Open Access Research Journal of
Biology and Pharmacy
Journals home page: https://oarjbp.com/
ISSN: 2782-9979 (Online)

OARJ OPEN ACCESS RESEARCH JOURNALS

(RESEARCH ARTICLE)

Effect of low-level laser therapy during non-surgical periodontal treatments on pocket depth and HbA1c in type 2 diabetic patients

Omid Omidbeigi * and KimiaZahra Afshar

Alborz University of Medical Sciences, Alborz, Iran.

Open Access Research Journal of Biology and Pharmacy, 2024, 10(02), 072–080

Publication history: Received on 25 January 2024; revised on 11 March 2024; accepted on 14 March 2024

Article DOI: https://doi.org/10.53022/oarjbp.2024.10.2.0011

Abstract

Introduction: Periodontal diseases are generally divided into two groups: Gingivitis and periodontitis. Diabetes Mellitus is a group of metabolic diseases that are characterized by increased blood sugar levels (due to defects in insulin production or insulin resistance or both). The aim of this study was to investigate the effect of low-power laser in non-surgical periodontal treatments on pocket depth and HbA1c in type 2 diabetic patients.

Methods: Relevant articles were reviewed through searching Embase, PubMed, Google Scholar, Scopus in the 10-years from 2015 to 2021. Cochrane collaboration tool was used to evaluate the quality of articles.

Results: From 160 studies, 120 articles were selected after removing duplicate articles and finally 6 studies were reviewed. The test group, which was under diode laser radiation, showed a greater decrease in pocket depth during the three and six-month follow-up. Diode laser irradiation with SRP during 3 and 6 months led to more changes in HbA1C levels.

Conclusion: Low level lasers can be used well in non-surgical periodontal treatment in type 2 diabetic patients.

Keywords: Low level laser therapy; Periodontal parameter; Diabetes type 2; Chronic periodontitis

1. Introduction

Periodontal diseases are a group of inflammatory diseases, which are generally divided into two groups: gingivitis and periodontitis. Periodontitis has a multifactorial etiology, and microbial, environmental, genetic, and systemic disease factors such as diabetes affect the susceptibility of this disease (1-4). Diabetes Mellitus is a group of metabolic diseases that are characterized by increased blood sugar levels (due to a deficiency in insulin production or insulin resistance or both). Diabetes is the most common chronic disease in the world (5-9).

In a diabetic person, due to the hyperglycemic condition, proteins and extracellular background molecules are subjected to an enzymatic glycosylation process and ultimately disrupt tissue integrity and periodontium. The effects of diabetes on periodontium include the tendency to increase the volume of gums, gingival polyps, abscesses, laxity and periodontitis (10,11). The rate of destruction of periodontium before the age of 56 is similar in diabetic and non-diabetic people, but in people over 56 years of age, this value is higher in diabetic people, in people who have been diagnosed with diabetes for more than 16 years, periodontal destruction is more severe (12-16).

Various methods including mechanical, chemical and surgical periodontal methods have been used to treat this disease. Among these methods, mechanical methods are more important and effective and are the most important methods for treating periodontal disease (17).

* Corresponding author: Omid Omidbeigi Orchid ID: 0009-0000-7162-3086

Mechanical treatment includes scaling and root planning (SRP), and the purpose is to remove the calcified plaques from the root surfaces to obtain a planned surface. This operation is done with the help of manual instruments or ultrasonic devices (18-22).

In order to evaluate the effect of periodontal treatment, periodontal indices including GI (Gingival Index), BI (Bleeding Index), PI (Plaque Index) and PPD (Pocket Probing Depth), SBI (Sulcus Bleeding Index), BOP (Bleeding On Probing) and CAL (Clinical Adhesion Level) are used (23).

In many surgical procedures, the laser is an adjunctive method compared to the conventional surgical blade (traditional surgery). Many studies have been conducted on the use of lasers with different wavelengths in oral soft tissues. Clinical use of laser includes frenectomy, gingivectomy and gingivoplasty, periodontal epithelium removal flaps, granulation tissue removal, second stage surgery of implants, lesion removal, excisional and incisional biopsies of benign and malignant lesions, radiation to aphthous lesions, blood coagulation in free gingival graft and removal of gingival pigmentation (24, 25).

