International Journal of Research in Medical Sciences
Sahu N et al. Int J Res Med Sci. 2023 Jan;11(1):423-429
www.msjonline.org
pISSN 2320-6071 | eISSN 2320-6012
DOI: https://dx.doi.org/10.18203/2320-6012.ijrms20223329

Review Article

Effects of photo biomodulation on peri-implantitis

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Received: 27 November 2022
Revised: 11 December 2022
Accepted: 12 December 2022

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ABSTRACT

Periodontitis is a prevalent infectious disease in which the accumulation of bacterial plaque leads to an inflammatory reaction and destruction of supporting tissues around the teeth. The optimal goal in periodontal treatment is to eliminate the infection and to recreate the lost structures of cementum, periodontal ligament (PDL), and the alveolar bone with the reestablishment of their functions. Achieving this regenerative aim, however, remains a major challenge for periodontists. In order to increase the predictability and the efficacy of regenerative periodontal therapies, treatment modalities have moved from the conventional guided tissue treatments to novel tissue engineering and stem cell–based treatments. This is achieved either by transplantation of cells from outside sources to the periodontal defects or by enhancing the recruitment of endogenous host cells present in the area, known as cell homing methods. Photobiomodulation (PBM) therapy is a term used for exposure of cells/ tissues to low-level laser light or light-emitting diodes (LEDs), which is absorbed by specific photoreceptors in cells and may cause alteration at a molecular level inside cells without any heat generation leading to biological changes in cell metabolism and function.

Keywords: Photobiomodulation, Peri-implantitis, Laser in Periodontics

INTRODUCTION

Periodontitis could be a current communicable disease during which the buildup of dental plaque ends up in associate inflammatory reaction and destruction of supporting tissues around the teeth. The optimum goal in dentistry is to eliminate the infection and to recreate the lost structures of cementum, PDL, and therefore the alveolar bone with the reestablishment of their functions. Achieving this regenerative aim, however, remains a significant challenge for periodontists. With the identification of stem cells at intervals force unit and their vital potential in creating dental structures, periodontal regeneration has stepped into a brand-new era. So as to extend the certainty and therefore the effectivity of regenerative dentistry therapies, treatment modalities have affected from the traditional radio-controlled tissue treatments to novel tissue engineering and stem cell–based treatments. This is often achieved either by transplantation of cells from outside sources to the dentin defects or by enhancing the achievement of endogenous host cells within the space, referred to as the cell homing ways.[1]

Improving and enhancing the regenerative and therapeutic potentials of cells through pretreatment or

modification techniques are attention-grabbing analysis topics within the field of stem cell–based therapies. Photobiomodulation (PBM) technique with low levels of optical device or lightweight irradiation with output powers of but five hundred mW has been shown to be able to modification the cellular behavior through absorption by photochromophores that trigger biological interactions at intervals cells. This non-invasive methodology has been shown to be effective in clinical drugs and medical specialty with the potential of reducing inflammation, pain relief, and therefore the acceleration of tissue healing and regeneration.[2]

The introduction of lasers, as sources of amplified, stirred up emission of radiation, gave researchers a chance to get and use high-powered lightweight (at specific wave-lengths) in biology, making a brand new perspective for its application in healing and tissue engineering. In drugs and medical specialty, lasers utilized in radiotherapy associated enclosed in photobiomodulation (PBM) area unit low-level lasers (class III) that area unit outlined with an output power of five hundred mW, and there are high-level lasers (class IV) with an influence output of five hundred mW or additional.

Photobiomodulation (PBM), conjointly referred to as low-level optical device medical aid (LLLT) or cold optical device medical aid, was developed in 1967 by Endre Mester, United Nations agency was the primary to explain the "biostimulation" result of lasers. PBM could be a sober, non-invasive clinical application of red (600–700 nm) and close to infrared radiation (NIR) (700–950 nm, sometimes created by low-to-mid power coherent lasers or non-coherent light-emitting diodes [LED]), with an influence density (irradiance) between one mW and five W/cm^2 over injuries or lesions to boost wound and soft tissue healing, cut back inflammation, and provides relief for each acute and chronic pain.[3] In the late Nineteen Seventies, and for the primary time, Dr. Endre Mester explained the results of optical device biostimulation following associated animal study to check the role of ''ray of light'' in cancer formation. Later, thousands of clinical and laboratory studies are conducted to explain physiological activity additionally as clinical effects of low-level optical device medical aid (LLLT). In accordance with the definition of the North American association of laser, LLLT is ''Nonthermal laser light application using photons (light energy) from visible and infrared spectrum for tissue healing and pain reduction.'' Further, with advancement of optical device science, it absolutely was found that additionally to lasers as coherent radiation, noncoherent radiations like light-emitting diodes (LEDs) even have biostimulatory properties, and therefore the term "low-dose lightweight therapies" was used for this cluster of treatments.

