More References: Perio Articles and Implant Uncovering Article

1. Yeh S, Jain, Andreana S. Using a diode laser to uncover dental implants in
2. V. I Haraszthy et al., "Microbiological Effects of Diode Laser Treatment of
3. J. Sanz et al., "A Diode Laser as an Adjunct to Periodontal Surgery" J Dent
4. S. G Ciancio et al., "Clinical Effects Of Diode Laser Treatment on
Wound
   Healing" J Dent Res 85
Diode Laser as Adjunct to Scaling and Root Planing

J.L. LEYES BORRAJO, M.D., Ph.D., D.D.S., L. GARCÍA VARELA, M.D., Ph.D., D.D.S.,
G. LÓPEZ CASTRO, D.D.S., I. RODRÍGUEZ-NUNEZ, Ph.D., D.D.S., and
M. GALLAS TORREIRA, Ph.D., D.D.S.

ABSTRACT

Objective: The aim of this study was to evaluate clinical efficacy of InGaAsP diode laser as adjunct to traditional scaling and root planing. Background Data: The use of laser is one of the most recent methods in non-surgical periodontal treatment. Efficacy and side effects of each type of laser treatment have yet to be determined. Methods: Thirty patients suffering from moderate periodontal disease have been considered. They were randomly selected to undergo either scaling and root planing with curets, or scaling and root planing combined with InGaAsP laser (980 nm and 2 W). The papilla bleeding index (PBI), bleeding on probing (BOP), and clinical attachment level (CAL) were registered at the beginning and end of treatment. Results: At the end of treatment, PBI average in the group treated with laser was 0.24 versus 0.43 in the group undergoing conventional treatment (p = 0.014). In the group undergoing scaling and root planing, BOP decrease is 19.55% less (p < 0.0001) than in the group also treated with laser. Nevertheless, CAL differences cannot be considered significant between both groups (p = 0.67). Conclusions: Scaling and root planing in combination with laser produce moderate clinical improvement over traditional treatment.

INTRODUCTION

CALING AND ROOT PLANING

Health by removing plaque, calculus, and endotoxins adhered to tooth roots, causing gum inflammation. This, along with the patient’s instruction for correct oral hygiene, constitutes the basis of non-surgical periodontal treatment. Nevertheless, this type of therapy has its own limits, and so, many researchers have proposed the use of several kinds of laser as a more efficient method of root planing. The possibility of substituting conventional treatments for laser therapy is still very controversial. One of the most successful clinical uses in daily practice is the combination of laser treatment and conventional treatment with manual instruments. The beam of laser light would be capable of completing scaling and root planing started by hand, fulfilling a delicate cutterage, preventing dentine hypersensitivity, and sterilizing the gingival sulcus.

Good clinical results have been reached with the use of Er:YAG and Nd:YAG laser, but these techniques are restricted due to the cost of the necessary systems and possible side effects. Moritz et al. have proved significant bacterial decrease and reduction of inflammation when using a diode laser of 805 nm wavelength combined with scaling and root planing. Other authors have proved good results with the use of diode laser to decontaminate during periodontitis and perimplantitis surgical treatments. Nevertheless, Yilmaz et al. have not found additional benefit in the use of galium arsenide laser with regard to other types of periodontal treatment. Other authors have suggested that the use of laser for the periodontal treatment could be more harmful than beneficial. The objective of this study is to confirm whether the use of diode laser as adjunct to traditional scaling and root planing improves the results of traditional therapy.

MATERIALS AND METHODS

In this prospective double-blind study, 30 patients were included. They presented moderate periodontal disease. They were randomly selected to undergo either scaling and root planing with manual instruments, or scaling and root planing with manual instruments combined with diode laser following the
Clinical attachment level (CAL), gingival recession, and probing depth have also been measured. Periodontal probing was performed in the whole dental perimeter, roughly 10 sec by tooth face. Access to interproximal and furcation areas is important increase in temperature. The clinical procedure is as follows:

- Periapical anesthesia using lidocaine 5% and adrenaline 1:100,000.
- Conventional scaling and root planing with manual instruments in order to remove calculus and ease the following use of laser optical fiber.
- Laser procedure. The optical fiber becomes introduced and parallel to the tooth root main axis. The procedure has to be performed in the whole dental perimeter, roughly 10 sec by tooth face. Access to interproximal and furcation areas is easy due to scarce thickness of the optical fiber.
- Repetition of scaling is done to remove detritus and calculus remnants within the sulcus. It is extremely simple since the remnants are loose.
- As in the first procedure, the second laser procedure is done to remove calculus remnants, prevent sensitivity of the working area, and undergo curettage of periodontal pocket.

Statistical analysis

The statistical tests carried out were mean differences with Student's t test for independent and related variables, for PBI, CAL, and BOP, which followed normal distribution. All the tests were carried out with the aid of the statistical packet SPSS, version 10.0 (SPSS, Inc., Chicago, IL). Unless otherwise indicated, p < 0.05 is considered statistically significant.