Therefore, considering the concept variations regarding the combined use of SRP with or without laser, as well as the importance of treating periodontal disease in diabetic patients and the strong relationship between systemic diseases and periodontal disease, choosing the best method in improving periodontal parameters is of high importance (26). Considering the lack of studies regarding the investigation of different methods to improve periodontal parameters, this study was aimed at determine the effect of low power laser in non-surgical periodontal treatments through pocket depth and Hba1c in type 2 diabetic patients.

2. Method

Relevant articles were reviewed through searching PubMed, Web of Science, Scopus, ProQuest and Google Scholar during a 10-year period from 2015 to 2021. Considering that the current study was a review therefore, sampling method and sample size were not considered in this study.

Inclusion criteria were studies in English language, mostly randomized clinical trias (RCTs) based on research keywords such as SRP, Diode, LLLT, Periodontal Parameters and type II diabetes (table 1). Studies not indexed in Embase, Central Cochran, Clinicaltrials.gov, Science Direct, Scopus PubMed, Google Scholar were excluded.

This research reviewed the available articles on determining the effect of low-level laser therapy during non-surgical periodontal treatments on periodontal parameters and Hba1c in type 2 diabetic patients.

Table 1 Search strategy

Database	Search strategy	Results
PubMed	((((("low level laser therapy"[Title/Abstract]) OR ("LLLT"[Title/Abstract])) OR ("photobiomodulation"[Title/Abstract])) AND ((((((((("periodontal"[Title/Abstract]) OR ("HbA1c"[Title/Abstra))) AND ((((((((("diabetes"[Title/Abstract]))))	20
WOS	TOPIC: (("low level laser therapy" OR LLLT* OR photobiomodulation) AND (periodontal outcome* OR periodontal parameter* OR Periodontal status* OR HbA1c OR probing pocket depth OR probing depth OR bleeding on probing OR BOP OR PPD) AND diabetes type 2 OR diabetes type II OR diabetes mellitus) Timespan: All years. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, BKCI-S, BKCI-SSH, ESCI.	23
Scopus	(TITLE-ABS-KEY ((low level laser therapy) OR (LLLT) OR (photobiomodulation)) AND TITLE-ABS-KEY ((periodontal outcome*) OR (periodontal status*) OR (HbA1c*)) AND TITLE-ABS-KEY ((diabetes mellitus) OR (diabetes type II) OR (type 2 diabetes)))	25

ProQuest	ab(low level laser therapy OR LLLT* OR photobiomodulation) AND ab(periodontal outcome* OR probing pocket depth * OR HbA1c) AND ab(diabetes mellitus)	12
Google scholar	(low level laser therapy OR LLLT * OR photobiomodulation) AND (periodontal outcome* OR probing pocket depth* OR HbA1c) AND diabetes	80
Total	Total=160 After deleting duplicated records:120	

Figure 1 Search in web of science database

After entering all the studies in the Enodnote X9 software, duplicate studies were removed, then the screening process was performed based on the title and abstract of the studies. To avoid bias, the search was done by two researchers independently. The screened studies were selected based on the entire text of the review and based on the criteria of the checklist. The cases of disagreement between the two reviewers were decided by a third person. After the selection process, two reviewers independently extracted the data from the study.

3. Results

160 studies were reviewed from electronic databases. After removing duplicate articles, 120 articles were reviewed. Further screening of titles and abstracts led to the review of 21 studies. The full text of the remaining studies was reviewed. Of these, 6 studies were selected. The basic characteristics of the 6 included studies are shown in Table 2. The year of publication of the articles was from 2016 to 2019. These studies were conducted in different countries including Turkey (n = 2), China (n = 2), India (n = 1) and Brazil (n = 1). All selected studies were randomized clinical trials (RCTs). Among these, 4 studies used the parallel method. Blinding was performed in all 6 studies. All studies compared scaling and root planning (SRP) with the use of diode laser (DL) versus SRP alone, and only one study (13) used a sham laser in the control group. Follow-up times included 1, 3, and 6 months, and only 1 study (16) investigated the effect of 12 months.

