ISSN: 2581-5989
PubMed - National Library of Medicine - ID: 101738774

International Journal of Dental Science and Innovative Research (IJDSIR)
IJDSIR : Dental Publication Service
Available Online at: www.ijdsir.com
Volume – 4, Issue – 1, February - 2021, Page No. : 621 - 627

An update on Low Level Laser Therapy in Paediatric Dentistry

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Citation of this Article: Dr. Rajiv Prajapati, Dr. Mayuri Singh, Dr. Moon Ramraika, Dr. Yogesh Bande, Dr. Indrajeet Deshpande, “An update on Low Level Laser Therapy in Paediatric Dentistry”, IJDSIR- February - 2021, Vol. – 4, Issue - 1, P. No. 621 – 627.

Type of Publication: Original Research Article

Conflicts of Interest: Nil

Abstract

Low-level laser therapy is a newly developing technique in paediatric dentistry. It generates light of single wavelength which do not elevate temperature, but rather produce their effects from photobio stimulation effect within the tissues. The therapy performed with low-level lasers is called as LLLT. LLLT is a device which include gallium arsenide, gallium aluminum arsenide infrared semiconductor (gallium-aluminum-arsenide), and helium-neon lasers. LLLT which can offer tremendous therapeutic benefits to patients, such as accelerated wound healing and pain relief. The output powers range from 50 to 500 mW with wavelengths in the red and near infrared of the electromagnetic spectrum, from 630 to 980 nm with pulsed or continuous-wave emission. Therefore, the purpose of this review article was to summarize the literature describing the use of Photobiomodulation in pediatric dentistry.

Keywords: LLLT, Gallium Aluminum, Photo-bio

Introduction

Paediatric dentistry encompassing all aspects of child development and it is essential to familiar with age-appropriate skills and functioning, and development.

Changing trends to treat the children will help paediatric dentist to raise the standards by incorporating child-friendly approaches into dental care.[1]

Laser light has unique properties of coherency and, monochromatism. Albert Einstein (1916) introduced the concept of LASER.[2] Gordon Gould (1957) named the acronym for "light amplification by stimulated emission of radiation" as LASER. Theodore Maiman was the first to invent laser in 1960.[3] Lasers utilize the physical phenomenon of stimulated emission to create a monochromatic and coherent beam of light of low divergence.[4] Laser are applied to both the hard tissue and soft tissue, but is costly and can cause thermal damage to tooth pulp. So, photobiomodulation covers these limitations of lasers as they are low-cost devices. It is comfortable to use and having high efficiency. With the first dental laser in market in 1980 to now, innovations and renovations are continued along with laser uses in dentistry. Newer advances and its clinical applications have attained particular significance and these are believed to offer exceptional results in dentistry. [5]

Laser biomodulation is an important tool in therapeutic and surgical procedures.[5] The term photobiostimulation was coined by Professor Endre Mester, the Father of Photobiomodulation.[6, 7] Other names are Photobiomodulation, Low Level Laser Therapy, Biostimulation, Photostimulation, Photodynamic therapy (PDT), soft laser and cold laser. It is defined by North American Association of Laser as ‘‘Nonthermal laser light application using photons from visible and infrared spectrum for tissue healing and pain reduction.[8] PBM has begun to gain popularity after 1980s when controlled and randomized studies began to be published.[9]

Photobiomodulation (PBM) includes nonionizing light sources such as lasers, light-emitting diodes (LEDs), and broadband visible light. It stimulates and promotes wound healing, regeneration, immune responses.[6] Photodynamic therapy (PDT) involves the transfer of energy from the activated photosensitizer to available oxygen results in formation of free radicals which are reactive and damage proteins, lipids, nucleic acids, and other cellular components.[10] It produces energy levels below 0.5 W and are often semiconductor diode lasers of InGaAlP (Indium-Gallium-Aluminum-Phosphide) in the visible light range of 630 to 680 nm or GaAlAs (Gallium- Aluminum-Arsenide) in the invisible range of 750 to 910 nm.[11] It also includes Krypton (521, 530, 568, and 647 nm), Helium/Neon (632.8 nm),Ruby (694 nm), Argon (694 nm) and Gallium/Arsenide (904 nm).[8] It resolves acute inflammation and pain and also chronic pain but should be treated using lower doses for a longer period of time.[9]