RESULTS

PBI average value was reduced from 1.38 ± 0.54 (mean ± SD) to 0.43 ± 0.22 (p < 0.0001) and BOP average value was reduced from 58.97 ± 17.71 to 27.71 ± 14.41 (p < 0.0001) in the group undergoing conventional treatment. The group treated with laser had PBI decrease from 0.95 ± 0.57 to 0.24 ± 0.13 (p < 0.0001) and decrease in the BOP average value from 39.37 ± 19.90 to 11.02 ± 7.36 (p < 0.0001) (Table 1).

The average PBI at the beginning of the study was similar in both groups (p = 0.065). Six weeks after the treatment had finished, average PIB in the group undergoing conventional treatment was 0.43 versus 0.24 in the group which was treated with laser, having a statistically significant difference of p = 0.014 (Fig. 1). The group undergoing scaling and root planing presented a BOP reduction 19.55% smaller than the group treated with laser (p < 0.0001). CAL average value at the beginning of treatment was 4.78 ± 1.25 mm in the group undergoing traditional treatment while 5.12 ± 1.14 mm in the group treated with laser, being both groups similar (p = 0.71). At the end of treatment, CAL average value decreased in both groups (up to 3.93 ± 1.14 mm and 4.17 ± 1.17 mm respectively, p < 0.0001 in both instances) but there are not statistically significant differences between both groups (p = 0.67) (Table 1).

Clinically, the group treated with laser had an important reduction of sensitivity and patients undergoing this type of treatment reported less discomfort during treatment as well as an important decrease in sensitivity previous to periodontal treatment.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>PBI baseline</th>
<th>PBI 6 weeks</th>
<th>p value&lt;sup&gt;a&lt;/sup&gt;</th>
<th>CAL baseline&lt;sup&gt;b&lt;/sup&gt;</th>
<th>CAL 6 weeks&lt;sup&gt;b&lt;/sup&gt;</th>
<th>p value&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>RSP</td>
<td>101.75</td>
<td>029.057</td>
<td>&lt;0.0001</td>
<td>402.554</td>
<td>324.462</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>RSP + laser</td>
<td>066.125</td>
<td>016.031</td>
<td>&lt;0.0001</td>
<td>453.571</td>
<td>357.468</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>p value</td>
<td>NS</td>
<td>0014</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

<sup>a</sup>Between baseline and 6 weeks.

<sup>b</sup>Millimeters.

<sup>c</sup>Between no laser and laser groups.

NS, not significant; PBI, papilla bleeding index; RSP, root scaling and planing; CAL, clinical attachment level.
Diode Laser as Adjunct to Scaling and Root Planing

**DISCUSSION**

Like Moritz et al., using diode laser and Schwarz et al. with Er:YAG laser, we have observed that those patients treated with laser as adjunct to SRP presented a more significant clinical improvement than those conventionally treated. In our study, a statistically significant reduction of PBI and CAL is confirmed in both groups after the treatment was completed but the group undergoing laser treatment showed a statistically more significant improvement on bleeding on probing.

The clinical protocol we followed is more simple than the one described by Moritz et al., and so, easier to adapt to the daily clinical practice. It is also important to mention that we used a wavelength of 980 nm, while theirs was of 805 nm. On the other hand, we have observed statistically significant differences in clinical indexes between both groups while they only refer to the average of patients who showed a reduction on bleeding on probing and depth of the periodontal pocket. These results contrast with those obtained by Yilmaz et al., as they state that the laser procedure does not provide additional clinical benefits to the conventional treatment. The differences this study presents, can be due to several reasons such as different design of the research (quadrants instead of the whole mouth like in ours), small number of patients (only 10 were included), selection of single rooted teeth where the implementation of SRP is more effective and also, that the evaluation of treatment was done 32 days after the beginning of treatment versus 48 days later in our research (estimated time for regeneration of connective tissue).

In our study, we have not observed any clinical side effect caused by the use of diode laser in the periodontal pockets. Although the use of Nd:YAG and Er:YAG diode lasers has been proposed for tissues adjacent to the periodontal pocket, their use can be detrimental.

According to Radvar et al., damage is unlikely to occur when the laser beam of light is used in parallel to the root surface and adequate intensity is applied. Moreover, we have used low intensity in pulse mode with exposure times of less than 10 sec and additional refrigeration to minimize possible negative side effects. On the whole, more exhaustive research needs to be done on the effects of different types of laser as well as on their different wavelengths and intensity over the tissues we want to remove and those we want to keep.

One of the most important side effects in periodontal treatment is the increase of tooth hypersensitivity. Laser treatment of the root surfaces to ease hypersensitivity has been proved to be highly effective. Our group of patients stated a much lower sensitivity after undergoing treatment than the group which was not treated with laser. Nevertheless, the data needs to be carefully evaluated since it is based upon subjective impression of patients and it is not based on objective proof.

**CONCLUSION**

The results of this research seem to prove that the use of the diode laser on periodontal pockets as a complement to scaling and root planing treatment produces qualitative improvement in the clinical indexes compared to conventional treatment. This data should be confirmed with a larger number of patients and a longer follow-up period. The differences shown in the subjective perception of discomfort during and after treatment are indicative of the importance of carrying out more research evaluating this parameter.

