A Short-Term Evaluation of Nd:YAG Laser as an Adjunct to Scaling and Root Planing in the Treatment of Periodontal Inflammation

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**Background:** This split-mouth, single-masked, randomized, controlled clinical trial compares the short-term outcomes of a combined treatment with scaling and root planing (SRP) and neodymium-doped:yttrium, aluminum, and garnet (Nd:YAG)-laser irradiation with treatment with SRP alone.

**Methods:** Thirty patients were recruited. The mandibular left or right side was randomly assigned as the test side (SRP with laser treatment) or control side (SRP alone). The water-cooled Nd:YAG laser was used at 4 W, 80 mJ/pulse, 50 Hz, and with a pulse width of 350 μs. At baseline, gingival crevicular fluid (GCF) samples were taken from the test and control sides, and levels of matrix metalloproteinase (MMP)-8 and interleukin (IL)-1β, -4, -6, and -8 were measured using standard techniques. The plaque index (PI), gingival index (GI), and probing depth (PD) were measured by calibrated examiners.

**Results:** At the 1-week follow-up, PD (P <0.001), PI (P <0.05), and GCF volume (P <0.001) showed significant improvement on test sides compared to control sides. At the 3-month follow-up, PD (P <0.01), PI (P <0.01), GI (P <0.01), and GCF volume (P <0.05) also showed significant improvement on test sides compared to control sides. At the 1-week follow up, IL-1β and MMP-8 levels were significantly reduced on test sides compared to control sides. The 3-month follow-up confirmed that the improvements on test sites had been sustained compared to the treatment outcomes of control sites.

**Conclusion:** In the short-term, SRP in combination with a single application of a water-cooled Nd:YAG laser significantly improves clinical signs associated with periodontal inflammation compared to treatment with SRP alone. *J Periodontol 2010;81:1161-1166.*

**KEY WORDS**
Cytokines; dental scaling; inflammation; Nd:YAG; root planing.

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The neodymium-doped:yttrium, aluminum, and garnet (Nd:YAG) laser has been used in dentistry, primarily in minor surgery and endodontics, for nearly 2 decades.¹,² Several potential roles for lasers in periodontal treatment were proposed, such as the removal of calculus, the epithelial lining of periodontal pockets, and granulomatous tissue.³-⁷ However, the reported outcomes of such interventions are contradictory.⁸ Consequently, laser periodontal therapy has yet to achieve the status of a routine treatment modality. It was reported that Nd:YAG and erbium-doped:yttrium, aluminum, and garnet lasers may be comparable to scaling and root planing (SRP) with respect to reducing periodontal inflammatory conditions.⁹ However, other studies¹⁰-¹² reported limited evidence to support the efficacy of laser treatment as an adjunct to non-surgical periodontal treatment in adults with periodontal inflammation. This lack of consensus among studies could partly be attributed to a lack of conformity in study methods including laser settings (water cooling, power output, pulse-repetition rate, and fiber diameter) and study design.

Theoretically, the Nd:YAG laser has a potential application in periodontal therapy because the wavelength is not readily absorbed by hard tissues such as cementum or dentin. Within the dose
ranges recommended for clinical application, the Nd:YAG laser (even without water cooling) only affects the soft tissues such as the pocket epithelial lining.\textsuperscript{3} Israel et al.\textsuperscript{13} showed that the use of high energy powers, such as 9 W, can have negative effects on root surfaces. However, Spencer et al.\textsuperscript{14} reported that the use of the Nd:YAG laser at 4 W is safe and does not have damaging effects on root surfaces.

An unresolved issue is that the Nd:YAG laser may cause overheating of the irradiated tissues.\textsuperscript{11} Earlier studies\textsuperscript{15-17} used a laser instrument (without water cooling) with a probe diameter of 300 \(\mu\)m for periodontal therapy, which may expose the oral tissues to thermal damage. However, using a laser instrument with a probe diameter of 600 \(\mu\)m (with water cooling) may relatively reduce the risk of thermal damage to periodontal tissues and root surfaces. Another advantage of a larger-diameter instrument tip (with water cooling) is that the energy density at the laser tip is reduced, and the water irrigation reduces the clogging of the probe with debris, thereby preventing a buildup of areas of excessive heat.

The aim of the present short-term study is to test the hypothesis that a water-cooled Nd:YAG laser (wavelength: 1,064 nm) as an adjunct to SRP in the treatment of periodontal inflammation can improve periodontal healing.