Today, the term ''Photobiomodulation'' (PBM), provides a additional correct interpretation of low-power treatments, as a result of it includes a good vary of magnetism wavelengths like broadband lights, LEDs, and lasers. Photobiomodulation (PBM) medical aid could be a term used for exposure of cells or tissues to low-level optical device lightweight or light-emitting diodes (LEDs), that is absorbed by specific photoreceptors in cells and should cause alteration at a molecular level within cells with none heat generation resulting in biological changes in cell metabolism and performance. This non-invasive treatment conjointly has dental applications to produce pain relief, cut back inflammatory mediators, and accelerate the wound healing method. In recent years, several treatment modalities are developed for victorious regeneration of the periodontium supported radio-controlled tissue regeneration and therefore the application of photobiomodulation and tissue engineering techniques or cell homing of the stem cells within the periodontium defect. A outline of categorization of the articles on periodontology were reviewed within the given study. The articles enclosed during this review were searched from PubMed, Google Scholar, and Cochrane databases. the aim of this review was to critically analyze the effectiveness of photobiomo-dulation on periodontium tissue so as for dentists and specialists to possess a transparent understanding of the clinical applications of similar defects in oral cavity.

MECHANISM OF ACTION

A key space of interest regarding PBM is its result on stem cells, root cells, and its potential in enhancing differentiation, that successively improves the healing rate of tissues. Multiple studies have according that vegetative cell proliferation is improved by photobiomodulation, like gingival fibroblasts, dental pulp stem cells extracted from permanent teeth, exfoliated deciduous teeth, additionally to mesenchymal stem cells derived from bone marrow or fatty tissue. Liao et al analyzed on the result of PBM on dermal stem cells that cell migration, additionally to proliferation, was conjointly improved, but there was no discovered result on differentiation. In one study, variety of dental derived mesenchymal vegetative cell markers (including STRO-1, CD90, CD117, and CD44) slashed once PBM, suggesting differentiation was promoted. However, Ferreira et al found contrary proof in their study when they used PBM on dental pulp stem cells, which highlights the pattern of difficult to replicate studies in laser research.[4]

The application of red light-weight (600–810 nm) is absorbed by the catalyst cytochrome enzyme, that is found within the unit IV metastasis chain of the mitochondria. Gas (NO) is then displaced and activates the catalyst and this ends up in a nucleon gradient. Consequently, metallic element ions (Ca2+), reactive chemical element species (ROS), and ATP production levels ar magnified. On the opposite hand, the appliance of near-infrared light-weight (810–1064 nm) activates photosensitive particle channels, and will increase the degree of Ca2+. ROS and cyclic AMP (cAMP) then move with the metallic element ions.[5] All of those

activities increase cell differentiation, proliferation and migration, among alternative things.

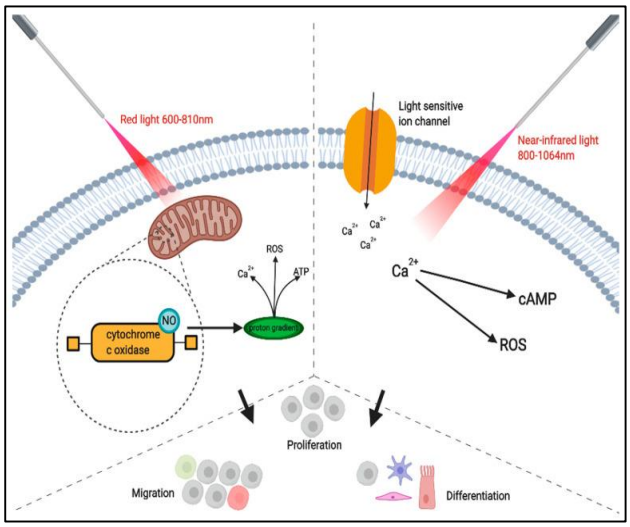

Figure 1: Action of photobiomodulation on tissue.
Source- https://www.mdpi.com/2077-0383/9/6/1724