Table 2 Data extraction of 6 included studies

Study, year/country	Study design	Study groups Test (*n*) Control (*n*)	Sample size	Systemic disease	Mean age (with SD or range)
Cai et al., 2018, China	RCT, parallel	SRP+ DL (31) SRP (31)	62	T2DM	47.81 (35–75)
Castro et al., 2019, Brazil	RCT, split-mouth, double-blinded	SRP+ DL (19) SRP (19)	19	T2DM	52.26 ± 9.87
Chandra et al., 2019, India	RCT, parallel, single-blinded	SRP+ DL (18) SRP (18)	36	T2DM	49.6 (30–60)
Dengizek et al., 2019, Turkey	RCT, parallel, single-blinded	SRP+ DL (18) SRP+ sham DL (19)	37	T2DM	50.77 ± NA
Feng et al., 2018, China	RCT, parallel, single-blinded	SRP+ DL (20) SRP (20)	40	T2DM	36 ± NA
Ozberk et al., 2019, Turkey	RCT, split-mouth, single-blinded	SRP+ DL (22) SRP (22)	22	T2DM	45.32 ± 6.19

Table 3 shows the HbA1C level, follow ups and periodontal parameters in the 4 included studies.

Table 3 HbA1C level, follow ups and periodontal parameters in the 4 included studies

Study, year/country	HbA1c levels (%)	Follow-up(months)	Clinical parameters
Cai et al., 2018, China (22)	NA	3, 6	PD, CAL
Castro et al., 2019, Brazil (16)	8.10 ± 1.83	3, 6, 12	PD, CAL
Chandra et al., 2019, India (23)	8.05 ± 1.27	3	PI, GI, PD, CAL
Dengizek et al., 2019, Turkey (13)	50.77 ± NA	3, 6	PI, GI, BOP, PD, CAL
Feng et al., 2018, China (24)	36 ± NA	3, 6	PD, CAL
Ozberk et al., 2019, Turkey (14)	45.32 ± 6.19	1, 3, 6	PI, GI, PD, CAL

Table 4 Diode laser parameters of interest

Study, year/country	Wavelength	Energy settings	Contact time	Brand
Cai et al., 2018, China	810 nm	2 W contact mode, 0.1 J	N.A	FotonaXD-2; Germany
Castro et al., 2019, Brazil	660 nm	0.03 W, continuous wave 22 J/cm^2, 1.1 W/cm^2, 0.06 J	20 seconds per envelope	TheraLase, DMC Ltda., São Carlos, SP, Brazil
Chandra et al., 2019, India	808 nm	1.5 W–1.8 W continuous wave	According to the depth of the envelope in millimeters	Mikro® Sunny, India

Dengizek et al., 2019, Turkey	810 nm	1 W contact mode	3 sets of 15 s per tooth (PD = 3–3.5 mm); 3 sets of 20 s per tooth (PD > 4 mm)	Gigaa Cheese GaAlAs, Diode laser, China
Feng et al., 2018, China	810 nm	1.75 W		FotonaXD-2; Germany
Ozberk et al., 2019, Turkey	980 nm	0.4 W, continuous wave, 0.5 J/cm^2		CHEESETM, GIGAA Laser, Wuhan Gigaa Optronics Technology Co., Ltd., China

Finally, two studies out of the 4 final studies measured the effect of low-power laser in periodontal non-surgical treatment on BOP, both the study by Feng et al. (24) and the study by Dengizek et al. (13) showed that BOP in the test group has decreased significantly compared to the control group. Table 5 shows the effect of low power laser on the reduction of periodontal pocket depth in the control and test groups of each study which the test group showed a greater decrease in the depth of the pocket during the 3 and 6 month follow-up.

Table 5 Pocket depth reduction in 4 studies

Study, year/country	Groups	1 month follow up	3 month follow up	6 month follow up
Cai et al., 2018, China	Control	-	3.77	3.8
	Test	-	4.38	4.51
Castro et al., 2019, Brazil	Control	-	1.8	2.4
	Test	-	2.2	2.7
Chandra et al., 2019, India	Control	-	0.96	-
	Test	-	1.84	-
Dengizek et al., 2019, Turkey	Control	-	0.47	0.4
	Test	-	0.56	0.68
Feng et al., 2018, China	Control	-	-	3.8
	Test	-	-	4.1
Ozberk et al., 2019, Turkey	Control	1.15	1.09	1.18
	Test	0.97	1.37	1.49

4. Discussion

The present systematic review was conducted to investigate whether the adjunct use of low-power laser improves periodontal parameters and blood sugar control in patients with diabetes. The results showed that DL had a significant role in reducing PD, improving CAL and reducing HbA1c in patients with type 2 diabetes and chronic periodontitis. Therefore, DL combined with SRP can be a suggested treatment for patients with chronic periodontitis who have type 2 diabetes.