**MATERIALS AND METHODS**

**Patient-Selection Criteria**

In April, 2005, in Enköping, Sweden, 30 adults (13 males and 17 females, age range 26 to 70 years; mean age: 50 years) were questioned about their systemic health status, use of medications, and tobacco habits.

**Inclusion and Exclusion Criteria**

To be included in the study, the participants had to have \(\geq 26\) periodontal pockets of 4 to 8 mm (periodontal inflammation) on each side of the mandible. Patients were excluded from the study if they had a history of systemic disease requiring medications, received antibiotics within the 12-week period preceding the study, or exhibited class II or III tooth mobility. Based on a previous study\textsuperscript{18} involving a therapeutic laser, 25 patients were considered the minimum number of participants.

**Ethical Considerations**

The protocol was explained to the patients, and volunteering individuals were requested to sign a consent form. The study was approved by the Regional Ethics Review Board, Stockholm, Sweden.

**Periodontal Examination**

At baseline, two trained and calibrated examiners (PP and F.J.), who were masked to the test and control groups, measured the clinical periodontal parameters (i.e., probing depth [PD],\textsuperscript{5} gingival index [GI],\textsuperscript{19} and plaque index [PI]\textsuperscript{20}) on all mandibular teeth excluding third molars. These measurements were recorded on four sites per tooth (mesial, distal, buccal, and lingual). Oral hygiene instructions were given to all participants on enrollment and at the two treatment sessions.

**Treatment Protocols**

Patients underwent two different treatment modalities. The teeth on test sides of the mandible received SRP and laser treatment, whereas control sides were treated with SRP alone. The assignment of the left or right side for the respective treatments was randomly determined by a coin toss prior to initiating therapy. Prior to treatment, baseline gingival crevicular fluid (GCF) samples were procured for teeth \#19, \#20, \#29, and \#30.

Under local anesthesia, all mandibular teeth, excluding third molars, were scaled and root planed using hand\textsuperscript{6} and ultrasonic\textsuperscript{8} instruments. All treatments were carried out by one operator (TQ), whereas the baseline and follow-up examinations were performed by two observers (PP and F.J.). Follow-up examinations were performed 1 week and 3 months after the final treatment by the same observers.

At the follow-up appointments, patients were questioned concerning the occurrence or lack of any adverse events related to treatment.

**Laser Parameters**

The laser treatment was accompanied by air and water cooling. The irradiation parameters were determined through the fiber diameter, treatment time, power of the laser at the tip of the fiber, and the surface area of the irradiation site. The laser treatment was performed by inserting the fiber into the periodontal pocket almost parallel to the tooth and moving from mesial to distal directions continuously. The distal end of the laser probe was used to transfer the radiation because this surface was presumed to have sufficient energy to reduce inflammation. The laser equipment used in this study was an Nd:YAG\textsuperscript{7} laser that emitted pulsed light at 1,064 nm. To avoid the thermal effect and maintain the optimal therapy effect, the instrument was set at level five at the following parameters: average output: 4 W; energy per pulse: 80 mJ; pulse width: 350 \(\mu\)s, pulse-repetition rate: 50 Hz; pulse peak power: 240 W; average power density at the fiber end: 1,430 W/cm\(^2\); and peak-power density: 85,800 W/cm\(^2\). The laser energy per treated tooth was 240 to 480 J. The fiber diameter

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\(\textsuperscript{5}\) PerioWise, Premier Products, Plymouth Meeting, PA.
\(\textsuperscript{6}\) American Eagle Curette, Missoula, MT.
\(\textsuperscript{7}\) Sonosoft Lux, KaVo Dental, Biberach, Germany.
\(\textsuperscript{8}\) Genius Dental, Tureby, Denmark.
was 600 μm (0.002826 cm²). Water cooling and air cooling were always used during irradiation. The time spent on each tooth varied between 60 to 120 seconds, depending on accessibility. The fiber was held in a constant motion in contact with the pocket epithelial lining almost parallel to the long axis of the root. The power density and peak-power density were calculated by a hypothetical 100% emission through the small fiber tip. However, the energy was not emitted solely from the tip of the fiber; there was also considerable lateral emission. Because of the high uncertainty about the total area of irradiated tissue, the energy density (joules per square centimeter) was not calculated.

