








The use of diode lasers in non-surgical therapy of periodontitis

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Abstract

Introduction. Periodontitis is a disease of multifactorial etiology and complex clinical manifestation. Removal of subgingival bacterial biofilm is a fundamental procedure in the treatment of periodontitis. Scaling and root planing (SRP) is currently the gold standard in the treatment of periodontitis, but in some cases such a procedure does not provide satisfactory results. The use of lasers in the treatment of periodontitis is one of the alternative adjunctive methods that has recently become more popular.

Objective. The aim of the study was to evaluate the effectiveness of diode lasers in the treatment of periodontitis, based on the literature found in the Medline, Pubmed and Scopus databases published from June 2013 – June 2020. Results were based on a comparison of the effectiveness of SRP treatment in combination with photodynamic therapy or SRP in combination with laser irradiation of periodontal pockets.

Results. The majority of studies confirmed the effectiveness of periodontal treatment combining SRP with photodynamic therapy or SRP with laser irradiation, compared to an SRP alone.

Conclusions. Based on the recent literature, it can be concluded that SRP combined with photodynamic therapy or SRP in combination with a diode laser irradiation are effective methods to improve the outcomes of non-surgical periodontal treatment.

Key words

aPDT, PDT, periodontal treatment, photodynamic therapy, SRP

INTRODUCTION

Periodontitis is an inflammatory disease that affects tooth-supporting tissues [1]. The etiology of periodontitis is complex, involving primarily the interplay between subgingival bacterial biofilm and the immune response of the host. Symptoms of periodontitis depend on the interaction between environmental and genetic factors. Pro-inflammatory mediators (IL-1, IL-6, TNF) released in response to Gram-negative bacteria (periopathogens) present in subgingival biofilm, trigger inflammation in periodontal tissues [2]. The progressive disease process leads to the destruction of tooth-supporting tissues, and, consequently, tooth loss [3].

Scaling and root planing (SRP) is a basic procedure in the treatment of periodontitis that aims at the removal of the subgingival biofilm. SRP results in the resolution of inflammation and healing of periodontal pockets, mainly by formation of a long epithelial junction. Clinical effectiveness of this technique is well-documented and nowadays SRP is the ‘gold standard’ in the treatment of periodontitis [4, 5]. Unfortunately, sometimes clinical improvement is insufficient, which may result from local conditions, such as pocket depth or tooth furcation area, as the accuracy of subgingival instrumentation decreases with the increase of

the probing depth (PD) [6, 7]. An additional problem is the increasing resistance of subgingival microorganisms to the antimicrobials used locally or systemically as an adjunct to SRP. These factors contributed to the need for alternative methods in the non-surgical treatment of periodontitis.

The use of lasers has been reported for many years as a method complementary to standard procedures in the treatment of periodontitis [8]. However, there is still much controversy about their effectiveness. Diode lasers with a wavelength of 630–690 nm, 805 nm, 808–810 nm, can be used for antibacterial photodynamic therapy (aPDT), while diode lasers with a wavelength of 940 nm or 980 nm are used in bacterial decontamination, soft tissue curettage in periodontal pockets, and photobiomodulation therapy.

OBJECTIVE

The aim of this review article was to evaluate the effectiveness of the diode lasers in the treatment of periodontitis, based on the literature found in the Medline, Pubmed and Scopus databases published over the last seven years. Taken into account were the research studies that analysed the effectiveness of SRP treatment in combination with photodynamic therapy or SRP in combination with laser irradiation of periodontal pockets, in comparison to SRP alone. Databases were searched by using the following keywords: ‘diode laser and periodontitis’, ‘diode laser and periodontal therapy’, ‘photodynamic therapy and periodontitis’.