**REFERENCES**


Address reprint requests to:
I. Rodríguez-Núñez, Ph.D., D.D.S.
Facultad de Medicina y Odontología
Rúa Entrerrios, s/n
Santiago de Compostela, CP: 15705, Spain
E-mail: irodriguezn@infomed.es
Brief Report

Histological Evaluation of the Use of Diode Laser as an Adjunct to Traditional Periodontal Treatment


ABSTRACT

Objective: The aim of this study was to describe in vivo effects of scaling and root planing associated with 980-nm diode laser irradiation on periodontally diseased root surfaces. Background Data: Rapid advances in the development of laser technologies used in dental offices demand careful evaluation of the respective histopathologic effects of each new system. There have been no reports of scaling and root planing associated with 980-nm diode laser effects on root surfaces after in vivo application. Methods: Single rooted teeth and multiple rooted teeth considered for extraction due to severe periodontal disease were included in the study. For light microscopic investigation, a resin-embedding technique was used to cut the undecalcified teeth into 30-µm-thick cross-sections and stained. The following parameters were recorded by a blind examiner: remaining debris, root surface morphology, and thermal side effects. Results: Root surfaces instrumented with hand instruments and diode laser in vivo did not show detectable surface alterations. There were no signs of thermal side effects in any of the teeth treated. Conclusion: The present in vivo study showed that associated therapy was suitable for non-surgical periodontal treatment. The results suggest that the diode laser may be routinely used as an adjunct to scaling and root planing without damage to the cementum tissue.

INTRODUCTION

The adjunctive use of lasers in the treatment of inflammatory periodontal diseases is a fairly recent clinical procedure that is gaining momentum in dental practice. Scaling and root planing are traditionally used to restore gingival health by removing plaque, calculus, and endotoxins adhered to tooth roots causing inflammation and periodontal disease. The use of lasers is one of the most recent methods in non-surgical periodontal treatment.1-2 Clinical studies demonstrated a positive effect of many laser systems (Nd:YAG, Er:YAG, argon, CO2, and diode laser) when used alone and associated with root scaling and planing.3-6 Laser application counteracts some limits of conventional treatment (dentine hypersensitivity and local infection). In this way, thermal and photodisruptive laser effects result in the elimination of periodontopathogenic bacteria regardless of laser wavelength.7-9 However, several in vitro studies indicated that diode lasers may severely damage root surface structures and inhibit new cellular attachment when certain energy levels are exceeded, and concluded that the use of laser could be more harmful than beneficial.10-12 Side effects of this type of laser treatment have not been completely determined yet.

1Periodontology, School of Dentistry, Faculty of Medicine and Dentistry, University of Santiago de Compostela, Santiago de Compostela, Spain.
2Adult Comprehensive Dentistry, School of Dentistry, Faculty of Medicine and Dentistry, University of Santiago de Compostela, Santiago de Compostela, Spain.
3Periodontology, School of Dentistry, Faculty of Medicine and Dentistry, University of Santiago de Compostela, Santiago de Compostela, Spain.
Diode Laser as Adjunct to Traditional Periodontal Treatment

The aim of this study was to analyze morphological changes of the root cementum after conventional periodontal treatment and diode laser at clinical power outputs, at irradiation times, and at working angles in real clinical conditions of use.

METHODS

Specimens

Five, non-carious, single-rooted and multiple-rooted periodontally involved teeth after conventional scaling and root planing and diode laser irradiation in vivo were extracted. The teeth were considered for extraction due to severe destructive periodontal disease and based on informed consent of the patients included in this study. Each tooth satisfied the following criteria:

• Probing pocket depths >8 mm
• Mobility in horizontal and vertical direction (grade 3)
• No signs of carious or artificial damage on the root surface (dental restorations, crowns)
• No periodontal root surface treatment within the last 12 months
• No root fractures or anatomical abnormalities

Furthermore, patients suffering from systemic diseases that could influence the outcome of periodontal therapy were excluded from the study.

Apparatus and devices

The laser equipment used in this study was an InGalAsP diode laser device (Intermedic, Barcelona, Spain) with a wave-length of 980 nm, energy of 2 W of power applied with pulse repetition (100-msec pulse and stop of 50), 2-mm-diameter tip, focused and in contact with continuous isotonic normal saline for cooling to avoid any undesired change in temperature. The clinical procedure has been described previously as follows:

a. Periapical anaesthesia using 5% lidocaine and adrenaline 1:100,000.
b. Conventional scaling and root planing with new hand instruments (Gracey curets) in order to remove calculus and facilitate the application of laser optical fiber.
c. For the laser procedure, the optical fiber is introduced, and ascending and descending movements are practiced; those movements should be slow to increase laser efficacy, since it works with low intensity (the maximum power of this diode laser is 15 W). Special attention has to be paid to the direction of the optical fiber, since it must be parallel to the tooth longitudinal root axis.
d. Repetition of scaling is done to remove detritus and calculus remaining within the sulcus.
e. In the second laser procedure, as in the first procedure, this is done to remove calculus remains, prevent sensitivity of the working area, and undergo curettage of periodontal pocket.

