ORIGINAL RESEARCH PAPER

Volume - 12 | Issue - 01 | January - 2023 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

PHOTOBIOMODULATION IN DENTISTRY: A REVIEW OF THE LITERATURE

Dental Science

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ABSTRACT

Photobiomodulation therapy (PBMT), is the ability to modulate cell growth, survival, and differentiation processes of cells using optimal amount of energy ,not causing phototoxicity . It includes a wide range of electromagnetic wavelengths such as broadband lights, LEDs, and lasers that may have both photo stimulation and photo inhibitory effects on the target tissues, each of which can be used in therapeutic applications. Some of the benefits of using PBMT in dentistry include reducing dentin sensitivity to tactile and thermal stimulations, improving dentin formation from dental pulp, reducing inflammation of oral mucosa, accelerating bone formation, reducing pain after all types of dental treatments, and improving wound healing processes. In this review of literature, we emphasize that PBMT itself or as an adjunct can have a crucial role in decreasing postoperative dental pain, increasing depth of anesthesia during cavity preparation, decreasing tooth hypersensitivity, reducing inflammation of the tissues, and healing of denture stomatitis.

KEYWORDS

INTRODUCTION

Stem cells have the ability of self-renewal and differentiation into various other types of cells. [1] Due to its undifferentiated nature, they can be blueprinted to play specific biological functions, that helps in the treatment of diseases or in regenerative processes. [2] Photo biomodulation therapy (PBMT), is the ability to modulate cell growth, survival, and differentiation processes of cells using optimal amount of energy ,not causing phototoxicity .[3-10] It includes a wide range of electromagnetic wavelengths such as broadband lights, LEDs, and lasers that may have both photo stimulation and photo inhibitory effects on the target tissues, each of which can be used in therapeutic applications.(13,14) Some of the benefits of using PBMT in dentistry include reducing dentin sensitivity to tactile and thermal stimulations, improving dentin formation from dental pulp, reducing inflammation of oral mucosa, accelerating bone formation, reducing pain after all types of dental treatments, and improving wound healing processes etc.(27)

Circulatory systems of our body can make almost every area of our body accessible to light, directly or indirectly. This has been very much contributory in the successes of a large number of clinical cases using photobiomodulation.[11] . Biomodulation Law proposed by Arndt-Schultz states that low-dose energy stimulates biological processes, and high-dose energy inhibits biological responses. [22]. Principles of biostimulation and bioinhibition, or otherwise called the “biphasic response”, helps in customizing treatment doses based on the physiological response of the cell. [12]. Application of photo biomodulation therapy (PBMT) is increasing in dentistry mainly due to their painless and noninvasive function. Karu et al [23] were among the first groups of researchers who had investigated the mechanism of photobiomodulation therapy (PBMT). Here, light energy is directly applied to the body that have the ability to biologically stimulate cells of the body. Cellular photoreceptors, like Cyto-chromophores and pigments, can absorb radiation and transfer to the mitochondria where activity of cytochrome oxidase enzyme and Krebs cycle are affected that can increase the production of adenosine triphosphate (ATP). Increase in ATP production leads to increased cellular activity. These changes can influence macrophages, fibroblasts, endothelial cells, proliferation of mast cells, secretion of bradykinin, and neurotransmission.[24,17,19,25,22,26]

Electromagnetic radiations of visible light wavelengths (380–700 nm) or near infrared wavelengths (700–1070 nm) are used. It has a depth of penetration of 3–15 mm in soft and hard tissues. Radiation power is less than 250 mW or between 250 and 500 mW. [15–18]Lasers are also used for photobiomodulation therapy as they are capable of inducing biological response through energy transfer.(21) Commonly used lasers are Ruby (694 nm), Argon (694 nm), Helium/Neon (632.8 nm), Krypton (521, 530, 568, and 647 nm), Gallium/Aluminum/ Arsenide (805, 808, 810, and 650 nm), Aluminum/Gallium/ Indium/Phosphide (650 nm), and Gallium/Arsenide (904 nm).[19,20]Noncoherent radiations such as Light-Emitting Diodes (LEDs) also have bio stimulatory properties. These group of treatments are also known as "low-dose light therapies." [13,14) Advantages of photobiomodulation therapy are they are non-invasive, treatments can be done by experienced auxiliary staff and can be easily integrated into practice.

Inspite of extensive studies on PBMT in various dental treatments, inadequate understanding of mechanism of action of PBMT, complexity of radiation parameters, and contradictory results of studies have made it difficult to have access to a precise protocol of PBMT.(21) The main goal of this article is to provide a review of the literature about the PBM dental treatment protocols published so far.

Benefits of photobiomodulation in dentistry

Direct Pulp Capping

PBMT is suggested as an adjuvant in the Direct Pulp Capping (DPC) technique as it can reduce inflammation and pain, accelerate wound healing, and stimulate formation of dentin tissue. But,most of the previous research in this field have shown that, proper technique and type of materials in Direct Pulp Capping are a priority over laser radiation, and findings of laboratory studies have not yet generalized to clinical scenarios.(28-30)