In recent years, low-power laser has been widely used in non-surgical periodontal treatment (NSPT) since it has beneficial effects on wound healing and local inflammation control (26, 27). However, a number of previous studies, unlike our study, have shown that the use of DL in patients with CP is controversial and no clear evidence has been reported (28, 29). Diabetes aggravates periodontal lesions, and for this reason, effective treatments are necessary for these patients. Research evidence has confirmed that DL is beneficial for the healing of chronic diabetic wounds, which is consistent with our findings (30, 31). In our study, DL improved the results of PD and CAL, which is probably due to its effects in disinfection, and unique photobiomodulation in periodontal tissue (32, 33). In the present study, no

significant difference was observed in PD and CAL within 1 month; however, it should be noted that DL may accelerate wound healing, through collagen deposition, tissue regeneration, and epithelialization over time. And therefore, lead to positive short-term changes in chronic periodontitis in patients with DM (34).

Castro et al.'s study (16) was the study that investigated the long-term effects (12 months) of low-power laser on the periodontal pocket, but no significant difference was found between the test and control groups. Limited evidence prevented us from drawing conclusions about long-term effects, so further studies with long-term follow-up are needed. The split mouth study type should be chosen for this type of research studies so that differences in host response were eliminated in statistical analysis and differences between treatments were prioritized. This criterion is particularly useful for patients who are likely to present systemic changes that may affect the periodontal tissue and cannot be managed or controlled by periodontists (drug-induced changes, weight gain/loss, etc.). The main weakness of the study by Castro et al. (16) was that the analyzes related to inflammatory markers were not performed, which limited the possibility of understanding the response of periodontal tissue to PBM in patients with periodontitis and diabetes.

In the present study, DL had positive effects on HbA1c value, which confirms previous findings that periodontal treatment can improve glycemic control in patients with diabetes, possibly due to its potential to prevent or minimize transient bacteremia (35).

Many studies have been published on the use of low power laser in patients with chronic periodontitis (CP) (29, 36). Our results showed that low power laser has more benefits for patients with DM. The reason for this difference may be that the low-power laser contributes to the microbiological parameters in improving periodontitis (38). In addition, low-power laser has advantages in complete epithelial removal in periodontal pockets, which leads to improved connective tissue adhesion (39). Another explanation can be attributed to the ability of low power laser to create more stable blood clots and wound healing (40).

A systematic review (41) in 2016 showed that PBM has a positive effect on the oral epithelium, which can be observed in some clinical trials (42-44). Makhlouf et al. (43) investigated the use of PBM as an adjunctive therapy with SRP through a split mouth clinical trial. Sixteen patients received PBM + SRP in one quadrant and SRP in the opposite quadrant. The laser protocol was performed in 10 sessions as follows: 830 nm wavelength, 0.10-watt power, 0.03 square centimeters region. A statistically significant between-group difference was found for PD at weeks 5 and 12, but no statistically significant difference was found at any time point for GI.

In this systematic review, the included studies were heterogeneous in some aspects such as follow-up time, treatment area, and different laser devices due to the lack of well-designed studies. In addition, only four of our studies clearly indicated that their definition of chronic periodontitis was based on the 1999 classification (45), and in other studies, different descriptions such as generalized CP and "moderate to severe generalized CP" were used. Accordingly, this issue may bias the results of the studies.

The laser wavelength factor plays a key role in the laser-tissue interaction by modulating the scattering and absorption characteristics (46). The studies in this review primarily used DL with wavelengths between 660 and 980 nm in this review. It has been confirmed that wavelengths of 390-600 nm are used in superficial tissues such as the epidermis, while lasers with wavelengths between 600-1110 nm can penetrate deeper tissues to treat gingival epithelium and connective tissue (36, 47). In addition, fibroblasts, as the main periodontal cells, show different responses to different wavelengths, so that the most proliferation of fibroblasts occurred at 665 and 675 nm wavelengths (48). To better understand the underlying mechanism of laser interaction with periodontal tissue, further research on different cell types is necessary.