Several professional and learned societies are now wholly devoted to photobiomodulation: World Association of Laser Therapy (WALT); North American Association for Photobiomodulation Therapy (NAALT); or partly devoted: SPIE Photonics West; American Society of Lasers in Medicine and Surgery (ASLMS); and (soon) Optical Society of America (OSA).[12]

The use of different types of new lasers enables paediatric dentist to provide minimally invasive dentistry for hard and soft tissue procedures with no pain during and after treatment, eliminated the vibrations, smell of conventional dentistry and was appreciated by parents and children. Thus, it instils a positive dental attitude in a child. Recent advances in laser technology provides optimal, preventive, interceptive and restorative dental care in a stress-free environment in paediatric dentistry.[1]This article is based on a review of current dental literature related to photobiomodulation and its use in paediatric dentistry.

Mechanism

Photobiomodulation is based on the "ARNDT- SHULTZ LAW". The horizontal axis depicts an increasingly higher dose from left to right, and indicates that biostimulation occurs with relatively smaller doses when compared to the higher doses that cause bioinhibition. LLLT stimulates the tissue repair processes, influencing many cell systems, reducing the exudative phase and stimulating the reparative process. Biostimulation can result in a considerable reduction of swelling and an acceleration of the epithelization and collagen deposition. PBM lasers create a photo biomodulation effect within the target tissue.[9]

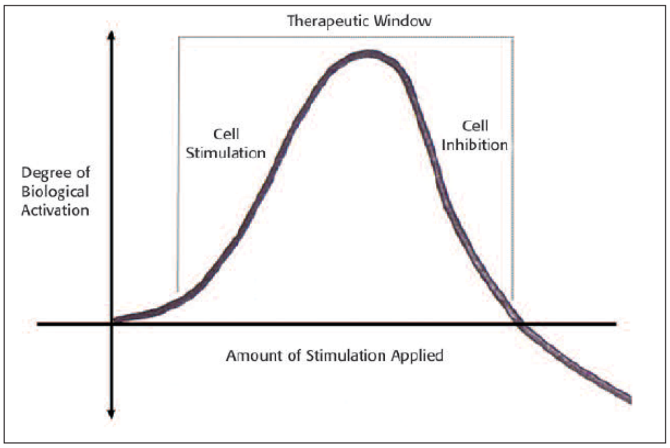

Figure 1: ARNDT- SHULTZ LAW

PBM causes tissue repair, relief of inflammation and pain, and repair of nerve damage. It affects the mitochondria of the cell, primarily cytochrome-c oxidase in the electron transfer chain and porphyrins on the cell membrane. 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 nitric oxide from its binding site on cytochrome-c oxidase.[9]

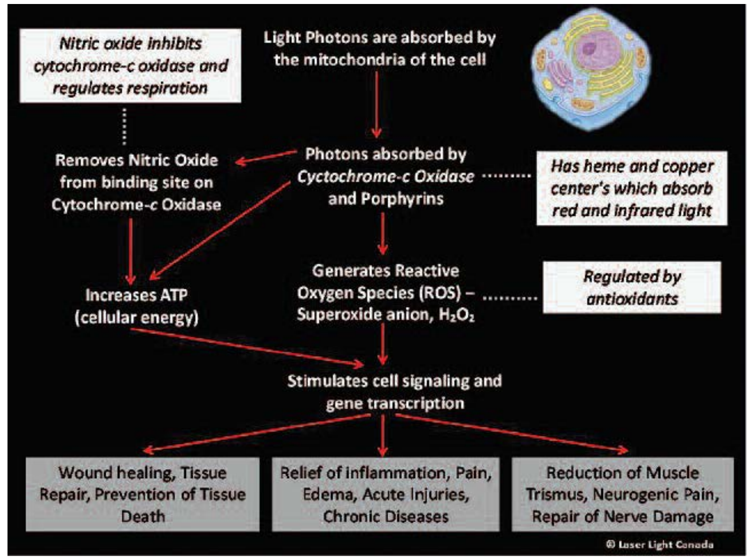

Figure 2: Primary mechanisms of photobiomodulation

The parameters of PBM lasers are power (10^{-3} to 10^{-1}W), wavelength (300 to 10,600nm), Pulse rate (0 to 5000 Hz), intensity (10^{-2} to 10^{2}J/cm^{2}) and electromagnetic spectrum (630 to 980 nm).[13] **The factors affecting the efficacy of photobiomodulation are p**atient factors which are use of anaesthesia, follow up, standardized clinical presentation and timing of treatment. Also, optical factors such as wavelength, spot size, laser or LED light source, power density, energy density, mode of operation, timing of treatment.[14] Therapeutic lasers weaker than 500 mW are considered to be devices of low risk, but naturally, the use of protective glasses both for the patient and the clinician is a must.[13]

