Role of Diode Lasers (800–980 Nm) as Adjuncts to Scaling and Root Planing in the Treatment of Chronic Periodontitis: A Systematic Review

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Abstract

Objective: The purpose of this study was to systematically review currently available evidence regarding the role of diode lasers (810–980 nm) as adjuncts to scaling and root planing (SRP) in the treatment of chronic periodontitis (CP).

Background data: Mechanical instrumentation of periodontal tissues followed by diode laser application leads to complete removal of pocket epithelium compared with conventional SRP.

Materials and methods: To address the focused question “Is SRP with adjunct diode lasers (810–980 nm) therapy more effective in the treatment of CP than when CP is treated by SRP alone?” databases were searched using the following key words: chronic periodontitis, diode laser, surgical, AND scaling and root planing, periodontal diseases, periodontal therapy, AND periodontal treatment. Original studies were included. Letters to the editor, case reports, commentaries, and reviews were excluded.

Results: Ten clinical studies were included. In all studies, patients were systemically healthy, and cigarette smokers were included in two studies. In five studies, SRP plus diode laser application was more effective in the treatment of CP than SRP, and three studies showed no difference. In two studies, there was a moderate reduction in periodontal inflammation using SRP plus diode laser. The diameter of optic fiber, laser wavelengths, power, pulse repetition rate, and duration of laser exposure ranged between 300 μm and 2 mm, 810–980 nm, 0.8–2.5 W, 10–60 Hz, and 10–100 ms, respectively.

Conclusions: In CP patients with probing depths ≤5 mm, diode lasers, SRP plus diode laser (800–980 nm) is more effective in the treatment of CP than when SRP is used alone.

Introduction

Traditionally, chronic periodontitis (CP) is treated by scaling and root planing (SRP) in which dental plaque and calculus deposits are removed from supra- and subgingival teeth and root surfaces using hand instruments (such as curettes and scalers). The primary function of scaling and root planing is to promote new connective tissue attachment around the teeth by removing the pocket lining and junctional epithelium. Although SRP reduces periodontal inflammation to an extent, this treatment approach is unable to completely eradicate periodontal disease. It has also been reported that the outcomes of SRP dependent on the manner in which SRP is performed. In a study, higher forces were shown to remove significantly more root substance.

An explanation for this is the incomplete removal of epithelium and persistence of periodontopathogenic bacteria (such as Aggregatibacter actinomycetemcomitans and Porphyromonas gingivalis) in sites (such as gingival epithelium) inaccessible by hand instruments. The not entirely successful long-term outcomes of SRP in the treatment of CP have put a focus on adjunctive treatment such as lasers or chemical plaque control.

Use of lasers is a modernization in clinical dentistry and research. A vast variety of dental lasers are commercially available, each having specific advantages. The diode laser is a semiconductor laser that generally includes a combination of gallium, arsenide, and other elements such as aluminum and indium to convert electrical energy into light energy. The wavelength of diode laser ranges between 800 and 980 nm. Because diode lasers do not affect dental hard tissues, they can be safely used for surgical interventions, including cutting and coagulating gingivae and soft tissue curettage. In a recent randomized, parallel, controlled clinical trial, Saglam et al. assessed the clinical
and biochemical efficacy of diode laser as an adjunct to SRP in the treatment of CP. In this study, 16 CP patients were treated with SRP alone, whereas 15 patients underwent SRP with adjunct 980 nm diode laser therapy. The 6-month follow-up results showed a significant reduction in plaque index, gingival index, bleeding on probing, probing depth, and clinical attachment level (CAL) in patients having undergone SRP with adjunct diode laser therapy as compared with patients who received SRP alone.16 In another study, Moritz et al.19 reported significant reduction in bacterial count and periodontal inflammation when 805 nm diode laser was used as an adjunct to SRP compared with when SRP was used as a sole therapeutic protocol for the treatment of CP. Moreover, Romanos et al.20 showed that that mechanical instrumentation of periodontal tissues followed by diode laser application led to complete removal of pocket epithelium compared with conventional SRP with curettes, which leaves significant epithelial remnants. These results16,19,20 suggest that SRP with adjunct diode laser therapy is a more promising treatment strategy for the treatment of CP than conventional SRP alone. In a recent systematic review and meta-analysis, Roncati and Gariffo21 demonstrated that diode laser, when used in an adjunctive capacity to SRP, may provide some additional benefit, in 6-month studies, compared with mechanical debridement. However, results by Krohn-Dale et al.22 failed to support that diode lasers as adjuncts may be superior to conventional debridement in the treatment of periodontal disease. Similar results were reported by Slot et al.23 and Sgolastra et al.24

