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

Małgorzata Majka Kulińska-Michalska1A-D, Natalia Ćwiklińska1B-D, Magda Lisiecka1A-G, Patrycja Czaplicka-Szydlik1A-G, Natalia Lewkowicz1A-E-F

1 Department of Periodontology and Oral Disease, Medical University, Łódź, Poland
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of article

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 940–980 nm are 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 he 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’.
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 peroxyde (H2O2) which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which destroy cell membranes, enzymes and DNA (9). In an oxygen-rich environment, singlet oxygen is formed which destroy cell membranes, enzymes and DNA (9).

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

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

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-1β – interleukine 1β; 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 Deumert 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-1β 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 periopathogenes 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:YSGG), 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 periopathogenes, 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 periopathogenes 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 irradiatio, 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 periopathogenes 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
Diode laser 808 nm, 1.5-1.8 W, N

**Type of study**

Microbiological study

**Diode lasers 980 nm, 0.2 W, 6 J/23 mo**

**Diode laser 940 nm, power 1.1 W,**

**Diode laser 980 nm, a power of 2.5 W, pulsed mode**

Use of LLLT brings additional benefit in the surgical treatment to achieve long-term effects.

**Author**

Kachapilly et al. 2016 (38)

Suryakanth Malgikar et al. 2016 (37)

Meseli et al. 2017 (39)

Demirturk-Gocgun et al. 2017 (44)

Petrović et al. 2018 (35)

Chandra and Shashikumar 2019 (41)

Manjunath et al. 2020 (36)

Odor et al. 2020 (45)

**N**

15

24

21

24

11

22

60

36

40

38

**Duration**

3 mo

6 mo

19 weeks

3 mo

1 mo

3 mo

12 weeks

**Laser parameters**

Diode laser 880 nm, 4.46 J/cm²

Diode laser 980 nm, 0.2 W, 6 J/cm²

Diode laser 808 nm, 1.5-1.8 W, continuous wave

Diode laser 980 nm, 2.0 W, 0.5 sec per site, inside the pocket

Diode laser 940 nm, power 1.1 W, inside the pocket

Diode laser 980 nm, 2.5 W, pulsed mode

Diode laser 940 nm, power 1.1 W, 30 sec per site, inside the pocket

**Results**

Additional use of LLLT after SRP did not provide any significant clinical improvement compared to SRP alone

Improvement in clinical parameters with LLLT compared to SRP alone

LLLT as an adjunct to mechanical treatment have no additional effects on clinical parameters and GCF volume compared to SRP alone

Use of LLLT brings additional benefit in the treatment of deep pockets compared to SRP alone

LLLT as an adjunct to periodontal therapy demonstrates additional bacteriological, cytological and clinical benefits compared to SRP alone

Statistically significant improvement in clinical and microbiological parameters after LLLT compared to SRP alone

Significant decrease in clinical parameters after LLLT compared to SRP alone

Significant bacterial reduction of P.g., T.d., P.i., P.m., F.n., E.n.

Greater improvement in clinical parameters compared to SRP alone

Additional use of LLLT after SRP did not demonstrate additional bacteriological, cytological and clinical benefits compared to SRP alone