The advantages are power of laser can be controlled, broad spectrum of indications, period of application can be selected, aseptic, atraumatic, painless, short treatment period, analgesic, antiphlogistic and wound healing stimulatory effect occurs simultaneously. While it has some disadvantages such as therapeutic effects are often hard to control by objective parameters. Use of PBM laser is contraindicated in coagulation disorders, malignant disease, precancerous lesions, pregnancy, menstruation and febrile conditions.[14]

Photobio modulation laser uses

Analgesic effect: PBM lasers accelerates the reparative processes especially in medically compromised patients with children affected by insulin dependent diabetes, endocarditis, cardiac malformations and cardiac surgical or prosthetic valves reconstruction and cancer patients undergoing chemotherapy or radiation. It stimulates the tissue repair processes, causes reduction in swelling and also helps in epithelization and collagen deposition. Hence, it helps in inducing analgesia, neural regeneration, temporomandibular pain reduction, post-surgical pain, and in orthodontic pain reduction.[14] It often eliminates need for local anaesthetic during restorative dental procedures. There is less damage to the odontoblasts and faster formation of collagen and secondary dentin.[15] PBM laser of 660nm helps in achieving adequate pulpal analgesia. Treated by placing the laser probe on the occlusal surface of a primary molar for 1 to 2 minutes. For permanent dentition, the probe is placed for 1 minute next to gingival tissue over the roots of the treated tooth but analgesia is affected with pigmentation of the patient's gingival tissue, because diode may react with the pigment in the tissue rather than be absorbed by the pulpal tissue.[16]

Treatment of soft tissue injuries: PBM with 660- or 808-nm probe over injured area for 1 to 2 minutes, helps in the healing and reducing post trauma discomfort.[16] Traumatic fibroma (irritation fibroma) is a benign exophytic oral lesion that develops secondary to tissue trauma. Pedron et al. (2009)[17] published a case report of excision of a traumatic fibroma using the Nd:YAG laser (1.34 µm, 250 mW, 30 Hz) followed by photobiomodulation with InGaAlP laser (InGaAlP; 660 nm;40 mW; 3 J/cm^2). At the follow up, the patient reported no pain or discomfort and the wound healing was satisfactory with no scarring. Hence, the postoperative photobiomodulation with low-intensity laser could be considered to reduce edema and to improve the wound healing.[17]

Orthodontic and temporomandibular joint discomfort: Patients having orthodontic adjustments or having temporomandibular joint discomfort may experience relief using the PBM laser over the area for 3 minutes. More than 1 treatment over a 24- to 48-hour period may be needed to reduce the discomfort.[16]

Pulpal protection: The early primary tooth loss results in has functional, esthetic and phonetic disturbances causes repercussions in the skeletal growth and tooth development. Hence, the preservation of the primary dentition is of utmost importance and helps in maintaining both the tooth arch length and the muscular balance.[18] For indirect and direct pulp capping, irradiation with 2 to 4 J over the area is recommended.[15] PBMT has been proposed as an adjuvant in the Direct Pulp Capping (DPC) technique, due to its significant effects in reducing inflammation and pain, accelerating process of wound healing, and stimulating formation of hard dentin tissue.[8] The maintenance of primary teeth with pulp changes caused by caries or trauma is a major therapeutic challenge in pediatric dentistry because of the pulpal biological cycle characteristic of these teeth as well as internal anatomy, hence the need for sanitizers root canal procedures that have a high performance in eliminating bacterial, since this leads to the success. Most failures or unsuccessful endodontic treatment is related to the persistence of microorganisms that survived the chemomechanical preparation or medications and dressing. PAT has emerged as adjuvant therapy for endodontic treatment in an attempt to eliminate the microorganisms persistent chemical-mechanical preparation.[15] The histopathological assessment revealed statistically significant differences among groups ($P<0.05$). The lowest degree of pulpal inflammation was present in LLLT+ calcium hydroxide (P=0.0296). Calcium hydroxide showed the highest rate of hard tissue barrier (P= 0.0033), odontoblastic layer (P=0.0033), and dense collagen fibers (P=0.0095). On the other hand, formocresol showed the highest incidence of internal resorption (P=0.0142). Based on this study, low-level laser therapy preceding the use of calciumhydroxide exhibited satisfactory results on pulp tissue healing.[19] Neto et al. (2013) had performed pulpotomy with LLL therapy and have clinical and radiographic success rate at 6, 12 and 18 months. He said that the biomodulatory effect of LLLT reduces the inflammation and accelerates tissue repair by creating a fibrous matrix and dentin bridge and increase in production of collagen.[20]