Because there is a controversy over the efficacy of diode lasers as a useful adjunct to conventional SRP in the treatment of periodontal disease, the aim of the present study was to systematically review currently available evidence regarding the role of diode lasers (800–980 nm) as adjuncts to SRP in the treatment of CP.

Materials and Methods

Focused question

Based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, a specific question was constructed according to the Participants, Interventions, Control, Outcomes (PICO) principle.25 The addressed focused question was “Is SRP with adjunct diode laser (810–980 nm) therapy more effective in the treatment of CP than when CP is treated by SRP alone?”

(P) Participants: population of the study who underwent SRP with or without diode laser therapy

(I) Types of interventions: SRP with and without adjunct laser therapy

(C) Control Intervention: SRP alone

(O) Outcome measures: reduction in the severity of periodontal inflammatory parameters (such as plaque index, bleeding on probing, probing depth, and CAL).

Eligibility criteria

The eligibility criteria were (1) original articles, (2) clinical studies, (3) intervention; role of diode laser as adjunct to SRP in the treatment of CP, and (4) use of a control group (patients with CP receiving SRP alone). Case reports, commentaries, letters to the editor, review articles, and unpublished data were excluded.

Search protocol

In order to identify studies relevant to the PICO question, the MEDLINE® (Ovid) database, the EMBASE database, the Cochrane Central Register of Controlled Trials (CENTRAL), Scopus, Web of Knowledge, The Cumulative Index to Nursing and Allied Health Literature, and Google Scholar databases were electronically searched for available data. Databases were searched from 1986 up to and including June 2015 using different combinations of the following key words: chronic periodontitis, diode laser, surgical, AND periodontal diseases, periodontal.

quality of the studies included in the present review26:

- Grade A (High)—A randomized controlled trial or prospective study, composed of a well-defined control group; defined diagnosis and end-points; diagnostic reliability tests and reproducibility tests described; and blinded outcome measurements (all criteria should be met)
- Grade B (Moderate)—A cohort study or retrospective study, composed of a defined control group; defined diagnosis and end-points; and diagnostic reliability tests and reproducibility tests described (all criteria should be met; otherwise, grade C)
- Grade C (Low)—One or more of the following settings are encountered: poorly defined patient material, unclear diagnosis and end-points, and large attrition of the samples

The initial search yielded 43 studies. Thirty-one studies did not fulfill the eligibility criteria and were excluded. In total, 10 studies9,15–18,27–33 were included and processed for data extraction.

Results

General characteristics of studies

All studies9,15–18,27,28,31–33 were clinical and were performed at University settings. The number of study participants ranged between 13 and 36. The mean age of the study participants ranged between 26 and 55.8 years. In three studies,31–33 the mean age of the patients was not reported. Eight studies9,15–18,27,28,30,33 reported the gender of participants. The study follow-up period ranged between 1 and 6 months (Table 1).
In 8 studies, participants were nonsmokers. In studies by Zingale et al. and Kamma et al., the number of smokers were 2 and 18 patients, respectively. In the study by Kamma et al., patients were smoking 31.1 cigarettes daily whereas in the study by Zingale et al. patients were smoking less than one pack of cigarettes daily. In this study, the precise quantity of cigarettes smoked daily remained unclear. None of these studies reported the duration of the patients’ cigarette smoking habit (Table 1).