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Antimicrobial photodynamic therapy. Antimicrobial photodynamic therapy is a form of phototherapy that utilizes light and a photosensitizer used in conjunction with molecular oxygen to cause cell death. In periodontal treatment, it aims to reduce the number of periopathogens. A photosensitizer is activated by an appropriate light length emitted by a low power laser 630–690 nm or a light emitting diode (LED) lamp. Toluidine blue is the most commonly used photosensitizer in the treatment of periodontitis, this is due to high effectiveness against Gram (-) and (+) bacteria [9, 10]. Depending on the oxygen availability in the environment and the photosensitizer used, two types of reactions can occur. At low oxygen concentrations, free radicals are formed, i.e. superoxide radical (O₂), hydroxyl radical (OH), hydroxide radical (HO₂) and hydrogen peroxide (H₂O₂) which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which contributes to the increased permeability of bacterial cell membranes mediating cell death. When using toluidine blue

as a photosensitizer, the second type of reaction is primarily induced [9]. Single deep periodontal pockets (>5 mm) which did not react properly to mechanical instrumentation are the indication for the use of aPDT in periodontal treatment (1). An additional benefit of using aPDT is the lack of adverse effects on dentine, pulp and alveolar bone [11].

Several studies analysing the effectiveness of non-surgical treatment supplemented with photodynamic therapy were found during the database search (Tab. 1). It was shown that application of aPDT as supportive treatment had a beneficial effect on both clinical and microbiological parameters. The improvement was observed in the probing depth (PD), clinical attachment level (CAL), gingival index (GI) and bleeding on probing (BOP) levels, but there was also a reduction in the number of periodontal bacteria *A. actinomycetemcomitans*, *T. forsythia*, *P. gingivalis* [12, 13, 14, 15]. A very recent randomized clinical trial in 2020 showed significant improvement of PD and CAL after aPDT, in comparison to SRP alone [16]. It was also demonstrated that SRP plus aPDT

Table 1. The use of PDT in the treatment of periodontitis – a summary of clinical studies

Author	Type of study	Study groups	Study outcomes	Study duration	Laser parameters	Results
Balata et al. 2013 (22)	Randomized control clinical trial	22 patients aged 31-62	PD, BOP, CAL	6 months	Diode laser 660 nm, methylene blue	No significant benefits of aPDT in comparison to patients who receive full-mouth ultrasonic debridement alone compared to SRP alone
Arweiler et al. 2013 (24)	Randomized control clinical study	36 patients aged 23-55	PD, CAL, BOP, PI	3 months	Diode laser 660 nm, phenothiazine chloride	Larger number of residual pockets after treatment in aPDT in comparison to patients who receive systemic antibiotic treatment
Chitsazi et al. 2015 (21)	Randomized clinical study	24 patients	PD, BOP	3 months	Diode laser 670-690 nm, a power of 75 mW, toluidine blue	No statistically significant improvement in PD after treatment aPDT as compared to SRP alone
Skurska et al. 2015 (25)	Randomized clinical trial	36 patients aged 30-60	Levels of MMP-8 and MMP-9 in GCF	6 months	Diode laser 660 nm, HELBO® Blue Photosensitizer	Significant decrease of MMP8 and MMP9 in patients who additionally received systemic antibiotic therapy compared to SRP + aPDT
Kastriot Meqa et al. 2016 (12)	Randomized double-blind prospective study	50 patients aged 20-50	PD, CAL, GR, GI, BOP	2 months	Diode laser 660 nm, power of 100 mW, phenothiazine chloride	Greater improvement in PD, CAL, GI and BoP parameters using aPDT compared to SRP alone
Sheedhar Annaji et al. 2016 (14)	Randomized clinical trial, split-mouth design study	15 patients aged 18-35	PI, BOP, PD, RAL	3 months	Diode laser 810 nm, toluidine blue 1 mg/ml	With increase of treatment time, the highest decrease in the periodontal indicators (PI, PD, BOP) compared to SRP alone and SRP + diode laser
Abbas Monzavi et al. 2016 (13)	Randomized clinical trial	50 patients aged >35	PD, BOP, CAL, PI, FMBS, FMPS	3 months	Diode laser 810 nm, a power of 200 mW, indometacin green	Combining SRP and aPDT results in a significant improvement in PD, BOP and FMBS in comparison to SRP alone
Vohra et al. 2018 (18)	Randomized control clinical trial	53 patients	BOP, CAL, PD, PI, GCF	12 weeks	Diode laser 670nm, methylene blue	Significant improvement in clinical and immunological parameters after treatment with aPDT and SRP compared to SRP alone
Soares et al. 2019 (23)	Randomized clinical trial, split-mouth design study	20 patients aged 39-61	BOP, CAL, PD, PI, GCF	90 days	Diode laser 660nm, a power of 70 mW, phenothiazine chloride	Combining SRP and aPDT did not promote additional clinical, immunological, and microbiological benefits in smokers with chronic periodontitis compared to SRP alone
Deumer et al. 2019 (19)	Randomized clinical trial, split-mouth design study	20 patients aged 30-70	aMMP-8 in GCF, PD, BOP	4 weeks	Diode laser 820nm, a power between 200 and 300 nW, photothermic dye was infracyanin green	Larger decrease of the aMMP-8 and PD after treatment with aPDT in comparison to control group
Al Habashneh et al. 2019 (20)	Randomized clinical trial, split-mouth design study	16 patients aged 30-60	PI, GR, BOP, PD, CAL, IL-1 β level in GCF	6 months	Red LED light system of wavelength of 635 nm, toluidine blue	Significant improvement after SRP + aPDT of clinical parameters, aPDT treatment had no effects on the level of expression of IL-1 β compared to SRP alone
Joshi et al. 2020 (16)	Randomized clinical trial	29 patients aged 30-60	PI, mSBI, PD, CAL	3 months	Diode laser with wavelength of 810 nm, power 0.2 W with indocyanine green 1mg/ml	Significant reduction in clinical parameters (PI, mSBI, PD, CAL) in both groups, statistically significant improvement in PD and CAL after SRP + aPDT compared to SRP alone