The precise mechanism underlying the therapeutic effects of PBM haven't nevertheless been well established. There is a growing body of proof that means that the first impact is that the stimulation of mitochondrial cytochromes, that successively initiates secondary cell-signaling pathways. The general results of PBM is magnified energy metabolism and improved cell viability. Within class tissues, there ar 3 major photo acceptor molecules: haemoglobin, myoglobin, and CCO.[6]

Of these, CCO is that the one concerned in energy metabolism and production. This was confirmed once absorption spectra obtained for CCO in several oxidization states were found to be terribly like the action spectra for biological responses to light-weight. In mitochondria, particularly of stressed/ hypoxic cells, gas (NO) binds to CCO by competitively displacing chemical element, inhibiting metabolism, and so decreasing assembly of ATP. PBM may work by photo dissociating NO from CCO, thereby reversing mitochondrial inhibition of respiration and therefore the generation of reactive-oxygen species (ROS). This shift in overall cell oxidation-reduction potential, toward larger oxidization and magnified ROS generation, causes the activation of redox-sensitive transcription factors, like gangrene factor-Kb, resulting in the expression of associate array of sequence merchandise that forestall caspase-mediated cell death and death, stimulate formative cell proliferation, migration and albuminoid synthesis, modulate the inflammatory and inhibitor response, and stimulate development and tissue repair.

In addition to current, NO is photo dissociated from alternative living thing stores, like nitrosylated haemoglobin and nitrosylated hemoprotein, inflicting dilatation. Laser technology in photobiomodulation PBM uses numerous light-weight sources (e.g., lasers, LED) with completely different parameters (e.g., wavelength, output power, continuous-wave or periodic operation modes, pulse parameters). In recent years, longer wavelengths (~800-900 nm) and better output powers (up to one hundred mW) are most popular in therapeutic devices, particularly to permit deeper tissue penetration. The agency has granted promoting clearances to many devices, though none ofthese clearances ar specifically for odontology, that ar thought of as "off-label" uses.[7]

In 2002, MicroLight (Missouri town, TX, USA) received 510K agency clearance for the cubic centimeter 830 nm diode optical device to treat carpal tunnel syndrome. Lasers generally ar classified supported completely different properties (i.e. coherence of the beam, depth of penetration, wavelength), still because the amount of the "on time" once periodic, and their impact on the attention. Lasers utilized in PBM belong to category three or category 3B, supported the optical hazards that they create to patients and workers. The class three infrared wavelengths A and B seek advice from NIF or short wavelengths (A) and much infrared or long wavelengths (B). Classes 1, 2, and three (A and B) lasers don't damage tissue, however protecting eyewear is critical for the healer and therefore the patient.[17] PBM lasers also are thought of to possess the most effective balance of power output.[8]

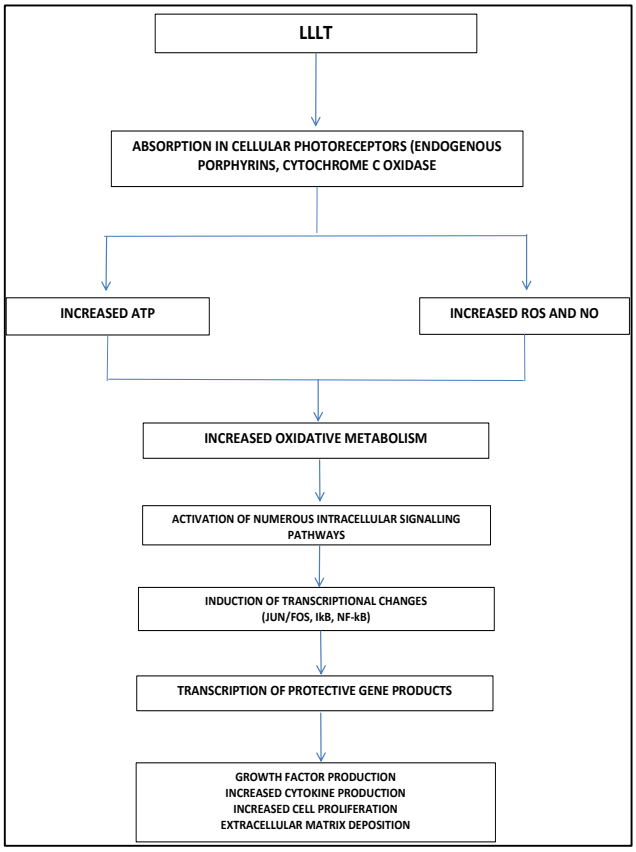

Figure 2: Flowchart of mechanism of low level laser therapy.