**GCF Collection**
Baseline GCF samples were collected from teeth #19, #20, #29, and #30. Prefabricated paper strips** were inserted into the pockets until resistance was felt and were removed after 30 seconds. If the GCF sample was contaminated with blood, it was discarded, and fresh samples from the same site were collected after an interval of 10 minutes. In total, ~10 blood-contaminated samples were discarded.

The collected volume was measured with a calibrated electronic gingival fluid measuring device.†† The two samples from the same side were pooled and eluted in 1 ml phosphate buffered saline for 60 minutes prior to freezing at −20°C.

**Analysis of GCF Samples**
GCF samples from test and control sites were analyzed for the concentrations of interleukin (IL)-1β, -4, -6, and -8 and matrix metalloproteinase (MMP)-8. These cytokines were analyzed using standard techniques.‡‡ The results were calculated using a software program,§§ and the cytokine levels were determined as the total amount per side in picograms in the fluid. The collagenases were analyzed similarly using a kit.¶¶

**Statistical Analyses**
All statistical analyses were performed using a software program.** Changes in the clinical parameters from baseline to follow-up and between treatment modalities were assessed for statistical significance using a paired t test. The corresponding differences in laboratory data were analyzed using the Wilcoxon signed-rank test. Significance was set at

**RESULTS**

All 30 participants attended the baseline examination and the follow-up appointments. The test and control sides included 201 teeth (487 sites) and 204 teeth (494 sites), respectively. Five patients were smokers, and one patient used smokeless tobacco.

**Clinical Outcomes**

One week post-treatment, the PI (P < 0.05), PD (P = 0.001), and GCF volumes (P < 0.001) significantly decreased at test sides compared to control sides. The GI also decreased on test sides, but the difference did not reach significance (Table 1).

The 3-month follow-up confirmed that the improvements were sustained. The treatment outcomes for test sites had significantly improved compared to the treatment outcomes for control sites (PD [P < 0.01], GI [P < 0.01], PI [P < 0.01], and GCF volume [P < 0.05]) (Table 1). During the 3-month follow-up, the mean PD decreased by 0.6 mm on test sides compared to control sides.

None of the participants reported any adverse side effects that could be related to the laser irradiation.

**Laboratory Variables**

One week post-treatment, the IL-1β (P < 0.05) and MMP-8 (P < 0.05) levels were significantly reduced on test sides compared to control sides (Table 2). With respect to the other cytokines, no significant differences were disclosed between the two treatment modalities (Table 2).

**DISCUSSION**

In the present study, sites irradiated with the Nd:YAG laser as an adjunct to SRP exhibited enhanced periodontal healing compared to sites treated by SRP alone. Improvement in all the registered periodontal variables, including GCF volume, was greater for the irradiated sites than for control sites. The mean PD after the 3-month follow-up had decreased by 0.6 mm on test sides compared to control sides. The gingival inflammation, measured as GI, decreased on both sides, but the decrease was significantly larger on the laser side after 3 months. The combination of reduced GI and reduced PD was an indication of decreased periodontal inflammation.

In contrast, a study by Sjöström and Friskopp that used a similar Nd:YAG laser (with water cooling) immediately after SRP disclosed no additional benefit for laser irradiation at the control side at 4 months. The reason for the discrepancy between the two studies is unclear; however, it might be attributable to differences in the laser settings: in the earlier study, the laser was set to 7 W in accordance with the manufacturers’ recommendations, whereas in the present study, the setting was lower (at 4 W).
Table 1.
Periodontal Inflammatory Parameters (mean [SD]) in 30 Patients

<table>
<thead>
<tr>
<th>Variable</th>
<th>SRP</th>
<th>SRP Plus Nd:YAG-Laser Irradiation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>1 Week</td>
</tr>
<tr>
<td>PD (mm)</td>
<td>4.41</td>
<td>3.88</td>
</tr>
<tr>
<td></td>
<td>4.59</td>
<td>3.61</td>
</tr>
<tr>
<td>PI</td>
<td>1.96</td>
<td>1.26</td>
</tr>
<tr>
<td></td>
<td>1.96</td>
<td>1.05</td>
</tr>
<tr>
<td>GCF volume (µL)</td>
<td>1.40</td>
<td>1.53</td>
</tr>
<tr>
<td></td>
<td>1.40</td>
<td>1.12</td>
</tr>
</tbody>
</table>

* Differences in variables from baseline to the 1-week follow-up.
† Differences in variables from baseline to the 3-month follow-up.
‡ Significant differences between the two treatment groups (paired t test).