PD – probing depth; BoP – bleeding of probing; PI – plaque index; mSBI – modified sulcus bleeding index; GR – gingival recession; CAL – clinical attachment level; RAL – Relative Attachment Level; GCF – gingival crevicular fluid; IL-1 β – interleukine 1 β ; aMMP-8 – active matrix-metaloproteinase-8; FMBS – full mouth bleeding score; FMPS – full mouth plaque score.

resulted in the decrease of BoP, gingival pain and halitosis in comparison to SRP alone, but the difference was only short-term [17]. Vohra et al. showed significant improvement in clinical and immunological parameters in obese patients with chronic periodontitis after treatment with SRP and aPDT, compared to SRP alone [18]. The study performed by Deumer et al. showed a higher decrease of the MMP-8 in GCF, and statistically significant improvement in PD after aPDT application, compared to SRP alone [19]. Another clinical study showed improvement of clinical parameters after SRP and aPDT treatment, but no effects on the levels of IL-1 β was observed [20]. In contrast to these studies, others failed to demonstrate any statistically significant microbiological or clinical periodontal improvement when aPDT was additionally used with SRP in comparison to SRP alone [21, 22]. Also, Soares et al. confirmed no statistically significant immunological, microbiological or clinical periodontal improvement after combining SRP and aPDT in smokers with chronic periodontitis [23]. SRP supplemented with aPDT in patients with aggressive periodontitis resulted in a higher number of residual periodontal pockets after treatment, in comparison to systemic antibiotic therapy [24], and a lower decrease in the MMP8 and MMP9 in gingivocrevicular fluid (GCF) [25]. aPDT can also be used in the treatment of peri-implantitis with toluidine blue as a photosensitizer [1]. A clinical study showed a greater reduction of periopathogens around implants affected by peri-implantitis in the patients who underwent aPDT [26]. Several studies also confirmed the positive effect of aPDT on osseointegration as an additional procedure in the GBR technique [27].

Laser therapy. Laser irradiation is one of the methods that can supplement the mechanical debridement of the root surface in the treatment of periodontitis. Some types of lasers can be used as an alternative monotherapy for conventional treatments (Er:YAG, Er,Cr:YSSG), or as adjunctive therapy in combination with SRP (Nd:YAG, diode laser). The combination of Er:YAG and Nd:YAG lasers gives significant improvement in clinical parameters; additionally, considerable reduction of bacteria are demonstrated after connection Nd:YAG laser with oxidative disinfectant (0.5% NaOCl or H₂O₂) [28,29,30]. Research has shown notable reductions in *Candida albicans* and *Streptococcus mutans* and their metabolism after Nd:YAG laser irradiation [31]. Diode lasers in periodontology can also be used for gingivectomy/gingivoplasty of hypertrophic gingiva. A high relief of pain was also confirmed in orthodontic treatment of patients after application of a diode laser with wavelength 635 nm [34]. Photobiomodulation (PBM) is especially indicated in the treatment of patients at risk of bacteremia or with immune deficiency [28]. The advantages of using lasers in the treatment of periodontitis include bactericidal effect and photobiomodulation that results in local reduction of periopathogens, reduction of post-operative pain and swelling, reduced amount of anaesthetics during the procedure, as well as a reduced need for pharmacological treatment after procedure [28, 29]. In addition, the use of the laser improves access to the deep and narrow periodontal pockets, the bi- and tri-furcation area, and increases the visibility in the operating area by reducing bleeding.

