International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2016): 79.57 | Impact Factor (2015): 6.391

Laser Photobiomodulation and Photodynamic Therapy. A Literature Review

Rada Kazakova

Assistant Professor, DMD, PhD, Department of Prosthetic Dentistry, Faculty of Dental Medicine, Medical University – Plovdiv
Corresponding author: Dr. Rada Kazakova, DMD, PhD, Department of Prosthetic Dentistry, Faculty of Dental Medicine, Medical University – Plovdiv

Abstract: ***Laser photobiomodulation and photodynamic therapy are new methods for bacteria elimination. The use of low-level laser therapy (LLLT), especially in a combination with a photosensitizer, leads to increase of the ATP production, improvement of the oxy-reduction potential of the cells, as well as bacteriolysis. Neither the dye itself, nor the laseer is capable of reducing the number of bacteria as much as their combination. The advantages of these methods, compared to the use of antiseptics or antibiotics, are their local action, absence of systemic side effects and lack of need for maintaining high concentration of the dye.***

Keywords: laser photobiomodulation, laser photoactivated disinfection, laser PAD, laser photodynamic therapy, laser PDT, low-level laser therapy (LLLT)

1. Introduction

Surgical lasers (Nd:YAG, CO_2, Er:YAG, diode) change tissues now only by means of ablation, coagulation and evaporation, but also by stimulating the natural healing processes in cells. Other lasers and laser-emitting diodes (LED), applied with lower power than the surgical ones, also play the role of “biostimulators”.

Photobiomodulation

Such kind of therapy is known as “low level laser therapy” (“LLLT”), as well as “cold”, “therapeutic” or “soft” laser therapy, although “LED” changes the suggested nomenclature. The most exact term nowadays is “photobiomodulation” (“PBM”), as it best describes the process and includes the operational principles of all therapeutic light devices. [7]

The advantage of the therapeutic laser light is that it stimulates the natural biological processes and affects mainly cells with low level of oxy-reduction processes. Their pH is acidic, but they become more alkaline after the laser irradiation and are able to function optimally. Healthy cells cannot increase significantly their oxy-reduction potential, therefore they do not react notably to the laser energy; whereas cells in a low oxy-reduction potential will be stimulated. [2, 23]

The most significant effect is the increase of ATP, “the cells’ fuel”, produced in the mitochondria. [3] ATP is the final product of the Krebs cycle, and the photon-accepting enzyme cytochrome c oxidase is inhibited by nitrogen oxide (NO). Laser light will dissolve the bonding between NO and cytochrome c oxidase, allowing it to recover ATP production. [11] This basic mechanism initiates a cascade of cell signals, leading to optimizing cell functions.

Photoactivated Disinfection

There is an increasing interest in combining different dyes with therapeutic lasers. [5, 16, 17] Neither the dyes, nor the lasers themselves used separately affect bacteria, but their combination leads to singlet oxygen production, which has a strong bactericidal effect. [18, 21]

Photoactivated disinfection (PAD) is a method which has been already used in treating periodontal sockets, deep carious lesions and infected root canals. [4, 22] As far a prosthetic dentistry is concerned, it can be applied for impressions disinfection or treating decubitus ulcer caused by improper fitting and imprecise adjustment of dentures. [18, 19, 21]

Laser has to work within the absorption wavelength of the dye used. The chosen dye is applied and left to diffuse for a few minutes; after that laser irradiation is applied. [20, 21]

Photodynamic Therapy

Aphthous ulcers treatment time can be shortened and the pain – reduced immediately, after applying 4 to 6 J per lesion and 4 J to the submandibular lymph nodes on the affected side. [1, 2, 13, 20, 27] Patients, prone to aphthous ulcers formation have to avoid toothpastes, containing sodium lauryl sulfate, which can cause their reoccurrence. Photodynamic therapy (PDT) can be applied in periodontal treatment in addition to the mechanical causal therapy. [15] “Cold” (low-level) laser, or a traditional laser with wavelength, absorbed by the dye, is used (e.g. diode or Nd:YAG). [6, 8, 9, 10, 12, 14] The photosensitizer is applied in the sulcus as a subgingival irrigant. The wavelength of the laser is absorbed by the dye and reacts with it, destroying the membranes of the bacterial cells. The light energy activates the photosensitizer, reacts with the intracellular oxygen and destroys bacteria via lipid peroxidation and membrane lysis. [13] PAD using a photosensitize indocyanine green (EmunDo) and a diode laser is shown on Figure 1 and Figure 2.