In this study, only the effect of low-power laser on chronic periodontitis and in patients with type 2 diabetes was investigated, and patients with type 1 diabetes or other types of periodontal diseases were not included in our study. In the next step, the change in laser settings and CP classification caused a bias in the results. Furthermore, long-term evidence of 12 months or longer was not included in the studies. Consequently, high-quality, well-designed RCTs with larger sample sizes are needed to precisely address some of these limitations.

5. Conclusion

Diode laser irradiation with SRP during 3 and 6 months led to more changes in HbA1C levels. Low level lasers can be used well in non-surgical periodontal treatment in type 2 diabetic patients.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Daniel R GS, Shanmugasundaram N, Lakshmigandhan M, Kavin T. Diabetes and periodontal disease. J Pharm Bioallied Sci. 2012; 4 (Suppl 2): S280-S2.

[2] Newman M TH, Klokkevold P. Carranza's Clinical Periodontology. 12 ed. Carranza F, editor. St. Louis, Missouri: Elsevier; 2012.

[3] Ruospo M PS, Craig JC, Gentile G, Johnson DW, Ford PJ, et al. Prevalence and severity of oral disease in adults with chronic kidney disease: a systematic review of observational studies. Nephrol Dial Transplant. 2014; 29 (2)364-75.

[4] Kawar N GP, Hart TC, Nouneh R, Maniar N, Alrayyes S. Periodontal disease for the primary care physician. Dis Mon. 2011; 57 (4): 174-83.

[5] Hugoson A, Jordan T. Frequency distribution of individuals aged 20–70 years according to severity of periodontal disease. Community Dentistry and Oral Epidemiology. 1982;10(4):187-92.

[6] Listgarten MA. Nature of periodontal diseases: pathogenic mechanisms. Journal of periodontal research. 1987;22(3):172-8.

[7] Wang T-F, Fang C-H, Hsiao K-J, Chou C. Effect of a comprehensive plan for periodontal disease care on oral health-related quality of life in patients with periodontal disease in Taiwan. Medicine. 2018;97(5).

[8] Cobb CM. Lasers and the treatment of periodontitis: the essence and the noise. Periodontology 2000. 2017 Oct;75(1):205-95.

[9] Carranza FA NM, Glickman I. Clinical periodontology. 8th ed. London :W.B.Saunders; 2015. p. 455- 61.

[10] Gutknecht N, Raoufi P, Franzen R, Lampert F. Reduction of Specific Microorganisms in Periodontal Pockets with the Aid of an Nd: YAG Laser-An In Vivo Study. Journal of Oral Laser Applications. 2002;2(3).

[11] Konradsson K, Claesson R, Van Dijken JW. Dental biofilm, gingivitis and interleukin-1 adjacent to approximal sites of a bonded ceramic. Journal of clinical periodontology. 2007;34(12):1062-7.

[12] Wyman A, Duffy S, Sweetland HM, Sharp F, Rogers K. Preliminary evaluation of a new high power diode laser. Lasers in surgery and medicine. 1992;12(5):506-9.

[13] Dengizek Eltas S, Gursel M, Eltas A, Alptekin NO, Ataoglu T. Evaluation of long-term effects of diode laser application in periodontal treatment of poorly controlled type 2 diabetic patients with chronic periodontitis. International Journal of Dental Hygiene. 2019;17(4):292-9.

[14] Özberk SS, Gündoğar H, Özkaya M, Taner İ L, Erciyas K. The effect of photobiomodulation therapy on nonsurgical periodontal treatment in patients with type 2 diabetes mellitus: a randomized controlled, single-blind, split-mouth clinical trial. Lasers Med Sci. 2020;35(2):497-504.

[15] Al-Zawawi AS, Bukhari IA, Bello-Correa FO, Sheikh SA, Albaijan R, Vohra F. Influence of root debridement with adjunct photodynamic therapy on periodontal parameters and gingival crevicular fluid cortisol levels among patients with and without type-2 diabetes mellitus. Photodiagnosis Photodyn Ther. 2020;32:102076.