Table 2.
Levels of Cytokines (median ranges) in Pooled GCF Samples (N = 30)

<table>
<thead>
<tr>
<th>Cytokines (pg)</th>
<th>SRP</th>
<th>SRP Plus Nd:YAG-Laser Irradiation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>1 Week</td>
</tr>
<tr>
<td>IL-1β</td>
<td>0.32</td>
<td>0.42</td>
</tr>
<tr>
<td></td>
<td>0.46</td>
<td>0.24</td>
</tr>
<tr>
<td>IL-4</td>
<td>0.66</td>
<td>0.21</td>
</tr>
<tr>
<td></td>
<td>0.66</td>
<td>0.54</td>
</tr>
<tr>
<td>IL-6</td>
<td>0.08</td>
<td>0.00</td>
</tr>
<tr>
<td>IL-8</td>
<td>84.6</td>
<td>89.0</td>
</tr>
<tr>
<td></td>
<td>84.6</td>
<td>89.0</td>
</tr>
</tbody>
</table>

* Change from baseline to the 1-week follow-up.
† Change from baseline to the 3-month follow-up.
‡ Significant differences between the two treatment groups (paired t test).

The disruption of collagen fibers in the periodontal ligament is mainly attributed to the two collagenases MMP-1 and MMP-8. MMP-8 is released primarily from polymorphonuclear leukocytes (PMNs) and secreted predominantly into the GCF. The level of MMP-8 in a GCF sample reflects the number of PMN present and is an expression of the severity of inflammation.22 IL-1β is a proinflammatory cytokine that is mainly released from monocytes/macrophages, and is present in the gingival tissues and GCF of patients with periodontal inflammation.23 In the present study, a significantly greater reduction in MMP-8 and IL-1β was associated with the laser irradiation. Thus, the laboratory analyses confirm the clinical signs of improved healing at these sites. A study by Liu et al.24
compared the effects of SRP and SRP plus Nd:YAG laser on the laboratory markers of periodontal inflammation. The 6- to 12-week follow-up results showed a significant reduction in IL-1β levels after treatment with SRP plus the Nd:YAG laser compared to treatment solely with SRP. Similar results were reported by other studies. Studies have compared the effects of ultrasonic treatment, carbon-dioxide-laser treatment, and Nd:YAG-laser treatment. Compared to the baseline values, treatment with the Nd:YAG laser (without water cooling) and ultrasonic scaling resulted in significant improvements in clinical parameters.

In vivo, effects on the root surface and the pulp are not well documented. The effect of laser irradiation on the surrounding tissues is influenced by parameters such as power, pulse, fiber size, fiber angulations, and cooling/no cooling. A study by White et al. suggested that powers from 0.3 to 3.0 W should not cause a damaging rise in intrapulpal temperatures. Likewise, Spencer et al. reported that the use of the Nd:YAG laser at 4 W is safe and does not have damaging effects on root surfaces.

The laser fiber used in the present study was 600 μm in diameter and was operated with a water-cooling system. Compared to a 600-μm tip, the power density of the conventional 300-μm tip is four times higher, which causes greater carbonization and tissue adherence and results in less control over the energy output at the tip. The 600-μm tip reduces the power density, and so does the water spray. In the present study, to overcome the loss of power at the fiber tip, the following settings were selected: 4 W, 80 mJ/pulse, 50 Hz, and a pulse width of 350 μs. A further advantage of the 600-μm tip is the reduced risk of fiber fracture. Results by Israel et al. showed that the use of high-energy powers, such as 9 W, can have negative effects on root surfaces. However, if laser treatment is provided with water cooling at 4 W, there is no damage to root surfaces.

It is difficult to provide an absolute explanation for the improvement of periodontal status on the test sites compared to control sites; however, the partial removal of the pocket epithelial lining may be an important contributing factor. Simultaneously, the reduction in PI and PD in the test sites may be explained by the decrease in periodontal inflammation in these sites. This might have reduced the patients’ discomfort in these sites and allowed them to brush and maintain their oral hygiene in these areas.

CONCLUSION
The 3-month post-treatment results of this study indicate that treatment with SRP in combination with the Nd:YAG laser is more effective in reducing periodontal inflammation compared to treatment solely by SRP.

ACKNOWLEDGMENT
The authors report no conflicts of interest related to this study.

REFERENCES

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