Photoperiodontics: light therapies in periodontal disease management

Nay Aung[1,2]

1.Laser Light Dental Clinic, Yangon, Myanmar.

2.Photoperiodontics, Department of Periodontology, Tokyo Medical and Dental University (TMDU), Tokyo, Japan.

Abstract

Light therapies are commonly used to treat a wide variety of diseases in photomedicine and laser surgery. With recent development of new innovative laser/light-emitting diode (LED) devices, there has been increased interest in using light therapies to periodontal and peri-implant treatments in photoperiodontics. Laser therapy with surgical or nonsurgical periodontal procedures may improve prognosis of treatment outcomes due to its advantages of better access, minimally invasive surgery, reduction of inflammation and pain, wound detoxification, enhanced healing and regeneration, and greater patient acceptance. Adjunctive phototherapy using LED with or without a photosensitizer also seems to have clinical improvements and benefits. However, further researches are still needed to be evaluated and validated in well-designed controlled clinical studies. This review article briefly discusses the use of different light therapies in the management of periodontal and implant-related diseases including possible risks and complications.

Keywords: lasers, light-emitting diodes, photodynamic therapy, low level laser therapy, ultraviolet light

1.Introduction

Photomedicine is defined as the study of diseases caused by light and the use of light to detect, diagnose, and treat diseases[1]. It may be related to the practice of various fields of medicine including dermatology, surgery, interventional radiology, optical diagnostics, cardiology, circadian rhythm sleep disorders and oncology[2]. In dermatology, low-level laser (light) therapy (LLLT) has a wide range of applications of use, especially in indications where stimulation of healing and regeneration, reduction of inflammation and pain, reduction of cell death and skin rejuvenation are required[3].

In dentistry, there are various applications of light therapies using lasers, light emitting diodes (LEDs), and ultraviolet (UV) light to obtain therapeutic effects. Composite materials in restorative dentistry require light photo-activation for polymerization[4]. In endodontics, several in vitro and in vivo studies demonstrated promising results about the use of antimicrobial photodynamic therapy (aPDT) during root canal infection management[5]. Moreover, lasers have also been used in oral surgery and dental implantology in the past several years; the use of lasers has become a state-of-the-art treatment modality as compared to conventional techniques in some indications[6].

More recently, different types of laser/LED light therapies have been used for the treatment of periodontitis and peri-implantitis in periodontics due to their numerous favourable characteristics, such as ablation or vaporization, haemostasis, biostimulation (photobiomodulation), root surface detoxification, and microbial inhibition and destruction[7]. Among laser therapies, LLLT has a major role in performing periodontal treatments; their anti-inflammatory and pain-reducing effects have been variously reported in previous studies[8]. In addition, aPDT may also provide clinical improvements when compared with conventional periodontal therapy for both periodontitis and peri-implantitis patients[9].

Photoperiodontics may be defined as the study and use of different types of lasers/LEDs wavelengths to detect, diagnose and treat periodontal and peri-implant diseases. Photoperiodontics research includes application of lasers/LEDs in periodontal and peri-implant therapy, photobiomodulation effects of lasers/LEDs on cells/tissues, application of aPDT in periodontal and peri-implant therapy, application of optical coherence tomography (OCT) in periodontal therapy. Depending on the wavelength of each laser system, lasers are effectively being applied for various periodontal treatments, facilitating procedures and producing desirable clinical results[10].

The aim of this review article is to briefly discuss the use of various laser/LED light therapies for the treatment of periodontal and peri-implant diseases in photoperiodontics.

2. Literature Review

2.1 Applications and actions

Currently, lasers, light-emitting diodes (LEDs), ultraviolet (UV) lights are being used in photoperiodontics for surgical periodontal therapy, nonsurgical periodontal therapy, antimicrobial photodynamic therapy (aPDT) and photobiomodulation (PBM) of cells for better healing and regeneration of tissues[11]. The action of lasers on periodontal hard and soft tissues as well as bacteria depends on the absorption of laser by tissue chromophore (water, apatite minerals, and various pigmented substances) within the target tissue. The possible mechanisms include photothermal ablation, photomechanical action, and photochemical effects. Photothermal ablation occurs with high-powered lasers, when used to vaporize or coagulate tissue through absorption in a major tissue component. With photomechanical ablation, disruption of tissue occurs due to a range of phenomena, including shock wave formation, cavitations, etc. Photochemical effects can be obtained using light sensitive substances[7].

2.2 Surgical Periodontal Therapy

Different types of laser lights and their specific wavelengths have been used for surgical periodontal applications. At present, use of lasers in various periodontal surgical procedures such as gingivectomies, gingivoplasties, frenectomy, depigmentation, reshaping of drug-induced gingival overgrowth, exposure of short crowns associated with altered passive/delayed eruption, and operculectomy have been well documented. Among different lasers, diode lasers are relatively inexpensive, and it can be used to ablate soft tissue procedures such as frenectomy, gingivectomy, aphthous ulcers, etc. Lasers facilitate a relatively dry surgical treatment with better visualization as a result of coagulation, haemostasis, and minimal tissue damage without suturing. Besides, it increases tissue surface sterilization which reduces bacteraemia, and decreases swelling and scarring[7].