Several studies have been performed to assess the effectiveness of diode laser irradiation in the treatment of

periodontitis (Tab. 2). As clinical trials differed in terms of the study design, the wavelength of the laser and method of application, different results were obtained. Some studies showed that the additional use of a diode laser 980 nm provided statistically significant benefits in terms of clinical parameters PD, BOP and CAL, and a decrease in the number of periopathogens *A. actinomycetemcomitans* and *P. gingivalis*, in comparison to SRP alone [13, 33, 35, 36, 37]. Another study confirmed that the highest PD reduction was observed after the use of SR, in comparison to diode laser decontamination and SRP alone [38]. Only one clinical study showed no clinical difference when LLLT was additional used with SRP in comparison to SRP alone [39]. It was also demonstrated that non-surgical treatment, additionally supplemented with low energy laser irradiation, produced better results than SRP due to the photobiomodulation effect. LLLT can be used as an effective SRP support therapy helping to improve clinical parameters and promote resolution of inflammation [14, 40, 41, 42]. It was shown that a combination of Er, Cr: YSGG (2780 nm) laser used for pocket debridement, followed by a diode laser (940 nm), resulted in a statistically significant improvement in PD and a faster remineralization of bone defects [43]. Another clinical study demonstrated that in e patients with chronic periodontitis and type II diabetes treated with LLLT, a significant improvement in BOP and PD was achieved [44]. Photoactivation of hydrogen peroxide with 940 nm diode laser is a newly-described method [45]. A pilot study demonstrated statistically significant antimicrobial and clinical effects when SRP was followed by laser irradiation, especially in the presence of 3% hydrogen peroxide in the treated pockets. Together, these results suggest that diode laser irradiation is an effective type of therapy supporting SRP and helping to obtain better outcomes, compared to SRP alone.

CONCLUSIONS

Based on literature from the last seven years, it can be concluded that SRP combined with photodynamic therapy or SRP in combination with a diode laser irradiation are effective methods to improve the outcomes of non-surgical periodontal treatment. Among the analysed works, only two out of eleven did not confirm the effectiveness SRP in combination with diode laser; for comparison, five out of thirteen analysed works did not confirm the effectiveness of SRP in combination with aPDT. PBM resulted in a significant decrease of periopathogens and an additional reduction of periodontal pocket depth. The use of the diode laser in periodontal treatment is a method that supports conventional non-surgical therapy. The advantages of using lasers in the treatment of periodontitis include bactericidal effect, photobiomodulation, reduction of post-surgical pain and swelling. An additional benefit of laser therapy is the high acceptance by patients. Safety of use and potential benefits of laser therapy encourage its use in various areas of dentistry. However, it is worth mentioning that the European Federation of Periodontology (EFP) at present does not recommend the routine use of lasers as adjuncts to subgingival instrumentation, based on the five RCTs (n = 121, wavelength range 660–670 nm and 800–900 nm), with single aPDT application reporting 6-month outcomes [46]. The quality of evidence in this area is still low, mainly due to

Table 2. The effectiveness of diode laser irradiation in the treatment of periodontitis – a summary of clinical studies