Diode laser related parameters

The wavelengths of the diode laser used varied among 808, 940, and 980 nm. Ten studies reported the diameter of the optic fiber, which ranged between 300 μm and 2 mm. Euzebio Alves et al., Kamma et al., and De Micheli et al. reported the power density of the diode laser used, which were 1193.7, 2830, and 1193.7 W/cm², respectively. Three studies reported the pulse interval (duration) which ranged between 10 and 100 ms. In studies by Kamma et al., energy fluence of the diode laser was 94.3 J/cm². Ten studies reported the treatment time of laser application, which ranged between 10 and 80 sec. In five studies, frequency of diode laser delivery ranged between 20 and 50 Hz, and in five studies, the laser was delivered as a continuous wave. In 10 studies, the fiber was moved vertically (apicocoronally) on the side of the pocket. In the study by Kamma et al., the fiber was moved towards the top of the pocket with overlapping horizontal and vertical strokes, maintaining constant contact with the soft tissue (Table 2).

Outcomes of studies

Five studies showed no significant or only a slight improvement in CP after treatment with SRP plus laser. Caruso et al. showed a slight improvement, and results by Borrajo et al. and Zingale et al. reported moderate improvement in CP after treatment with SRP plus laser.

Five studies reported that SRP followed by diode laser therapy was more effective in the treatment of CP than when SRP was used alone. In the study by Borrajo et al., there was a significant reduction in bleeding scores in sites where SRP plus laser was used, as compared with sites where SRP alone was used; however, CAL remained unchanged. In three studies outcomes of SRP with adjunctive diode laser therapy and SRP alone in the treatment of CP showed no significant difference (Tables 1 and 2).

Quality assessment

Most of the studies were graded as “high,” mainly because of their methodological quality (Table 1). The moderate grading was mainly based on there being no
<table>
<thead>
<tr>
<th>Authors et al.</th>
<th>Study subjects (n)</th>
<th>Gender (M:F)</th>
<th>Mean age (age range)</th>
<th>Criteria for diagnosis of CP</th>
<th>Smokers (n)</th>
<th>Study groups</th>
<th>Follow-up (in months)</th>
<th>Outcome</th>
<th>Quality grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamma et al. 9</td>
<td>12</td>
<td>14:16</td>
<td>41.8 (35.6–48)</td>
<td>CAL &gt; 5 mm at 2–3 sites in &gt;14 permanent teeth and advanced bone loss on radiographs</td>
<td>18</td>
<td>CG: No treatment TG-1: SRP alone TG-2: Laser alone TG-3: SRP+laser</td>
<td>6</td>
<td>TG-3 showed a significantly lower PPD, CAL, and total bacterial load than other treatment groups.</td>
<td>A</td>
</tr>
<tr>
<td>Saglam et al. 16</td>
<td>19</td>
<td>18:12</td>
<td>CG: 40.8 TG: 42.1</td>
<td>None</td>
<td>CG: SRP alone TG: SRP+laser</td>
<td>1, 3, and 6</td>
<td>TG showed significantly better outcome than the CG in full-mouth clinical periodontal parameters.</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Dukic et al. 17</td>
<td>20</td>
<td>21:14</td>
<td>37 (26.2–48.8)</td>
<td>Severe CP diagnosed according to ADA criteria 4–6 mm 7–10 mm</td>
<td>None</td>
<td>CG: SRP alone TG: SRP+laser</td>
<td>1.5 and 4.5</td>
<td>The results were similar for both groups in BOP, PD in deep pockets, and CAL. Diode laser+SRP showed PD improvements only in pockets with PD 4–6 mm.</td>
<td>A</td>
</tr>
<tr>
<td>Zingale et al. 15</td>
<td>18</td>
<td>16:9</td>
<td>55.8</td>
<td>At least five sites with PD of 5–9 mm with BOP</td>
<td>2</td>
<td>CG: No treatment TG-1: SRP alone TG-2: Flap surgery+SRP TG-3: Laser curettage+SRP TG-4: Laser curettage+SRP+ laser sealing</td>
<td>1, 3 and 6</td>
<td>Periodontal inflammation reduced significantly in all groups except CG. There was no significant difference in periodontal inflammation among sites in TG-3 and TG-4.</td>
<td>B</td>
</tr>
<tr>
<td>Kreisler et al. 27</td>
<td>25</td>
<td>7:15</td>
<td>45 (34.2–55.8)</td>
<td>PD ≥ 3 mm, BOP and bone loss on radiographs</td>
<td>NA b</td>
<td>CG: SRP alone TG: SRP+laser</td>
<td>3</td>
<td>Teeth in TG showed higher reduction in tooth mobility, PD, and CAL than teeth in CG.</td>
<td>B</td>
</tr>
<tr>
<td>Caruso et al. 31</td>
<td>8</td>
<td>NA</td>
<td>NA</td>
<td>At least 2 sites with PD ≥ 5 mm</td>
<td>NA</td>
<td>CG: SRP alone TG: SRP+laser</td>
<td>3</td>
<td>Sites in TG showed significant reduction in periodontal inflammation. However, there was no significant difference in periodontal pathogens between the TG and CG.</td>
<td>A</td>
</tr>
<tr>
<td>De Micheli et al. 18</td>
<td>21</td>
<td>8:19</td>
<td>48.5 (NA)</td>
<td>CP and presence of a pair of single-rooted contralateral teeth with PD ≥ 5 mm</td>
<td>None</td>
<td>CG: SRP alone TG: SRP+laser</td>
<td>1.5</td>
<td>Slightly improved outcomes of diode laser + SRP and conventional SRP in reducing periodontal inflammation were better in SRP</td>
<td>A</td>
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</table>