2.3 Nonsurgical Periodontal Therapy

Lasers have been used as a monotherapy or as an adjunct to scaling and root planing in the nonsurgical periodontal treatment of moderate to advanced chronic periodontitis. The benefits include subgingival curettage, minimally invasive access for scaling and root planing, and calculus removal, as well as detoxification and killing of subgingival periodontal pathogens[12]. In the clinical situation, periodontopathic bacteria exist within a protective biofilm in a deep periodontal pocket. Consequently, conventional periodontal therapies cannot completely eliminate bacteria from difficult-to-access areas compared to laser light therapy[13].

2.4 Antimicrobial Photodynamic Therapy (aPDT)

Antimicrobial photodynamic therapy involves the use of a photosensitizer (photoactive dye) that is activated by exposure to a specific wavelength of light in the presence of oxygen. The activated photosensitizer transitions to an excited state and subsequently reacts with oxygen to create singlet oxygen and free radicals, which can damage proteins, lipids, nucleic acids, and other vital elements leading to destruction of the target tissues[14]. In the case of biofilm and periodontal pathogens, aPDT may kill bacteria by disrupting the biofilm and bacterial cell walls. However, the power and irradiation time of lights, photosensitizer concentration, combination of different photosensitizers and different light wavelengths may affect clinical effects of aPDT[15].

2.5 Low-Level Laser Therapy

Low-level laser therapy (LLLT) is a biostimulation therapy in periodontics. It is referred to as ‘low level’ because the density of light energy is low compared with other high power laser parameters. The power (energy) of low-level light is generally in the range of 1 to 1000 mW. It is assumed to promote wound healing and tissue regeneration effect by reducing inflammation, enhancing epithelialization, fibroblast proliferation, and matrix synthesis, as well as neovascularization[16]. In a meta-analysis of eight research articles (seven RCTs) about the use of LLLT as an adjunct to nonsurgical periodontal treatment, short-term (1-2 months) improvements in probing pocket depth and gingival crevicular fluid levels of IL-1β were shown. However, it showed no significant intermediate-term (3-6 months) effects in terms of clinical parameters[17]. This therapy has also been used in pain management protocols following gingivectomies, and as an adjunct treatment in nonsurgical periodontal procedures[18].

2.6 Ultraviolet (UV) LED light therapy

UV irradiation (wavelength: 100-400 nm) can be subdivided into UVA (315-400 nm), UVB (280-315 nm), and UVC (100-280 nm). Narrowband UVB-LED 310 nm irradiation showed a weak bactericidal effect on oral bacteria, but showed mild phototoxicity to gingival cells; its effect also induces the production of reactive oxygen species (ROS) from oral epithelial cells and may enhance bactericidal activity to specific periodontopathic bacteria[19]. Our research group also demonstrated that 265 and 285 nm UV LEDs may induce powerful bactericidal effects and severe fibroblast phototoxicity, and 310 nm may induce partial killing or growth suppression of bacterial cells with much less fibroblast phototoxicity. UV LED lights may have potential for bacterial suppression, with situations dependent on wavelength, in periodontal and peri-implant disease management[20].

2.7 Lasers therapy in peri-implant mucositis and peri-implantitis

Previous evidence-based studies showed that laser light therapy with surgical or nonsurgical therapy provided minimal benefit in probing depth reduction, clinical attachment level gain, amount of recession improvement, plaque index reduction in the treatment of peri-implant diseases. Lasers when used as an adjunct to non-surgical therapy might result in bleeding on probing reduction in the short term. However, current evidence allowed for analysis of only Er:YAG, CO2, and diode lasers. To clearly elucidate the effect of lasers on the biological basis of peri-implant new bone formation, integration with new bone and implant surfaces, and long term effects on peri-implantitis is still needed[21].

2.8 Complications and Risks of Laser/LED Therapy

High power lasers can generate excessive temperature elevation which may lead to unintended accidental tissue damage. Temperature elevation (≥47°C) can induce cellular damage and osseous resorption in bone tissue. Extreme temperature elevation (≥60°C) can result in tissue necrosis. Therefore, overexposure of laser energy can cause periodontal tissue damage and destruction. Both operator and patient need to wear safety glasses for the protection of their eyes from laser/UV light radiation. Inexperienced operators must learn knowledge of the laser/LED mechanisms and techniques to minimize tissue damage and other negative outcomes[7].

3. Conclusion

In conclusion, several factors favouring laser light therapy are better visualization of cutting, faster tissue ablation and healing, coagulation, wound sterilization, less invasive surgical access, little tissue shrinkage with less scarring, and patient comfort. Nevertheless, evidence-based studies with more well-designed, controlled research are limited. Further research on laser/LED light parameters for clinical efficacy and the biologic basis is essential although the use of laser/LED light may become an integral part of periodontal and peri-implant therapy in photoperiodontics.