All dental extraction was performed under local anesthesia without forceps by the same operator. Macroscopically, all root surfaces appeared unaltered by the extraction procedure. Then, the teeth were stored in 10% Formaldehyde prior to their histological examination.

Histological study

All teeth were dehydrated in a graded alcohol series and embedded in metacrylate resin (Technovit 7200; Heraus Kulzer GmbH, Werheim, Germany) using a standard method. After that, the cross-sections were cut with a diamond saw at 100-150 µm. The slices were ground automatically by a special machine to a thickness of 30 µm. All histological sections were stained with Levai Laczko staining and evaluated under a light microscope by one blind and calibrated examiner. The following parameters were recorded: remaining debris (yes/no), percentage of the observed root surface craters (yes/no), exposed dentin (yes/no), and thermal side effects, such as carbonization, melting, and cracking (yes/no).

RESULTS

Microscopic analysis of the irradiated specimens did not reveal any degree of alteration on the root surface. The specimens presented a superficial smear layer that varied in amount and shape, but there was practically no alteration on the root surface. Histologically, there were no signs of major thermal side effects on the teeth such as charring, melting, carbonization, necrosis, and fusion. The results are shown (Figs. 1-3). Calculus-free areas examined microscopically did not show grooves and crater-like defects in any cross-sections observed (Figs. 4 and 5). In one slice, we observed small remains of hard deposits (i.e., calculus) (Fig. 6).

Periodontal research in past years has been extensive, with researchers and clinicians looking for better treatment and therapy options. Root surface instrumentation (scaling and root planing) remains the cornerstone of non-surgical periodontal treatment. However, clinical observations and experimental studies show hopeful results for incorporating laser irradiation into non-surgical periodontal therapy. Laser devices are typically easy to handle and painless, and do not seem to produce adverse effects.

In clinical practice, however, the optic fiber must be inserted carefully into the periodontal space, with a fixed working angle between the laser fiber and the collateral periodontal tissues, which is not repeatable in experimental studies in vitro. This working angle varies between 0° and 30°, and for this reason we analyzed single-rooted and multi-rooted teeth (anterior and posterior teeth). Furthermore, environmental clinical conditions of temperature, humidity, and blood contamination cannot be reproduced in in vitro studies in spite of water irrigation of the optic fiber. In biological tissues, absorption is mainly due to the presence of free water molecules, proteins, pigments, and other macromolecules. Kreisler et al. indicated in their study that the diode laser application for pocket decontamination in periodontal therapy may cause damage to hard tissue when blood is present, if the laser parameters are not correct.12 In our study, the teeth were scaled and root planed, and then irradiated to reproduce a real clinical protocol previously tested.4 A blood film on the root surface may be decisive for possible morphological alterations, since it considerably enhances light absorption on the tooth structure.12 Because laser light is poorly absorbed in water but highly absorbed in hemoglobin and other dark pigments, tissues with good blood supply (such as the periodontal ligament) or tissues with blood contamination reveal a high absorption capacity. This possible adverse effect might be mitigated by constant cooling of the laser tip; however, it is still hypothetical whether the cooling would be sufficient to avoid all adverse effects. The results that we obtained in this study, nonetheless, confirm the absence of collateral effects.

The findings of this study do not agree with results from a previous in vitro and in vivo study that showed that the diode laser (GaAlAs, 810 nm, 1.8 W pulse/pause relation 1:10) was unsuitable by itself for calculus removal and altered the root surface in an undesirable manner.10 However, in this study

**FIG. 2.** Photomicrograph of *in vivo* treated root surfaces. Original magnification, 40.

**FIG. 3.** Cemento-enamel junction of a treated teeth. Original magnification, 40.

**FIG. 4.** Photomicrographs of furcal area in a molar teeth after scaling and root planning with hand instruments and diode laser irradiation. Original magnification, 20.
Diode Laser as Adjunct to Traditional Periodontal Treatment

gingival calculus (inclusive of molar furcations). The objective of using diode laser irradiation as adjunct scaling and root planing would be to improve the efficacy of root instrumenta-
tion and to minimize collateral effects (decontamination effect and dentine hypersensitivity).

In another in vitro study, Theodoro et al. reported that the application of an 810-nm diode laser did not cause any micro-
scopically detectable alterations on the root surface, because the absorption coefficient of water is small. However, these findings might be due to the mode of laser emission, to differ-
ent laser wavelength, to the time of exposure, to the working angle, and to use of a saline solution to minimize the thermal
damage of laser irradiation.

CONCLUSION

Our study supports the clinical use of diode laser in peri-
odontology because of its minimal effect on the cementum tis-
sue. The results of this study have prompted us to begin treating periodontal patients with a association of conventional and laser
therapy in order to make best use of the specific ad-
vantages of each clinical procedure.