Biostimulatory effect of PBM: Low power laser light can stimulate and enhance the proliferation and differentiation of bone marrow stem cells and increase the growth factors secretion. Depends on two separate effects:

- The photochemical effect, in which the photon energy of the laser is absorbed by cytochrome-c oxidase which causes changes of redox states of the mitochondrial plasma and help establish a chemiosmotic potential.
- The photomechanical effect, in which the photons from a high intensity, low-average power, pulsed laser interacts within the target tissues to promote gene expression.[21]

This therapy provides pain reduction with consequent anti-inflammatory effects. Hence, LLLT offers low energy density for the target cell in order to stimulate membranes or organelles, leading to positive biomodulation.[19]

Pre-treatment of Surgical Sites: It may reduce postoperative haemorrhage and discomfort, which involves placing the 660-nm laser over the surgical area for 1 minute before lasing the soft tissue. [16]

Cellular effects of photobiomodulation during wound healing: LLLT modulates the healing of wounds by increase in mitotic activity, fibroblasts, collagen synthesis and neovascularization. Also, an immunomodulatory effect was demonstrated by Júniora (2009) on TGF^{-2} expression at sites of wound healing.[22] Vasodilalation causes increased local blood flow and relaxation of smooth muscles associated with endothelium. This vasodilation brings in oxygen and also allows for greater migration of immune cells into tissue.[23]

Viability of stem cells: de Souza et al. (2018) conducted a study to evaluate the effect of LLLT on the viability and proliferation of stem cells from exfoliated deciduous teeth (SHED) cultured under nutritional deficit (cellular stress) or regular nutritional conditions and irradiated by a red laser between 1.2 and 6.2 J cm^2. Cell viability and proliferation were respectively determined by 3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide (MTT) and crystal violet assays 6 and 24 h after irradiation. They found At 24 h, SHED under nutritional deficit showed lower viability and proliferation after 1.2 J cm^{-2} irradiation. All of the irradiated groups revealed significantly higher viability and proliferation in SHED maintained under nutritional deficit than in regular nutritional conditions, except in the 3.7 and 6.2 J cm^{-2} groups by MTT assay. In the crystal violet assay, SHED irradiated with 1.2 J cm^{-2} showed no difference between the different nutritional conditions. Decrease of FBS concentration in the culture medium seems to enhance the sensitivity of SHED to the effects of photobiomodulation therapy. Nutritional stress conditions improved cell viability and proliferation of SHED after laser irradiation. The establishment of nutritional deficit through the decrease of FBS concentration in culture medium (1% FBS) seems to enhance the sensitivity of SHED to the effects of PBMT. Nutritional stress conditions stimulate the metabolism of SHED after laser irradiation, irrespective of the energy density employed, except for 1.2 J cm^{-2}, which did not improve cell viability and proliferation.[24]

Treated with Bell's palsy: The paralysis of the seventh cranial nerve, unilaterally leading to weakness of facial muscles and facial expression loss is Bell's palsy. It is the most common cause of the peripheral unilateral facial nerve paralysis, which can also affect children and adolescents. Treatment done previously using facial exercises, biofeedback, electrotherapy, massage, and thermotherapy. Paulomi et al. (2018) presented a case report of 13 years old girl treated with Bell's palsy with a new protocol of photobiomodulation. She was treated with three sessions of photobiomodulation using infrared laser, 100 mW output power, 100 J/ cm^2 of energy density, 28 seconds per point, applied at the origin and insertion of the right superficial masseter muscle. The patient presented complete regression of paralysis, improvement of speech and chewing, and absence of muscular pain. Hence, it was found that PBM is an effective treatment for Bell's palsy.[25]

Conclusion

Photobiomodulation has proved to be effective in paediatric dental patients as it represents a good treatment modality. It enables optimal preventive, interceptive, and minimally invasive interventions for both hard and soft tissue procedures. Thus, it is of utmost importance for the professionals to be acquainted with the physical characteristics of the different laser types according to the different wavelengths.

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