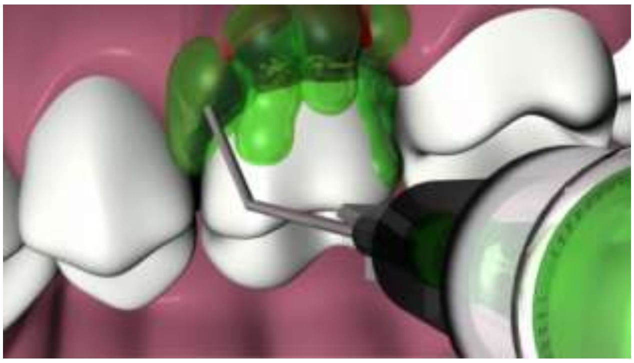

Figure 1: Indocyanine green dye (EmunDo) application in the gingival sulcus.

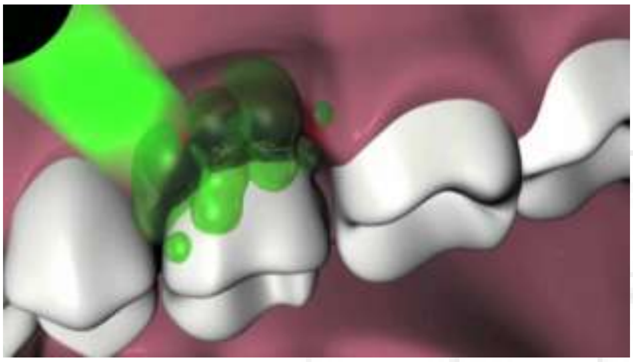

Figure 2: Laser activation of the photoinitiator using a diode laser (F.O.X. Lasers)

Conclusion

The advantages of PAD, compared to the traditional antimicrobial agents, are that it ensures faster bacteria destruction, without the need of maintain high concentrations of the photosensitizer in the infected area, as when using antiseptics and antibiotics. PAD affects the microorganisms locally, whereas the systemic medicines influence the whole organism. Moreover, PAD does not affect or change the adjacent periodontal or periapical tissues, even when high concentration of the dye and the laser energy is used.