REFERENCES

1. Walsh, L.J. (2003). The current status of laser applications in dent-
evaluation of the Nd:YAG laser in pocket periodontal therapy. Br.
periodontal pockets with a diode laser. Lasers Surg. Med. 22,
302-311.
22, 509-512.
laser for de-epithelization of periodontal flaps. J. Periodontol. 68,
763-768.
senide diode laser on human periodontal disease: a microbiologi-
sensitilization for decontamination of implant surfaces in the
reduction in periodontal pockets through irradiation with a diode
vitra effects of an Er:YAG laser, a GaAlAs diode laser, and scaling and
root planing on periodontally diseased root surfaces: a com-
perature changes during root surface irradiation with an 809-nm
Endod.93, 730-735.

FIG. 5. Higher magnification of previous image. Notice that
in the furcal area there was not signs of side effects. Original
magnification, 40.

Schwarz et al. had studied the use of laser irradiation without
conventional treatment (scaling and root planning), and there-
fore their study design is different from ours and the results not
comparable. In this respect, it is important to consider the re-
sults of our study, which have shown complete removal of sub-

FIG. 6. Note hard deposits (i.e., calculus) in enamel of a


Address reprint requests to:
Dr. Mercedes Gallas
Stomatology Department
Facultad de Medicina y Odontología
Rua Entrerríos, S/N
Santiago de Compostela, C.P. 15782
A Coruña, Spain

E-mail: mmgallas@usc.es
Clinical Efficacy of Semiconductor Laser Application as an Adjunct to Conventional Scaling and Root Planing

Matthias Kreisler, DDS, PhD, * Haitham Al Haj, DDS, and Bernd d’Hoedt, DDS, PhD
Department of Oral Surgery, Johannes Gutenberg-University Mainz, Mainz, Germany

Background and Objectives: The aim of the in vitro study was to examine the clinical efficacy of semiconductor laser periodontal pocket irradiation as an adjunct to conventional scaling and root planing.

Materials and Methods: Twenty-two healthy patients with a mean age of 45.0±10.8 years had at least four teeth in all quadrants, were included. Of them, 15 women and 7 men underwent a conventional periodontal treatment including scaling and root planing. Using a split mouth design, two randomly chosen quadrants (one upper and the corresponding lower one) were subsequently treated with an 809 nm GaAlAs laser operated at a power output of 1.0 Watt using a 0.6 mm optical fiber. The teeth in the control quadrants were rinsed with saline. The clinical outcome was evaluated by means of plaque index (PI), gingival index (GI), bleeding on probing (BOP), sulcus fluid flow rate (SFFR), Periotest (PT), probing pocket depth (PPD), and clinical attachment loss (CAL) at baseline and 3 months after treatment. A total of 492 teeth in both groups were evaluated and differences between the laser and the control teeth were analyzed using the Wilcoxon test (P<0.05).

Results: Teeth treated with the laser revealed a significantly higher reduction in tooth mobility, pocket depth, and clinical attachment loss. Twelve percent of the teeth in the laser group showed an attachment gain of 3 mm or more, compared to 7% in the control group. An attachment gain of 2-3 mm was found in 24% of the teeth in the laser group and 18% in the control group. No significant group differences, however, could be detected for the plaque index, gingival index, bleeding on probing, and the sulcus fluid flow rate.

Conclusions: The higher reduction in tooth mobility and probing depths is probably not predominantly related to bacterial reduction in the periodontal pockets but to the de-epithelization of the periodontal pockets leading to an enhanced connective tissue attachment. The application of the diode laser in the treatment of inflammatory periodontal-ontis at the irradiation parameters described above is a safe clinical procedure and can be recommended as an adjunct to conventional scaling and root planing. Lasers Surg. Med. 37:350-355, 2005. © 2005 Wiley-Liss, Inc.

Key words: diode laser; scaling and root planing

INTRODUCTION

A variety of surgical and non-surgical modalities are available for the treatment of inflammatory periodontal diseases [1]. Subgingival scaling and root planing are the most important procedures and clinical efficacy has been demonstrated in numerous clinical studies [2-5]. This is in particular true for periodontal pockets with a probing depth of below 6 mm. With rising pocket depth, however, calculus removal and plaque control is often difficult and surgical flap procedures are recommended, allowing a better access and visual control of the root surface. Beside conventional scalers and curettes, ultrasonic systems are commonly used for the removal of subgingival calculus and bacterial plaque [6]. Bactericidal chemicals as Chlorhexidine digluconate are useful adjuncts in the treatment of periodontitis [7].

Laser applications in the field of periodontology have been of enormous scientific interest throughout the last decade and a variety of laser systems have been investigated in numerous in vitro [8-27] and in vivo studies [28-43]. In the treatment of inflammatory periodontal diseases, lasers may contribute to the bacterial reduction in periodontal pockets as well as to the removal of calculus and granulation tissue and can be used for contouring hyperplastic gingiva. An interesting aspect of laser application is the possibility of flap de-epithelization resulting in a retarded epithelial migration and an increased connective tissue formation [44-46].

The aim of the present prospective randomized clinical study was to evaluate if the adjunctive irradiation of periodontal pockets by means of a semiconductor laser subsequent to conventional scaling and root planing results in an improvement of clinical parameters and therefore, in a better prognosis of the treated teeth.

MATERIALS AND METHODS

Patient Recruitment

A total of 25 patients with periodontal treatment needs were initially included in the study. The patients were recruited from the patient pool in the Department of Oral Surgery, Johannes Gutenberg-University Mainz. Inclusion criterion was a minimum of four teeth in each quadrant.