(continued)
<table>
<thead>
<tr>
<th>Authors et al.</th>
<th>Study subjects (n)</th>
<th>Gender (M:F)</th>
<th>Mean age in years (age range)</th>
<th>Criteria for diagnosis of CP</th>
<th>Smokers (n)</th>
<th>Study groups</th>
<th>Follow-up (in months)</th>
<th>Outcome</th>
<th>Quality grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Euzebio Alves et al.\textsuperscript{28}</td>
<td>26</td>
<td>13:23</td>
<td>46.8 (37–64)</td>
<td>One pair of contralateral single-rooted teeth with PD ≥ 5 mm</td>
<td>None</td>
<td>CG: SRP alone</td>
<td>6</td>
<td>Improvement in PI, BOP, PD, and CAL were comparable in the TG and CG.</td>
<td>A</td>
</tr>
<tr>
<td>Borrajo et al.\textsuperscript{32}</td>
<td>30</td>
<td>NA</td>
<td>NA</td>
<td>All subjects had gingival inflammation</td>
<td>NA</td>
<td>CG: SRP alone</td>
<td>1.5</td>
<td>Sites in the TG showed moderate reduction in periodontal inflammation compared with sites in the CG.</td>
<td>A</td>
</tr>
<tr>
<td>Ustün et al.\textsuperscript{33}</td>
<td>29</td>
<td>9:12</td>
<td>NA (26–55)</td>
<td>At least two incisors or canines at two quadrants (upper or lower) with PD between 4 and 7 mm</td>
<td>None</td>
<td>CG: SRP alone</td>
<td>1, 3, and 6</td>
<td>TG showed significantly better outcome than the CG in full-mouth clinical periodontal parameters.</td>
<td>A</td>
</tr>
</tbody>
</table>

\textsuperscript{a}Armitage\textsuperscript{28}.

\textsuperscript{b}Individuals consuming >10 cigarettes daily were excluded.

CP, chronic periodontitis; CAL, clinical attachment level; CG, control group; TG, treatment group; SRP, scaling and root planning; PPD, periodontal probing depth; ADA, American Dental Association; BOP, bleeding on probing.
randomized assignment to experimental and control treatment groups, and no description of reliability tests.

**Discussion**

The systematic review shows that a diode laser with a wavelength 808–980 nm and power of 0.8–2.5 W can be used as an adjunct therapy with good results.

Results from some studies16,17,27,33 included in the present review reflected that if the laser parameters are suitable, a good effect in up to 5 mm deep pockets can be achieved. This result is in contrast to the review by Slot et al.23 showing no additional effect.