References

[1] Abbas, M., C. Zahra, M. Mahvash, F. Reza, M. Neda, A. Adriano, B. Omid, C. Nasim. Antimicrobial photodynamic therapy using diode laser activated indocyanine green as an adjunct in the treatment of chronic periodontitis: A randomized clinical trial. Photodiag and Photodyn Ther, Mosby Elsevier, 2016, 14:93-97.
[2] Almeida-Lopes, L., J. Rigau, R. Zângaro, et al. Comparison of the low-level laser therapy effects on cultured human gingival fibroblast proliferation using different irradiance and same fluency. Laser Surg Med, 2001, 29:179:184.
[3] Amat, A., J. Rigau, R. Nicolau, et al. Effect of red and near-infrared laser light on adenosine triphosphate (ATP) in the luciferine-luciferase reaction. J Photochem Photobiol A Chem, 2004, 168(1-2):59-65.
[4] Bonsor, SJ, GJ Pearson. Current clnical applications of photoactivated disinfection in restorative dentistry. Dent Update, 2006, 33(3):143-144, 147-150, 153.
[5] Braun, A., C. Dehn, F. Krause, S. Jepsen. Short-term clinical effects of adjunctive antimicrobial photodynamic therapy in periodontal treatment: a randomized clinical trial. J Clin Periodontol, 2008, 35(10):877-884.
[6] Chan, Y., CH Lai. Bactericidal effect of different laser wavelengths in periodontopathic germs in photodynamic therapy. Lasers Med Sci, 2003, 18:51-55.
[7] Convissar, RA. Principles and practice of laser dentistry. Ed. 2. Elsevier Mosby, 2015.
[8] Fekrazad, R., A. Mir, V. Barghi, M. Shams-Ghahfarokhi. Eradication of C. albicans and T. rubrumwith photoactivated indocyanine green, Citrus aurantifolia essential oil and fluconazole. Photodiag and Photodyn Ther, Mosby Elsevier, 2015, 12:289-297.
[9] Fekrazad, R., F. Khoei, N. Hakimiha, A. Bahador. Photoelimination of Streptococcus mutanswith two methods of photodynamic andphotothermal therapy. Photodiag and Photodyn Ther, Mosby Elsevier, 2013, 10:626-631.
[10] Fekrazad, R., VG Barghi, A. Mir, M. Shams-Ghahfarokhi. In vitro photodynamic inactivation of Candida albicans by phenothiazine dye (new methylene blue) and Indocyaninegreen (EmunDo®). Photodiag and Photodyn Ther, Mosby Elsevier, 2015, 12:52-57.
[11] Hamblin, MR. The role of nitric oxide in PBM. Proc SPIE, 2008 (BiOS), 6846:1.
[12] Komerik, N., H. Nakanishi, AJ MacRobert, et al. In vivo killing of Porphyromonas gingivalis by toluidine blue-mediated photosensitization in an animal model. Antimicrob Agents Chemother, 2003, 47:932-940.
[13] Kosarieh, E., SS Khavas, A. Rahimi, N. Chiniforush, N. Gutknecht. The comparison of penetration depth of two different photosensitizersin root canals with and without smear layer: An in vitro study. Photodiag and Photodyn Ther, Mosby Elsevier, 2016, 13:10-14.
[14] Malik, Z., J. Hanania, Y. Nitzan. Bactericidal effects of photoactivated porphyrins: an alternative approach to antimicrobial drugs. J Photochem Photobiol B, 1990, 5:281-293.
[15] Mantareva, V., V. Kussovski, I. Angelov, S. Dimitrov. Advance photodynamic inactivation of dental pathogenic microorganisms with water-soluble and cationic phthalocyanines. Science against microbial pathogens: communicating current research and technological advances, Formatex, 2011, 650-661.
[16] Meire, MA, K. De Prijck, T. Coenye, et al. Effectiveness of different laser systems to kill Enterococcus faecalis in aqueous suspension and in an infected tooth model. Int Endod J, 2009, 42(4):351-359.
[17] Morselli, M. et al. Effects of very low energy-density treatment of joint pain by CO2 laser. Laser Surg Med, 1985, 5(5):150-153. (92, 221, 231).
[18] Popova, E., S. Dimitrov, Ch. Kissov, A. Vlahova, I. Angelov, V. Mantareva, V. Kussovski. Photodynamic destruction of Candida albicans on complete dentures with porphyrins and phthalocyanines. 14th Congress of BASS. 9th Scientific Congress of BgDA, Varna, Bulgaria, 6-9 May, 2009. Abstract Book, p. 82.
[19] Schillinburg, H., S. Hobo, LD Whitsett. Fundamentals of fixed prosthodontics, Quintessence, 2012, Chicago, ed 4.

[20] Vlahova, A., Chr. Kissov, E. Popova, G. Todorov. Photodynamic disinfection of dentures. American Journal of Infectious Diseases and Microbiology, 2013, Vol. 1, No. 2, 34-37.
[21] Vlahova, A., Chr. Kissov, E. Popova. Photodynamic disinfection of dental impressions and dentures. LAP Lambert Academic Publishing, Saarbrücken, Germany, 2013, ISBN 978-3-659-46063-0.
[22] William, JA, GJ Pearson, MJ Colles, M. Wilson. The photoactivated antibacterial action of toluidine blue O in a collagen matrix and in carious dentine. Caries Res, 2004, 38(6):530-536.
[23] Yamamoto, Y., T. Kono, H. Kotani, et al. Effect of low-power laser irradiation on procollagen synthesis in human fibroblasts. J Clin Laser Med Surg, 1996, 14(3):129-132.