Author	Type of study	N	Studied parameters	Duration	Laser parameters	Results
Mirjana Gojkov-Vukelic et al. 2013 (33)	Randomized clinical trial	24	Microbiological assessment of the number of bacteria	3 mo	Diode laser 980 nm, a power of 2.0 W, 5 sec per site, inside the pocket	Significant decrease in periopathogenes after LLLT compared to SRP alone
Üstün et al. 2014 (40)	Randomized clinical trial, split-mouth design study	21	Clinical parameters and IL-1 β level in the gingival fluid	6 mo	Diode laser 810 nm, a power of 2,5 W, pulsed mode	Greater improvement in clinical parameters and IL-1 β level in the gingival fluid after LLLT compared to SRP alone
Kachapilly et al. 2016 (38)	Clinical study	15	PI, GI, PD, CAL	3 mo	Diode laser 810 nm, a power of 0.5 W, 10 sec per site, inside the pocket	Additional use of LLLT after SRP did not provide any significant clinical improvement compared to SRP alone
Suryakanth Malgikar et al. 2016 (37)	Randomized controlled clinical trial, split-mouth design study	24	PI, GI, mSBI, PD, CAL	6 mo	Diode laser 980 nm, non-contact use at the gingival margin at a distance of approximate 1–2 mm, 1.5 W, continuous wave	Improvement in clinical parameters with LLLT compared to SRP alone
Meseli et al. 2017 (39)	Randomized clinical trial	11	PI, PD, CAL, BOP, GCF volume	19 weeks	Diode laser 810 nm, 1 W, inside the pocket	LLLT as an adjunct to mechanical treatment have no additional effects on clinical parameters and GCF volume compared to SRP alone
Demirturk-Gocgun et al. 2017 (44)	Randomized controlled clinical trial, split-mouth design study	22	PI, PD, BOP, CAL	3 mo	Diode laser 808 nm, 4.46 J/cm ²	Use of LLLT brings additional benefit in the treatment of deep pockets compared to SRP alone
Petrović et al. 2018 (35)	Randomized clinical trial	60	Microbiological and clinical assessment, CAL, BI, PI	1 mo	Diode lasers 980 nm, 0.2 W, 6 J/cm ²	LLLT as an adjunct to periodontal therapy demonstrates additional bacteriological, cytological and clinical benefits compared to SRP alone
Chandra and Shashikumar 2019 (41)	Randomized control clinical trial	36	PI, GI, CAL, PD, HbA1c, colony count of <i>A.a.</i> and <i>P.g.</i>	3 mo	Diode laser 808 nm, 1.5-1.8 W, continuous wave	Statistically significant improvement in clinical and microbiological parameters after LLLT compared to SRP alone
Manjunath et al. 2020 (36)	Randomized clinical trial	40	OHI, CAL, PD, BOP	12 weeks	Diode laser 980 nm, 2.0 W	Significant decrease in clinical parameters after LLLT compared to SRP alone
Odor et al. 2020 (45)	Randomized controlled trial, split-mouth design	38	PD, CAL, BOP, microbiological assessment included nine bacterial species (<i>A.a.</i> , <i>P.g.</i> , <i>T.f.</i> , <i>T.d.</i> , <i>P.i.</i> , <i>P.m.</i> , <i>F.n.</i> , <i>E.n.</i> , <i>C.g.</i>)	3 mo	Diode laser 940 nm, power 1.1 W, 30 sec. per site, inside the pocket	Significant bacterial reduction of <i>P.g.</i> , <i>T.f.</i> , <i>T.d.</i> , <i>P.i.</i> , <i>P.m.</i> , <i>F.n.</i> , <i>E.n.</i> and decrease in clinical parameters (PD, CAL, BOP) after SRP + photoactivation of H ₂ O ₂ with laser compared to SRP alone and SRP + diode laser.

PD – probing depth; BOP – bleeding of probing; PI – plaque index; mSBI – modified sulcus bleeding index; CAL – clinical attachment level; GCF – gingival crevicular fluid; GI – gingival index; BI – bleeding index; OHI – oral hygiene index; IL-1 β – interleukine 1 β ; IL-37 – interleukine 37; HbA1c – haemoglobin A1c; *A.a.* – Aggregatibacter actinomycetemcomitans; *P.g.* – Porphyromonas gingivalis; *T.f.* – Tanerella forsythia; *T.d.* – Treponema denticola; *P.i.* – Prevotella intermedia; *P.m.* – Peptostreptococcus micros; *F.n.* – Fusobacterium nucleatum; *E.n.* – Eubacterium nodatum; *C.g.* – Capnocytophaga gingivalis; H₂O₂ – hydrogen peroxide.

differences in terms of laser type, tip diameter, wavelength, mode of periodontal treatment, number of treated sites, population, and several possible combinations of these parameters. EFP claims that guidelines will change when more evidence becomes available. Further studies will help to define the best protocol of laser application during non-surgical treatment to achieve long-term effects.

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