[16] Castro Dos Santos N, Andere N, Miguel MMV, Dos Santos LM, Santamaria M, Jr., Mathias IF, et al. Photobiomodulation for the treatment of periodontal pockets in patients with type 2 diabetes: 1-year results of a randomized clinical trial. Lasers Med Sci. 2019;34(9):1897-904.

[17] Cao R, Li Q, Wu Q, Yao M, Chen Y, Zhou H. Effect of non-surgical periodontal therapy on glycemic control of type 2 diabetes mellitus: a systematic review and Bayesian network meta-analysis. BMC oral health. 2019;19(1):1-14.

[18] Demirturk-Gocgun O, Baser U, Aykol-Sahin G, Dinccag N, Issever H, Yalcin F. Role of low-level laser therapy as an adjunct to initial periodontal treatment in type 2 diabetic patients: a split-mouth, randomized, controlled clinical trial. Photomedicine and laser surgery. 2017;35(2):111-5.

[19] Koçak E, Sağlam M, Kayış SA, Dündar N, Kebapçılar L, G Loos B, et al. Nonsurgical periodontal therapy with/without diode laser modulates metabolic control of type 2 diabetics with periodontitis: a randomized clinical trial. Lasers in medical science. 2016;31(2):343.53-

[20] Roncati M, Gariffo A. Systematic review of the adjunctive use of diode and Nd: YAG lasers for nonsurgical periodontal instrumentation. Photomedicine and laser surgery. 2014;32(4):186-97.

[21] Cumpston M, Li T, Page MJ, Chandler J, Welch VA, Higgins JP, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. Cochrane Database Syst Rev. 2019;10(10.1002):14651858.

[22] Cai J ZQ, Hu Y, Liu B, Zhan C. Effect of periodontal initial therapy combined with semiconductor laser assisted therapy on the patients with chronic periodontitis with type 2 diabetes mellitus. Contemp Med Symp. 2018;16(11):26–28.

[23] Chandra S, Shashikumar P. Diode laser-a novel therapeutic approach in the treatment of chronic periodontitis in type 2 diabetes mellitus patients: a prospective randomized controlled clinical trial. Journal of Lasers in Medical Sciences. 2019;10(1):56.

[24] Feng C SX, Sun Y, Lu XY, Chen P, Xu Y, Gui Y. Effects of diode laser on the treatment for chronic periodontitis patients with type 2 diabetes mellitus. Stomatology. 2018; 38(3):237–240.

[25] Li M Z, Zhu S, Li R. Effect of low level laser treatment on metabolic control and high-sensitivity C-reactive protein of type 2 diabetes mellitus combined chronic peridontitis patients. Int J Biomed Eng. 2016; 1:24–27.

[26] Caruso U, Nastri L, Piccolomini R, d'Ercole S, Mazza C, Guida L. Use of diode laser 980 nm as adjunctive therapy in the treatment of chronic periodontitis. A randomized controlled clinical trial. New Microbiol. 2008;31(4):513-8.

[27] Harris DM, Yessik M. Therapeutic ratio quantifies laser antisepsis: ablation of Porphyromonas gingivalis with dental lasers. Lasers in surgery and medicine. 2004;35(3):206-13.

[28] Sgolastra F, Severino M, Gatto R, Monaco A. Effectiveness of diode laser as adjunctive therapy to scaling root planning in the treatment of chronic periodontitis: a meta-analysis. Lasers in medical science. 2013;28(5):1393-402.

[29] Slot DE, Jorritsma KH, Cobb CM, Van der Weijden FA. The effect of the thermal diode laser (wavelength 808–980 nm) in non-surgical periodontal therapy: a systematic review and meta-analysis. Journal of clinical periodontology. 2014;41(7):681-92.

[30] Kaviani A, Djavid GE, Ataie-Fashtami L, Fateh M, Ghodsi M, Salami M, et al. A randomized clinical trial on the effect of low-level laser therapy on chronic diabetic foot wound healing: a preliminary report. Photomedicine and laser surgery. 2011;29(2):109-14.