Postoperative Pain after Endodontic Treatment

Pain can result from mechanical, chemical, or microbial damage to the pulp tissue or areas around the root apex, and its emergence is significantly higher after root canal treatment. (31,32,33). Based on studies, Low-Power Laser is considered as one of the methods for pain relief. This technique has advantages such as being noninvasive, low cost, and minimal side effects.(34) Yildiz et al. investigated the effect of PBM on postoperative pain in patients with symptomatic apical periodontitis. They used a 970 – 15 nm laser with 200 lm optical fiber and bleaching tip placed 10 mm from the tissue surrounding the apex and activated at 0.5 W and 10 Hz. The tissues around the apex of mesial and distal roots were treated with laser for 30 sec. They concluded that PBM can be useful in reducing pain after endodontic treatment.(35) In another study, Asna Ashari et al. used an 808-nm low-power laser with 100 mW power, 600-lm fiber diameter at a dose of 70 J/cm2 for 80 sec. Pain severity was recorded before treatment, immediately after treatment, and 4, 8, 12, 24, and 48 h after treatment using visual analogue scale (VAS). But there was no difference in pain between the laser and control groups at any time, and the pain reduced for up to 48 h in both groups. They concluded that PBMT has limited effects on reducing the pain associated with root canal treatment in the first and second molars.(31) Studies showed that PBMT causes a delay in the onset of pain and reduces its severity and duration. Its mechanism of action is through increasing the production of anti-inflammatory prostaglandins, immunoglobulins, beta-endorphins, and lymphokines. It also inhibits synthesis of inflammatory factors and pain-related neurotransmitters.[36–38] Therefore; it has been proposed that PBMT can be effective in relieving pain after root canal retreatment.

Endodontic Surgery

Photobiomodulation therapy has been used in in Endodontic surgery for reducing pain, swelling, and soft and hard tissue healing. Radiation characteristics of lasers used for this purpose include: Diode lasers of 680 or 810 nm wavelength, 50–75 or 129 mW power output, 3–7.5 J/cm2 energy density, 360 to 600 seconds of irradiation time (300 sec of Laser irradiation in each buccal and palatal surface), non-contact scanning movement , irradiation area is 9–10 cm^2, intraoperatively and 1–7 days post-surgery.

Dentinal Hypersensitivity

Dentinal Hypersensitivity is one of the most common conditions with a low rate of predictability of treatment in dentistry.[21] Chemical/ osmotic/thermal or tactile stimulation in areas of exposed dentin can activate the A-delta nerve fibers in the dentinal tubules and cause sharp and short pain in the teeth.[41] Various methods of treatment have been proposed for DH treatment.[42] Laser treatment was first used by Matsumoto et al. to treat dentin hypersensitivity in mid-1980.[43] Their mechanism of action may be dentinal tubule obliteration by high power laser therapy or change in the pain threshold of pulp neural system or stimulation of reactive dentin deposition by the photobiostimulatory effect of low-power lasers.[44,45] Research in this field have shown that, the use of GaAlAs (795 or 830 nm) or InGaAlP (660 nm) wavelength ,power of 15–120 mW, energy density of 1.8– 10 J/cm^2 , 24–160 sec, 3–6 sessions, continuous mode, and scanning motion can have significant effect on reducing dentin hypersensitivity.

Tooth Bleaching

Generally,55– 100% of patients experience some degree of mild to severe tooth sensitivity after bleaching.[49] PBM is one of the methods to reduce postoperative sensitivity following bleaching. The effect Of photobiomodulation therapy has been on the odontoblastic cell response or neutralizing of gel bleaching byproducts. Application of Diode laser: (780, 810 nm) wavelength, 70–200 mW, 10– 15 sec, 12 J/cm^2 is found to be effective in reducing dental sensitivity after in-office bleaching.

Postoperative Sensitivity in Restorations

The use of low-power lasers has been proposed for its effect on postoperative sensitivity reduction. Moosavi et al. proposed that a protocol of 630 nm, 28 mW, continuous wave, 60 sec, and 1.68 J can significantly reduce postoperative sensitivity in class V composite restorations, and hence they recommended the use of of low-power lasers in deep cavities.[50]

Anesthetic effect of Photobiomodulation Therapy During Conventional and Laser-Assisted Cavity Preparation

Photobiomodulation therapy can help to induce anesthesia and its efficacy is found to be 60% - 95%.[51] PBMT protocol of 810 nm Diode laser, power of 250 mW, 53.3 J/cm^2 per side, 120 seconds of total irradiation time (60 sec on the buccal side, and 60 sec on the lingual side), and continuous mode can aim to achieve good-quality anesthesia during cavity preparation.[52] Also,Er:YAG laser 2940 nm wavelength, 60 mJ energy, and 20 Hz frequency, 2 mm from the tooth surface helps to achieve an appropriate level of anesthesia during cavity preparation of primary teeth.[51]

Denture-Related Traumatic Ulceration or Denture Stomatitis

Oral ulcers are one of the most common side effects after using removable prostheses. Thinning of oral mucosa and its increased incidence especially in the elderly and candidiasis infection are the most common causes for these ulcers. Old and Ill-fitting dentures can also cause denture-related traumatic ulcerations. Correction of margins of the prostheses and occlusal discrepancies are done in the first stage for the betterment. Antifungal agents like nystatin, amphotericin B, or clotrimazole may also be prescribed for the treatment of oral ulcers caused by Candida infections. But for painful ulcers, topical agents like topical anesthetics or Triester glycerol oxide gel is given. Photobiomodulation therapy can be useful in healing local ulcers.[53-55]

Results of clinical studies have indicated that using photo biomodulation therapy in the treatment of denture stomatitis can significantly reduce growth of Candida albicans,as well as reducing tissue inflammation without side effects. Diode lasers with 685–830 nm wavelength and output power of 60 mW, energy density of 3.0 J/cm^2 , 5–10 min exposure time, noncontact scanning have been used in the previous studies that have given good clinical results.[56-57]

CONCLUSIONS

Clinical studies indicate that PBMT in itself or as an adjunct can have a crucial role in decreasing postoperative dental pain, increasing depth of anesthesia during cavity preparation, decreasing tooth hypersensitivity, reducing inflammation of the tissues, and healing of denture stomatitis. But, lack of sufficient studies and reliable results intercept a precise treatment protocol. Hence,further clinical trials are warranted in this area.[21]

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