to pulp and less pain, No need for anaesthesia
- Post operatively less bleeding and edema, less post-operative pain, accelerates healing process
- Pre-treatment anesthetic for children
- Pediatric Restorative procedures - Short term superficial anesthesia, faster healing of pulp
- Scaling - Faster healing, less bleeding, decreased pain during scaling and post-scaling period.

The use of LLLT in dentistry is yet to pick up its pace as the awareness is still in its adolescence.

Low-power lasers can also be used instead of needles in acupuncture to decrease pain. [3,4,6, 10,11,14,15]

Advantages

Low-level laser therapy is painless, non-invasive, non pharmaceutical, reproducible, economical and without the need of anesthesia. No side effects of LLLT application has been reported yet.[6,14]

Contraindications and Adverse Effects

LLLT irradiation should be avoided over melanomas and cancerous lesions because the combination of hot lasers and high doses significantly increases the tumor growth.[7,16] Among adverse effects, which are rare, caused by the use of low-power laser is temporary increase in pain that usually disappears, tiredness and redness or warmth in the area treated due to increased microcirculation.[4]

Conclusion

Low level laser therapy is not the answer for every medical and surgical problem. Low level laser therapy is an alternative to pharmaceutical intervention in medical field. LLLT is gaining increasing acceptance. Its usefulness need to be harnessed in our country so that we too can give our patients treatment at par with the developed countries. LLLT has the potential to be a useful adjunct to conventional treatment procedures. Exact treatment protocols for various applications have to be determined. Patient cooperation has to be addressed when evaluating the success of a low level energy program. However, more research will be needed to establish appropriate protocols and dosage. This will improve clinical outcomes and patient satisfaction.

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