It is well-known that periodontal pathogens (such as *P. gingivalis* and *A. actinomycetemcomitans*) exhibit the potential to adhere and invade the periodontal epithelium.34–36 Therefore, elimination or removal of the periodontal pocket epithelium plays an essential goal in the treatment of CP by allowing a better connective tissue formation. In a histologic study on pig models, Romanos et al.20 demonstrated that treatment of periodontal tissues with a 980 nm diode laser completely removes the epithelium in periodontal pockets as compared with conventional treatment with hand instruments. Application of diode lasers on periodontal tissues has been reported to enhance the mRNA expression of insulin growth factor, transforming growth factor-beta and vascular endothelial growth factor in human gingival fibroblasts demonstrating a potent effect on the metabolism of connective tissues.37 Further, a gingival crevicular fluid concentration of matrix metalloproteinase (MMP)-8 (an MMP that plays an essential role in the degradation of collagen fibers), has also been reported to be significantly reduced following SRP plus diode laser therapy as compared with SRP alone.9 These results are a possible explanation for the outcomes of the present systematic review in which five studies9,16,17,27,33 reported SRP followed by diode laser therapy to be more effective in the treatment of CP than traditional SRP alone. Two studies14,32 showed slight improvement in CP following laser therapy, and three studies15,18,28 showed no difference in CP in sites treated with and without laser therapy.

From the literature reviewed9,15–18,27–33, it is speculated that following SRP, application of diode lasers (808–980 nm) at a power ranging between 1 and 2.5 W for 10–80 sec is sufficient to completely eliminate the periodontal epithelium. However, histologic evidence regarding the degradation of periodontal epithelium following SRP plus diode laser therapy was not reported in these clinical trials.9,15–18,27–33 Interestingly, two studies17,18,28,29 reported SRP plus diode laser and SRP alone to yield comparable clinical outcomes in treating CP.

In three studies,9,17,32 a power of 2 W was used, and in the study by Caruso et al.,31 a power of 2.5 W was used. In the study by Saglam et al.,16 diode laser with a wavelength of 940 nm was used at a power of 1.5 W. Limited clinical outcomes in the studies by De Micheli et al.,18 Ezebio Alves et al.28 could be associated with increased carbonization by a continuous wave of 1.5 W using a 810 nm laser that caused more carbonization, as lasers with 810 nm wavelength are absorbed more readily in hemoglobin than 980 nm lasers.9 Similarly, Zingale et al.15 used 0.8 W power, which may not have been enough to completely remove epithelium. It is also possible that the laser power may have decreased when used for a prolonged duration.

In this regard, use of a power meter is highly recommended when working with lasers, in order to verify the real amount of energy at the tip of the fiberoptic delivery system. It has also been suggested that optical fiber tips should be cleaved out frequently during laser curettage in order to minimize power output loss.38 It is noteworthy that the only laser-related parameters that were comparable between the studies included were laser wavelength and power. Power density, energy fluence, frequency, duration of laser application, and pulsing were reported by only a limited number of studies, and were inconsistent. For clinicians and researchers to reach a consensus and standardize the laser settings it is imperative that these variables be reported in future studies.

Chronic tobacco smoking has been reported to compromise the outcomes of periodontal surgical interventions.19,40 We were, therefore, tempted to speculate that the outcomes of SRP plus diode laser treatment would be compromised in