*Correspondence to: Priv.-Doz. Dr. Matthias Kreisler, Poliklinik für Zahnärztliche Chirurgie, Johannes Gutenberg-Universität Mainz, Augustusplatz 2, 55131 Mainz, Germany.
E-mail: matthiaskreisler@web.de
Accepted 12 September 2005
Published online in Wiley InterScience (www.interscience.wiley.com).
DOI 10.1002/lsm.20252
TABLE 1. The Study was Performed by Two Clinicians (c1, c2)

<table>
<thead>
<tr>
<th>Visit 1 (c1, c2)</th>
<th>Patient recruitment, oral hygiene instructions, removal of supragingival calculus, and plaque</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visit 2 (c1)</td>
<td>Clinical measurements (baseline values)</td>
</tr>
<tr>
<td>Visit 3 (c2)</td>
<td>Subgingival scaling and root planing (two quadrants)</td>
</tr>
<tr>
<td>Visit 4 (c2)</td>
<td>Subgingival scaling and root planing (two quadrants)</td>
</tr>
<tr>
<td>Visit 5 (c2)</td>
<td>Laser treatment</td>
</tr>
<tr>
<td>Visit 6 (c1)</td>
<td>Clinical measurements</td>
</tr>
</tbody>
</table>

Each patient presented at six visits with a minimum time period of 2 weeks between visit 1 and 2, and 12 weeks between visit 5 and 6.

with the following periodontal symptoms: Pocket depth of at least 3 mm, bleeding on probing, and radiographic signs of bone loss. Criteria for exclusion were systemic diseases, hemorrhagic disorders, epilepsy, pregnancy, mental disorders, tobacco consumption of more than 10 cigarettes per day. Not included were also patients who had a periodontal treatment shorter than 2 years prior to this study. All patients signed informed consent forms.

Study Design and Clinical Parameters

The study was performed by two clinicians (c1, c2). Each patient presented at six visits (Table 1) with a minimum time period of 2 weeks between visit 1 and 2, and 12 weeks between visit 5 and 6. Visits 2, 3, 4, and 5 took place within 1 week. The clinical parameters recorded at visit 2 (baseline) and 6 (12 weeks after treatment) were plaque index (QHI) [46], gingival index (GI) [47], Periotest values (PT), sulcus fluid flow rate (SFFR), bleeding on probing (BOP), probing pocket depth (PPD), and clinical attachment loss (CAL).

Scaling and Root Planing

The mechanical subgingival instrumentation was performed using Gracey curettes (Hu-Friedy Co., Chicago, Illinois). The treatment was continued until the root surfaces were adequately debrided and cleaned. After mechanical instrumentation, the sites were rinsed with a H2O2 (3%) solution.

Laser Treatment

A split-mouth design was chosen for the investigation. After scaling and root planing, two quadrants (one superior and one inferior quadrant) were randomly chosen and laser treated. The control quadrants were rinsed with saline.

An 809 nm GaAlAs semiconductor laser operated at a power output of 1.0 W (cw) was used. Laser light was delivered by means of a 600 micron optical fiber. The fiber was inserted into the periodontal pocket, the laser activated, and the fiber slowly moved from apical to coronal in a sweeping motion during laser light emission. This was done mesially, distally, buccally, and lingually. The treatment was repeated until the entire pocket was irradiated. Laser light emission was automatically interrupted for 30 seconds after irradiation exceeded 10 seconds in time in order to avoid thermal damages. All treatments were performed under local anesthesia. Both patients and the operator wore protective glasses.

Data collection was performed by clinician 1 (c1). Scaling and root planing as well as laser treatment was performed by clinician 2 (c2). Clinician 1 was blinded.

Statistical Analysis

The statistical analysis was carried out with a spreadsheet (Excel 97, Microsoft Corp., Richmond, VA) and a statistics package (SPSS for Windows, Release 10.0.5 (1999), SPSS Inc., Chicago, Illinois). A total of 492 periodontal (246 in both laser and control group) sites were evaluated. From each parameter recorded at each periodontal site, means were calculated and used for further statistical analysis. Group comparison was performed by means of the Wilcoxon test and differences considered to be significant when P<0.05.

RESULTS

Twenty-two patients (15 female, 7 male, mean age 45.0±10.8 years) with a total of 246 teeth in each group, were evaluated. Three patients did not present at the 3-month appointment and were excluded from the study. The follow-up period was uneventful and no complications occurred.

Fig. 1. Laser light was delivered by means of a 600 micron optical fiber. The fiber was inserted into the periodontal pocket, the laser activated, and the fiber slowly moved from apical to coronal in a sweeping motion during laser light emission.
The distribution of the periodontal pocket depths at baseline was predominantly in both groups. The plaque index (QHI) (Table 2), the gingival index (GI) (Table 3), and the sulcus fluid flow rate (SFFR) (Table 4) were significantly reduced in both groups at the end of the observation period (Wilcoxon Test, \( P < 0.001 \)). However, no statistically significant differences between the two respective groups were observed.