[31] Park JJ, Kang KL. Effect of 980-nm GaAlAs diode laser irradiation on healing of extraction sockets in streptozotocin-induced diabetic rats: a pilot study. Lasers in medical science. 2012;27(1):223-30.

[32] Mizutani K, Aoki A, Coluzzi D, Yukna R, Wang CY, Pavlic V, et al. Lasers in minimally invasive periodontal and peri-implant therapy. Periodontology 2000. 2016;71(1):185-212.

[33] Saglam M, Kantarci A, Dundar N, Hakki SS. Clinical and biochemical effects of diode laser as an adjunct to nonsurgical treatment of chronic periodontitis: a randomized, controlled clinical trial. Lasers in medical science. 2014;29(1):37-46.

[34] Silveira PC, da Silva LA, Fraga DB, Freitas TP, Streck EL, Pinho R. Evaluation of mitochondrial respiratory chain activity in muscle healing by low-level laser therapy. Journal of Photochemistry and Photobiology B: Biology. 2009;95(2):89-92.

[35] Darré L, Vergnes J-N, Gourdy P, Sixou M. Efficacy of periodontal treatment on glycaemic control in diabetic patients: a meta-analysis of interventional studies. Diabetes & metabolism. 2008;34(5):497-506.

[36] Qadri T, Javed F, Johannsen G, Gustafsson A. Role of diode lasers (800–980 nm) as adjuncts to scaling and root planing in the treatment of chronic periodontitis: a systematic review. Photomedicine and laser surgery. 2015;33(11):568-75.

[37] Chambrone L, Ramos UD, Reynolds MA. Infrared lasers for the treatment of moderate to severe periodontitis: an American Academy of Periodontology best evidence review. Journal of Periodontology. 2018;89(7):743-65.

[38] Moritz A, Gutknecht N, Doertbudak O, Goharkhay K, Schoop U, Schauer P, et al. Bacterial reduction in periodontal pockets through irradiation with a diode laser: a pilot study. Journal of clinical laser medicine & surgery. 1997;15(1):33-7.

[39] Kreisler M, Al Haj H, d'Hoedt B. Clinical efficacy of semiconductor laser application as an adjunct to conventional scaling and root planing. Lasers in Surgery and Medicine: The Official Journal of the American Society for Laser Medicine and Surgery. 2005;37(5):350-5.

[40] Hakki SS, Bozkurt SB. Effects of different setting of diode laser on the mRNA expression of growth factors and type I collagen of human gingival fibroblasts. Lasers in medical science. 2012;27(2):325-31.

[41] Cheng Y, Chen J, Ge M, Zhou Z, Yin X, Zou S. Efficacy of adjunctive laser in non-surgical periodontal treatment: a systematic review and meta-analysis. Lasers in medical science. 2016;31(1):151-63.

[42] Fernandes-Dias SB, de Marco AC, Santamaria Jr M, Kerbauy WD, Jardini MA, Santamaria MP. Connective tissue graft associated or not with low laser therapy to treat gingival recession: randomized clinical trial. Journal of Clinical Periodontology. 2015;42(1):54-61.

[43] Makhlouf M, Dahaba MM, Tunér J, Eissa SA, Harhash TA-H. Effect of adjunctive low level laser therapy (LLLT) on nonsurgical treatment of chronic periodontitis. Photomedicine and laser surgery. 2012;30(3):160-6.

[44] Hennessy M, Hamblin MR. Photobiomodulation and the brain: a new paradigm. Journal of optics. 2016;19(1):013003.

[45] Armitage GC. Development of a classification system for periodontal diseases and conditions. Annals of periodontology. 1999;4(1):1-6.

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

[47] Avci P, Gupta A, Sadasivam M, Vecchio D, Pam Z, Pam N, et al., editors. Low-level laser (light) therapy (LLLT) in skin: stimulating, healing, restoring. Seminars in cutaneous medicine and surgery; 2013: NIH Public Access.

[48] Moore P, Ridgway TD, Higbee RG, Howard EW, Lucroy MD. Effect of wavelength on low-intensity laser irradiation-stimulated cell proliferation in vitro. Lasers in Surgery and Medicine: The Official Journal of the American Society for Laser Medicine and Surgery. 2005;36(1):8-12.