References

1. Wolf P, de Grujil FR. Editorial: Photomedicine. Front Med. 2019;6 (July): 1–2.
2. Yun SH, Kwok SJJ. Light in diagnosis, therapy and surgery. Nat Biomed Eng. 2017;1(1).
3. Avci P, Gupta A, Sadasivam M, Vecchio D, Pam Z, Pam N, et al. Low-level laser (light) therapy (LLLT) in skin: Stimulating, healing, restoring. Semin Cutan Med Surg. 2013;32(1):41–52.
4. Sakaguchi RL, Douglas WH, Peters MCRB. Curing light performance and polymerization of composite restorative materials. J Dent. 1992;20(3):183–8.

5. Plotino G, Grande NM, Mercade M. Photodynamic therapy in endodontics. Int Endod J. 2019;52(6):760–74.

6. Deppe H, Horch HH. Laser applications in oral surgery and implant dentistry. Lasers Med Sci. 2007;22(4):217–21.

7. Aoki A, Mizutani K, Schwarz F, Sculean A, Yukna RA, Takasaki AA, et al. Periodontal and peri-implant wound healing following laser therapy. Periodontol 2000. 2015;68(1):217–69.

8. Sobouti F, Khatami M, Heydari M, Barati M. The role of low-level laser in periodontal surgeries. J Lasers Med Sci. 2015;6(2):45–50.

9. Chambrone L, Wang H-L, Romanos GE. Antimicrobial photodynamic therapy for the treatment of periodontitis and peri-implantitis: An American Academy of Periodontology best evidence review. J Periodontol. 2018;89(7):783–803.

10. Ishikawa I, Aoki A, Takasaki AA, Mizutani K, Sasaki KM, Izumi Y. Application of lasers in periodontics: True innovation or myth? Periodontol 2000. 2009;50(1):90–126.

11. Aoki A, Takasaki AA, Pourzarandian A, Mizutani K, Ruwanpura SMPM, Iwasaki K, et al. Photobiomodulation laser strategies in periodontal therapy. Lect Notes Electr Eng. 2008;12 LNEE:181–90.

12. Sumra N, Kulshrestha R, Umale V, Chandurkar K. Lasers in non-surgical periodontal treatment–a review. J Cosmet Laser Ther [Internet]. 2019;21(5):255–61. Available from: https://doi.org/10.1080/14764172.2018.1525744

13. Schwarz F, Aoki A, Becker J, Sculean A. Laser application in non-surgical periodontal therapy: A systematic review. J Clin Periodontol. 2008;35(SUPPL. 8):29–44.

14. Chui C, Aoki A, Takeuchi Y, Sasaki Y, Hiratsuka K, Abiko Y, et al. Antimicrobial effect of photodynamic therapy using high-power blue light-emitting diode and red-dye agent on Porphyromonas gingivalis. J Periodontal Res. 2013;48(6):696–705.

15. Uekubo A, Hiratsuka K, Aoki A, Takeuchi Y, Abiko Y, Izumi Y. Effect of antimicrobial photodynamic therapy using rose bengal and blue light-emitting diode on Porphyromonas gingivalis in vitro: Influence of oxygen during treatment. Laser Ther. 2016;25(4):299–308.

16. Chung H, Dai T, Sharma SK, Huang YY, Carroll JD, Hamblin MR. The nuts and bolts of low-level laser (Light) therapy. Ann Biomed Eng. 2012;40(2):516–33.

17. Ren C, McGrath C, Jin L, Zhang C, Yang Y. The effectiveness of low-level laser therapy as an adjunct to non-surgical periodontal treatment: a meta-analysis. J Periodontal Res. 2017;52(1):8–20.

18. Amorim JCF, De Sousa GR, Silveira LDB, Prates RA, Pinotti M, Ribeiro MS. Clinical study of the gingiva healing after gingivectomy and low-level laser therapy. Photomed Laser Surg. 2006;24(5):588–94.

19. Takada A, Matsushita K, Horioka S, Furuichi Y, Sumi Y. Bactericidal effects of 310 nm ultraviolet light-emitting diode irradiation on oral bacteria. BMC Oral Health. 2017;17(1):1–10.

20. Aung N, Aoki A, Takeuchi Y, Hiratsuka K, Katagiri S, Kong S, et al. The Effects of Ultraviolet Light-Emitting Diodes with Different Wavelengths on Periodontopathic Bacteria in Vitro. Photobiomodulation, Photomedicine, Laser Surg. 2019;37(5):288–97.

21. Lin G-H, Suárez López Del Amo F, Wang H-L. Laser therapy for treatment of peri-implant mucositis and peri-implantitis: An American Academy of Periodontology best evidence review. J Periodontol [Internet]. 2018;89(7):766–82. Available from: http://www.ncbi.nlm.nih.gov/pubmed/30133748