Initially, 70.7% of all tested sites in the laser group and 71.9% in the control group revealed a bleeding on probing (BOP). The values were significantly reduced to 32.8% and 38.4%, respectively, with no significant differences between both the groups (Table 5).

After 3 months, the Periotest value (PT) was lowered by 3.2 (mean) in the laser and by 2.9 in the control group. The difference in the reduction of the values between both groups was statistically significant (\( P < 0.001 \)) (Table 6).

The difference in both the reduction of PPD and CAL between both groups was statistically significant (\( P < 0.001 \)).

DISCUSSION

The use of lasers in the treatment of inflammatory periodontitis has been the subject of numerous investigations.

Schwarz and coworkers have demonstrated that the Er:YAG laser represents a suitable alternative for non-surgical periodontal treatment resulting in similar clinical outcomes and long-term results as manual instrumentation with scalers and curettes. They reported on periodontal pocket reduction of 1.4 mm after 3 months and 2.0 mm after 6 months in the laser group and of 1.2 mm and 1.6 mm, respectively, in the control group [38]. These results remained stable for at least 2 years after treatment [42].

The clinical application of the Nd:YAG laser in the treatment of periodontitis is well documented [29,31,33,37], the results, however, are controversial. According to the studies of Ben Havit et al. [29] and Neill and Melloning [33], the use of the Nd:YAG laser in combination with scaling and root planing can significantly contribute to bacterial reduction in the treated periodontal pockets. Radvar et al. [31], however, demonstrated that scaling and root planing yields better clinical results than Nd:YAG laser treatment alone. Liu et al. [37] also demonstrated that laser therapy is less effective than traditional scaling and root and that no additional benefit was found when laser treatment was used secondary to scaling and root planing.

| Table 2. Plaque Index (QHI) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group |
|---|---|---|---|---|
| QHI | n | Baseline | 12 weeks | Difference | \( P \) |
| Laser | 246 | 1.3 ± 0.9 | 0.9 ± 0.6 | *0.40 | <0.001 |
| Control | 246 | 1.4 ± 0.9 | 0.9 ± 0.7 | *0.5 | <0.001 |
| P-value | 0.443 | 0.753 | 0.423 |

Both treatment modalities resulted in a significant reduction of the QHI. The differences between both groups, however, were not significant.

| Table 3. Gingival Index (GI) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group |
|---|---|---|---|---|
| GI | n | Baseline | 12 weeks | Difference | \( P \) |
| Laser | 246 | 1.8 ± 0.8 | 1.0 ± 0.5 | *0.8 | <0.001 |
| Control | 246 | 1.7 ± 0.8 | 1.0 ± 0.6 | *0.7 | <0.001 |
| P-value | 0.143 | 0.861 | 0.292 |

Both treatment modalities resulted in a significant reduction of the GI. The differences between both groups, however, were not significant.
TABLE 4. Sulcus Fluid Flow Rate (SFFR) (Mean and Standard Deviation) at Baseline and 12 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Laser</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>SFFR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>30.6E10</td>
<td>32.6E12</td>
</tr>
<tr>
<td>12 weeks</td>
<td>11.0E03</td>
<td>15.0E06</td>
</tr>
<tr>
<td>Difference</td>
<td>1.2E03</td>
<td>4.9E06</td>
</tr>
<tr>
<td>P-value</td>
<td>0.665</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Both treatment modalities resulted in a significant reduction of the SFFR. The differences between both groups, however, were not significant.

Finkbeiner (1995) used an Argon laser and presented data on periodontal pocket reduction in a range of 1.6-3.3 mm after a mean observation period of 4.6 months. Bleeding on probing was reduced by 75%. The results, however, remain questionable since no data from control groups was presented. Moreover, all pockets were scaled and root planed prior to lasers treatment. Therefore, it is not clear whether the observed benefit has been due to laser treatment or due to scaling and root planing [28].

The application of the diode laser in the treatment of inflammatory periodontitis has been described by Moritz et al. [35,36]. Despite promising results, the authors used irradiation parameters, which may induce morphological change of root surfaces and cause thermal damage to adjacent tissues.

The selection of irradiation parameters used in the present study was based on former in vitro investigations. Potential morphological alterations of root surface irradiation were assessed in numerous studies under standardized in vitro conditions [25]. It is known that irradiation of dry or moist specimens does not result in any surface alterations within a clinically relevant power output range. Depending on different settings, however, irradiation caused damages to the root surface when the teeth were covered by a thin blood film and when lasing was performed at 1.5, 2.0, and 2.5 Watt (cw) using a 600 micron fiber at a distance of 0.5 mm to the specimen. Laser irradiation at a power output of 1.0 Watt and below, however, had barely any negative effect on the root surface and the laser treatment did not have a significant effect on the new attachment of PDL cells on the tooth specimens in vitro [24].