Table 1: List of lasers used in dentistry.

Lasers	Characters
HeNe or InGaAIP	
Wavelength	633-660nm
Pulsed or Continuous	Continuous, can be mechanically pulsed
Penetration depth	Shallow, ~ 1-2 cm
Ideal treatment applications	Wound healing, shallow muscles
Benefit	Beneficial effects on mucous membrane and skin Minimal risk of injury to eyes
GaAIA	
Wavelength	780-870nm
Pulsed or Continuous	Continuous , can be mechanically pulsed
Penetration depth	~2-3cm
Ideal treatment applications	Wound healing, muscle attachments,oral application
GaA	
Wavelength	904nm
Pulsed or Continuous	Always pulsed
Penetration depth	3-4cm(through depends on dose,power, application mechanism)
Ideal treatment applications	Deep muscles and inflammation treatment

HeNe- Helium Neon, InGaAIP- Indium Gallium Alluminium Phosphide, GaAIA- Gallium Alluminium Arsenide, GaA- Gallium Arsenide.

In this field, the most commonly used lasers include 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).[7]

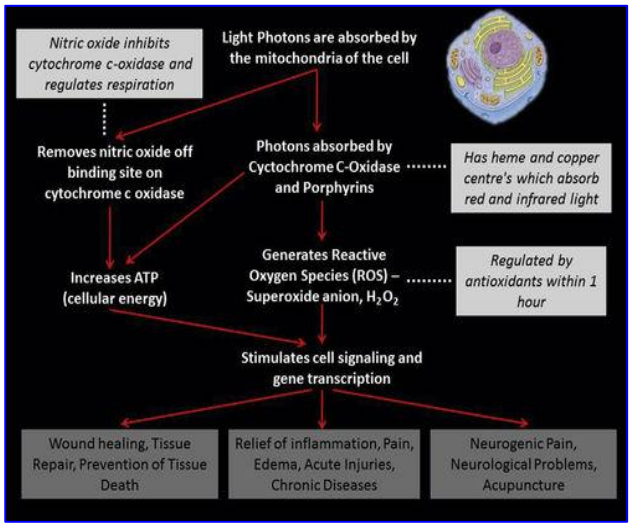

Figure 3: Action of photobiomodulation on tissue.
Source-pocketdentistry.com/photobiomodulation-in-dentistry/

Application of low-level lasers in medication was introduced within seventies and eighties. Since then, right smart scientific work and utilization of cell cultures, animal models and clinical studies are undertaken to judge its probably useful effects. The appliance of Photobiomodulation has become well-liked during a kind of clinical applications, as well as the promotion of wound healing and reduction of pain. Low level optical device applications in odontology embrace the promotion of wound healing during a vary of websites, and surgical wounds, extraction sites, and repeated aphthous ulceration.[3] Main advantage of victimisation Photobiomodulation in dental and odontology treatment is that it's the flexibility to hurry up healing method. it's conjointly used for pain management within treatment of gingivectomies. formative cell keratinocyte motility, albuminoid synthesis, development, and protein unharness all were expedited by low level laser.[4]

Tooth hypersensitivity tooth or dentinal hypersensitivity (DH) is one in every of foremost common chronic pain conditions with quite low rate of sure thing of treatment in odontology. Chemical/ diffusion and thermal/ tactile stimulation in areas of exposed dentin will activate A-d nerve fibers within dentinal tubules and cause a form of annoying sharp and short pain in teeth not resulting in alternative dental defects/ pathologies. Various strategies of treatment are explored for DH treatment. optical device technology is taken into account as a vital nondrug medical care and 1st utilized by Matsumoto et al to treat dentin hypersensitivity in mid-1980.[8]To date, many alternative lasers are examined and studied for DH treatment. These optical devices will act through 2 strategies of dentin anatomical structure obliteration victimisation dynamical optical device medical care or modification within the absolute threshold of pulp neural system or stimulation of reactive dentine formation as a results of the photo biostimulatory impact of low-power laser medical care.37,38 Results of clinical studies showed that, the utilization of GaAlAs (795 or 830 nm) or InGaAlP (660 nm) with special radiation protocol: power of 15-120 mW, energy density of one. 8-ten J/cm^2, 24-160 sec, 3-6 sessions, continuous mode, and scanning motion will have a big impact on reducing dentin sensitivity.[9]

Although several studies reported concerning effectualness and success of this type of treatment, there are still several controversies as a result of subjective nature of DH. Despite numerous PBMT protocols and completely different comparative strategies in clinical studies, still it appears that additional similar optical device medical care settings are required to be evaluated in well-designed studies to achieve evidence-based treatment protocols and conclusions.