**References**


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

<table>
<thead>
<tr>
<th>Author</th>
<th>Type of study</th>
<th>N</th>
<th>Studied parameters</th>
<th>Duration</th>
<th>Laser parameters</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mirjana Gjokov-Vukelic et al. 2013 (33)</td>
<td>Randomized clinical trial</td>
<td>24</td>
<td>Microbiological assessment of the number of bacteria</td>
<td>3 mo</td>
<td>Diode laser 980 nm, a power of 2.0 W, 0.5 sec per site, inside the pocket</td>
<td>Significant decrease in periopathogenes after LLLT compared to SRP alone</td>
</tr>
<tr>
<td>Üstün et al. 2014 (40)</td>
<td>Randomized clinical trial, split-mouth design study</td>
<td>21</td>
<td>Clinical parameters and IL-1β level in the gingival fluid</td>
<td>6 mo</td>
<td>Diode laser 810 nm, a power of 2.5 W, pulsed mode</td>
<td>Greater improvement in clinical parameters and IL-1β level in the gingival fluid after LLLT compared to SRP alone</td>
</tr>
<tr>
<td>Kachapilly et al. 2016 (38)</td>
<td>Clinical study</td>
<td>15</td>
<td>PI, GI, PD, CAL</td>
<td>3 mo</td>
<td>Diode laser 810 nm, a power of 0.5 W, 10 sec per site, inside the pocket</td>
<td>Additional use of LLLT after SRP did not provide any significant clinical improvement compared to SRP alone</td>
</tr>
<tr>
<td>Suryakanth Malgikar et al. 2016 (37)</td>
<td>Randomized controlled clinical trial, split-mouth design study</td>
<td>24</td>
<td>PI, GI, mSBI, PD, CAL</td>
<td>6 mo</td>
<td>Diode laser 980 nm, non-contact use at the gingival margin at a distance of approximate 1–2 mm, 1.5 W, continuous wave</td>
<td>Improvement in clinical parameters with LLLT compared to SRP alone</td>
</tr>
<tr>
<td>Meseli et al. 2017 (39)</td>
<td>Randomized clinical trial</td>
<td>11</td>
<td>PI, PD, CAL, BOP, GCF volume</td>
<td>19 weeks</td>
<td>Diode laser 810 nm, 1 W, inside the pocket</td>
<td>LLLT as an adjunct to mechanical treatment have no additional effects on clinical parameters and GCF volume compared to SRP alone</td>
</tr>
<tr>
<td>Demirturk-Gocgun et al. 2017 (44)</td>
<td>Randomized controlled clinical trial, split-mouth design study</td>
<td>22</td>
<td>PI, PD, BOP, CAL</td>
<td>3 mo</td>
<td>Diode laser 808 nm, 4.46 J/cm²</td>
<td>Use of LLLT brings additional benefit in the treatment of deep pockets compared to SRP alone</td>
</tr>
<tr>
<td>Petrović et al. 2018 (35)</td>
<td>Randomized clinical trial</td>
<td>60</td>
<td>Microbiological and clinical assessment, CAL, BI, PI</td>
<td>1 mo</td>
<td>Diode lasers 980 nm, 0.2 W, 6 J/cm²</td>
<td>LLLT as an adjunct to periodontal therapy demonstrates additional bacteriological, cytological and clinical benefits compared to SRP alone</td>
</tr>
<tr>
<td>Chandra and Shashikumar 2019 (41)</td>
<td>Randomized controlled clinical trial</td>
<td>36</td>
<td>PI, GI, CAL, PD, HbA1c, colony count of A.a. and P.g.</td>
<td>3 mo</td>
<td>Diode laser 808 nm, 1.5-1.8 W, continuous wave</td>
<td>Statistically significant improvement in clinical and microbiological parameters after LLLT compared to SRP alone</td>
</tr>
<tr>
<td>Manjunath et al. 2020 (36)</td>
<td>Randomized clinical trial</td>
<td>40</td>
<td>OHI, CAL, PD, BOP</td>
<td>12 weeks</td>
<td>Diode laser 980 nm, 2.0 W</td>
<td>Statistically significant improvement in clinical parameters after LLLT compared to SRP alone</td>
</tr>
<tr>
<td>Odor et al. 2020 (45)</td>
<td>Randomized controlled clinical trial, split-mouth design study</td>
<td>38</td>
<td>PD, CAL, BOP, microbiological assessment included nine bacterial species (A.a., P.g., T.d., T.d., P.i., P.m., P.m., F.n., E.n., C.g.)</td>
<td>3 mo</td>
<td>Diode laser 940 nm, power 1.1 W, 30 sec per site, inside the pocket</td>
<td>Significant decrease in clinical parameters after LLLT compared to SRP alone</td>
</tr>
</tbody>
</table>

**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; **Bl** – bleeding index; **OHI** – oral hygiene index; **IL-1β** – interleukine 1β; **IL-37** – interleukine 37; **HbA1c** – haemoglobin A1c; **A.a.** – Aggregatibacter actinomycetemcomitans; **Pg.** – Porphyromonas gingivalis; **T.f.** – Tannerella 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.


Odor AA, Bechir ES, Forna DA. Effect of Hydrogen Peroxide Irrigation on Periodontal Pathogens: An In Vitro Study. doi:10.1089/photob...