<table>
<thead>
<tr>
<th>Authors et al. (year)</th>
<th>Diameter of optic fiber (in μm)</th>
<th>Laser wavelength (in nm)</th>
<th>Power (in W)</th>
<th>Power density (W/cm²)</th>
<th>Pulse interval duration (in ms)</th>
<th>Frequency (in Hz)</th>
<th>Energy fluence (J/cm²)</th>
<th>Laser motion during application</th>
<th>Duration of laser application (in sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kamma et al.9</td>
<td>300</td>
<td>980</td>
<td>2</td>
<td>2830</td>
<td>—</td>
<td>CW</td>
<td>94.3</td>
<td>Vertical and horizontal strokes</td>
<td>30</td>
</tr>
<tr>
<td>Zingale et al.15a</td>
<td>400</td>
<td>810</td>
<td>0.8</td>
<td>—</td>
<td>—</td>
<td>CW</td>
<td>—</td>
<td>Vertical strokes</td>
<td>30–45</td>
</tr>
<tr>
<td>Saglam et al.16</td>
<td>300</td>
<td>940</td>
<td>1.5</td>
<td>—</td>
<td>20</td>
<td>20</td>
<td>15</td>
<td>Vertical strokes</td>
<td>20</td>
</tr>
<tr>
<td>Dukic et al.17</td>
<td>300</td>
<td>980</td>
<td>2</td>
<td>—</td>
<td>25</td>
<td>CW</td>
<td>—</td>
<td>Vertical strokes</td>
<td>20</td>
</tr>
<tr>
<td>De Micheli et al.18</td>
<td>400</td>
<td>808</td>
<td>1.5</td>
<td>1193.7</td>
<td>—</td>
<td>CW</td>
<td>—</td>
<td>Vertical strokes</td>
<td>10</td>
</tr>
<tr>
<td>Kreisler et al.27</td>
<td>600</td>
<td>809</td>
<td>1</td>
<td>—</td>
<td>—</td>
<td>CW</td>
<td>—</td>
<td>Vertical strokes</td>
<td>20</td>
</tr>
<tr>
<td>Ezebio Alves et al.28</td>
<td>400</td>
<td>810</td>
<td>1.5</td>
<td>1193.7</td>
<td>—</td>
<td>CW</td>
<td>—</td>
<td>Vertical strokes</td>
<td>20</td>
</tr>
<tr>
<td>Caruso et al.31</td>
<td>400</td>
<td>980</td>
<td>2.5</td>
<td>—</td>
<td>60</td>
<td>60/30</td>
<td>—</td>
<td>Vertical strokes</td>
<td>30</td>
</tr>
<tr>
<td>Borrajo et al.32</td>
<td>2000</td>
<td>980</td>
<td>2</td>
<td>—</td>
<td>100</td>
<td>50</td>
<td>—</td>
<td>Vertical strokes</td>
<td>10</td>
</tr>
<tr>
<td>Ustün et al.33</td>
<td>320</td>
<td>810</td>
<td>1.5</td>
<td>—</td>
<td>20</td>
<td>—</td>
<td>20</td>
<td>Vertical strokes</td>
<td>80</td>
</tr>
</tbody>
</table>

*aLaser sealing was performed the same laser at 0.8 W for 30–45 sec. CW, continuous wave.
smokers compared with nonsmokers. Interestingly, despite the inclusion of cigarette smokers in studies by Zingale et al.\textsuperscript{15} and Kamma et al.,\textsuperscript{9} the overall outcome of these studies reported better results for SRP plus diode laser therapy than for SRP in the treatment of CP. It is pertinent to mention that in the studies by Zingale et al.\textsuperscript{15} and Kamma et al.,\textsuperscript{9} it remained unclear which treatment group (either the SRP plus diode laser group or the SRP alone group) cigarette smokers belonged to. It is possible that smokers in these studies\textsuperscript{9,15} belonged to the SRP alone group, thereby augmenting the clinical outcomes of the SRP plus diode laser group. Further, neither of these studies\textsuperscript{9,15} reported the duration of smoking habit. Therefore, further studies are warranted to assess the effect of cigarette smoking on the clinical outcome of SRP plus diode laser therapy for the treatment of CP.

There are a few limitations of the studies that were included in the present systematic review. It is well known that periodontal inflammatory conditions are worse in patients with systemic conditions such as chronic hyperglycemia than in medically healthy individuals.\textsuperscript{41–43} In all studies included in the present review,\textsuperscript{9,15–18,27–33} patients with systemic disorders were excluded. Therefore, the outcome of periodontal therapy (with and without diode laser application) is expected to be compromised in patients with chronic systemic diseases such as diabetes. To our knowledge from the indexed literature, this hypothesis is yet to be investigated.

Conclusions

In CP patients with probing depths ≤5 mm, diode lasers (800–980 nm), when used as adjuncts to SRP, are more effective in the treatment of CP than when SRP is used alone.

Author Disclosure Statement

No competing financial interests exist.

References


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