Lasers are suggested for many aspects of implant medical specialty, as improvement of osseointegration through photo-bio-modulation (PBM), post-operative treatment (PBM: accelerated wound healing and analgesic effect),

second stage surgery for implant recovery, implant bed preparation, sinus elevate procedures, and PI treatment (implant surface remotion and implant surface modification). The optical maser result on tissue (laser-tissue interaction) is wavelength and energy dependent. All optical maser wavelengths with comparatively high fluence is wont to take away (ablate) infected tumor tissues around implants and at an equivalent time scale back microbic load within treated sites beside sensible stoppage, however solely metallic element family lasers square measure suggested for treating exposed bone throughout bone-defect surgical process in open flap surgery.[10] Lower levels of energy will stimulate tissues and cells while not manufacturing irreversible changes (PBM), therefore promoting wound healing. throughout optical maser surgery, PBM effects could also be evoked in tissue adjacent to the surgical website thanks to gauge boson scatter gradient effects over distance.[11]

The removal of suprabony pockets or pockets not extending to the mucogingival junction is that the purpose of a gingivectomy. Patients could expertise pain thanks to open wound secondary repair following gingivectomy. Amorim et al conducted a clinical study on animal tissue healing following gingivectomy and LLLT in a very split mouth irregular run. He studied twenty patients United Nations agency had two-sided enhanced animal tissue volume on a bicuspid. Gingivectomy was performed within the take a look at cluster then Associate in Nursing LLL was used for eighty seconds with a wavelength of 685 nm and an influence of fifty mW in continuous mode. All surgery dressings were revived when 24 hours, and postoperatively on the third and seventh days.[10] Following surgeries, photographic pictures were taken on the third, seventh, fourteenth, 21st and 45th days. They were reviewed by 3 periodontists and clinical condition was noted, that evaluated wound repair, tissue color, and contour. For biometric assessment, reference composite was inserted at medial section of buccal plane, then pocket depth and thickness of keratinized animal tissue measured. Clinical visits showed higher wound repair within the optical maser cluster patients when the 3rd operative day. On 21st and ordinal days, biometric assessment conjointly incontestible superior improvement within the optical maser cluster patients compared to the controls. Finally, Amorim et al finished that the appliance of Associate in Nursing LLL at the side of gingivectomy resulted in improved conditions and quicker repair.[11]

Findings of Karthikeyan et al conjointly make sure the results of Aena et al wherever LLL assisted Kirkland flap surgery showed important improvement plaque index, hurt on searching, searching pocket depth and clinical attachment level at 3rd and 6th month compared to Kirkland flap surgery alone.[12] Red advanced bacterium levels were conjointly considerably reduced within LLL assisted cluster compared to management cluster at the third and sixth months. Here, the authors explained that the connected use of the diode optical maser could aid within the complete removal of remnant animal tissue that isn't accomplished by the Kirkland flap alone.

Lasers is used for remotion of the implant surface. atomic number 22 absorbs irradiation made from infrared and mid-infrared optical maser wavelengths like diodes, Nd: YAG and also the metallic element family. greenhouse emission (CO2) (far-infrared) irradiation is principally mirrored (>90%), however there's invariably the danger of a temperature rise just in case of high energy delivery.[12]Absorption leads to heat production, that is associate in Nursing undesirable result, since it's going to cause surface alterations (melting and cracks) and injury the encircling tissues. thanks to their high peak power, Nd: YAG lasers aren't suggested for remotion of implant surfaces (risk of partial melting, cracking, and crater formation), regardless of facility output. Diode optical maser doesn't injury the atomic number 22 surface and it's capable of decontaminating rough implant surfaces, tho' it conjointly has the danger of warmth generation on peri-implant bone tissue once used with improper irradiation parameters and techniques. Er: YAG and Er, Cr: YSGG (2780 nm) lasers, once used with constant water irrigation and applicable irradiation, cause no visible changes on atomic number 22 surfaces with min temperature elevation. differently to clean the implant surface is via employment of antimicrobial photodynamic medical care (aPDT). This involves administration of non-toxic dye (photosensitizer) within peri-implant pockets, followed by illumination victimization light-weight of associate in nursing applicable wavelength that, within presence of gas, results in the formation of reactive gas species that causes microbic death.[13]

Therapies that lot of effectively promote osteoblastic growth and maturation would profit various patients United Nations agency need bone tissue regeneration and those with periodontitis, bone gangrene, and bone traumatisms/those undergoing repair with implants, among others.[14] One study has incontestible that irradiation with a low-level 940-nm optical maser diode in periodic mode not solely stimulates osteoblastic growth, however conjointly exerts associate in Nursing action on alternative cell parameters. Thus, cell differentiation irradiation at doses of one W/cm^2 /3 J, or 1.5 W/cm^2 /3 J made {a major|a serious|a important} and significant increase in mountain activity, suggesting a good result on maturation method. the foremost effective irradiation dose during this side was one W/cm^2/3J.[15]

Many authors have investigated the results of PBM on growth and differentiation of human formative cell cells for treatment of deep intra bone defects, employment of barrier membranes, and differing types of graft material-that square measure typically indicated. Makhlouf et al and Nadler et al studied similarly the result of a diode optical maser of 830 nm on periodontal disease victimization the facility setting of 100 mW for primary study and forty mW for 2nd and also irradiation time wass 30 each studies reported that searching depth within the

optical maser cluster improved when three months.[14] From these studies, there's well-documented proof to indicate that irradiation with energy 3 and 4 J is more practical, that may be a consider bone formation and formative cell growth.

Laser and light-emitting diodes (LEDs) are being used in almost every field of clinical dentistry, changing the dental healthcare approaches and patient's quality of life. Dental applications for PBM are based on usage of low dose of biophotonics therapy. PBM in orthodontic treatment is used to reduce pain after orthodontic appliance placement. It also improves osseointegration, collagen deposition, and achieves faster bone-remodeling. In surgical-assisted therapy, such as implant and mini-implant placement, it was shown to assist implant stability healing time was reduced, along with swelling, contributing to an improvement of postoperative comfort. In the literature, a significant number of scientific papers have reported advantages of using laser light stimulation in oral medicine, in clinical situations as recurrent aphthous stomatitis, herpes infections, mucositis, and burning mouth syndrome. Recurrence aphthous stomatitis (RAS), also known as the recurrent oral ulcer, is a most common oral lesion that can be classified as a minor, major, or herpetiform ulcers.[14] Although the cause of oral lesion formation is not entirely known, it is related to immune system dysfunction, genetic factors, allergic agents, nutrition, hormonal changes, stress, and infective viruses. Clinically it can be manifested as small, round or ovoid, painful, self-healing, and recurrent ulcers with circumscribed margins, erythematous haloes, and yellow or gray floors.

Jijin et al reported that low level diodide laser therapy, compared to of 5% Amlexanox oral paste, a commonly used treatment, presented a statistically significant reduction in pain score after three days, although no difference was observed after day seven. Tezel et al. reported that the Nd:YAG laser at 100 mJ, 2 W, 20 Hz for 2–3 min in contact mode has better patient acceptance, shorter treatment time, and lower rates of pain.[10] Recently Han et al reported significantly alleviated pain (especially the immediate pain relief) with facilitated healing compared with a placebo group. PBM in herpes infections treated at doses below 10 J/cm^2 has been shown to have positive effects in pain reduction, accelerating the healing process, as well as contributing to viral resistance mechanism inhibition and recurrence reduction.[16]

The application of PBM has been recognized as an adjunctive or alternative approach in periodontal and peri-implant inflammation therapy. From the reviewed articles, we could conclude some suitable parameters for PBM as an adjunctive therapy in periodontal disease treatment.[17]

CONCLUSION

PBM is steadily moving into mainstream medicine. There have been a substantial number of reports on the clinical benefits of PBM, which also includes dentistry, although the quality of these studies is yet to be subjected to detailed assessment through randomized, clinical trials. Furthermore, the science of PBM is complicated with the requirement for a combined knowledge of laser physics, medicine, and clinical procedures.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: Not required

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Cite this article as: Sahu N, Jalaluddin M, Kar SR, Swain SK, Brahma P, Nanda J. Effects of photo biomodulation on peri-implantitis. Int J Res Med Sci 2023;11:423-9.