TABLE 5. Bleeding on Probing (BOP) (Mean and Standard Deviation) at Baseline and 12 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Laser</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOP</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>70.7</td>
<td>71.9</td>
</tr>
<tr>
<td>12 weeks</td>
<td>32.8</td>
<td>38.4</td>
</tr>
<tr>
<td>Difference</td>
<td>37.9</td>
<td>33.5</td>
</tr>
<tr>
<td>P-value</td>
<td>0.537</td>
<td>0.163</td>
</tr>
</tbody>
</table>

Both treatment modalities resulted in a significant reduction of the BOP. The differences between both groups, however, were not significant.

The accidental or intentional application of laser irradiation on dental hard tissues results in thermogenesis, which requires special consideration of possible adverse effects on the pulp. The influence of root surface irradiation on the tooth pulp with regard to potential temperature elevations has been investigated with numerous laser systems [48-57], indicating that pulp vitality may be jeopardized if defined energy fluences are exceeded.

Investigations of intrapulpal heat generation induced by the 809 nm GaAlAs laser confirmed former studies indicating that a power output of 1.0 W and an irradiation time of 10 seconds should not be exceeded not only to avoid root surface alterations but also temperature elevations, which might jeopardize pulp vitality [26]. It is known, however, that an in vitro bacterial reduction of over 99% cannot be achieved at these irradiation parameters [27]. A microbiological examination was, therefore, not of clinical interest. Teeth treated with the laser revealed a significantly higher reduction in tooth mobility, pocket depth, and clinical attachment loss. No significant group differences, however, could be detected for the plaque index, gingival index, bleeding on probing, and the sulcus fluid flow rate.

Despite the statistical significance, it is questionable whether differences in PPD and CAL between both groups are of any clinical relevance. Only 12% of the teeth in the laser group showed an attachment gain of 3 mm or more, compared to 7% in the control group. An attachment gain of 2-3 mm was found in 24% of the teeth in the laser group and 18% in the control group (Table 9). The higher reduction in tooth mobility and probing depths is probably

TABLE 6. Periotest® Values (PT) (Mean and Standard Deviation) at Baseline and 12 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Laser</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>63.6E09</td>
<td>64.6E08</td>
</tr>
<tr>
<td>12 weeks</td>
<td>31.6E09</td>
<td>35.6E06</td>
</tr>
<tr>
<td>Difference</td>
<td>3.2</td>
<td>2.9</td>
</tr>
<tr>
<td>P-value</td>
<td>0.257</td>
<td>0.224</td>
</tr>
</tbody>
</table>

Both treatment modalities resulted in a significant reduction of the PT values. The difference in the reduction of the values between both groups was significant (Wilcoxon test, P<0.019).

TABLE 7. Periodontal Pocket Depth (PPD) (Mean and Standard Deviation) at Baseline and 12 Weeks

<table>
<thead>
<tr>
<th></th>
<th>Laser</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>PPD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline</td>
<td>4.2E1.15</td>
<td>4.3E1.26</td>
</tr>
<tr>
<td>12 weeks</td>
<td>2.4E0.67</td>
<td>2.7E0.73</td>
</tr>
<tr>
<td>Difference</td>
<td>1.8</td>
<td>1.6</td>
</tr>
<tr>
<td>P-value</td>
<td>0.012</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

Both treatment modalities resulted in a significant reduction of the PPD values. The difference in the reduction of the values between both groups was significant (Wilcoxon test, P<0.001).
not predominantly related to bacterial reduction in the periodontal pockets but to the de-epithelization of the periodontal pockets leading to an enhanced connective tissue attachment. Moreover, it should be stressed that the results in this study were obtained from a population with a rather mild form of periodontitis as shown by the distribution of periodontal pocket depths at baseline. Further studies are needed to evaluate if comparable results can be achieved in patients with a severe form of periodontal disease.

The application of the diode laser in the treatment of inflammatory periodontitis at the irradiation parameters described above is a potential adjunct to conventional scaling and root planning.

REFERENCES

SEMICONDUCTOR LASER AS AN ADJUNCT TO SCALING AND ROOT PLANING


Correlation between oral hygiene and periodontal condition.


Effect of Galium Arsenide Diode Laser on Human Periodontal Disease: A Microbiological and Clinical Study

Selcuk Yilmaz,1,2 Bahar Kuru,1,2* Leyla Kuru,1 Ulku Noyan,1,2 Dilek Argun,1 and Tanju Kadir3

1Department of Periodontology, Faculty of Dentistry, Marmara University, Istanbul, Turkey
2Department of Periodontology, Faculty of Dentistry, Yeditepe University, Istanbul, Turkey
3Department of Microbiology, Faculty of Dentistry, Marmara University, Istanbul, Turkey

INTRODUCTION

Successful periodontal treatment is dependent on the stoppage of tissue destruction, elimination or control of etiological agents together with a microbial shift toward one typically present in health [1,2]. The elimination of the pathogenic subgingival microbiota may be achieved by non-surgical scaling and root-planing [3±5]. However, mechanical therapy alone, may fail to eliminate the pathogenic bacteria because of their location within the gingival and dental tissues or in other areas inaccessible to periodontal instruments [6,7]. These limitations and the improved biological understanding of periodontal diseases together with the emerging evidence of bacterial specificity have led to a move in emphasis from a pure mechanical approach to other methods which include the use of adjunctive antimicrobial measures. Methods of killing periodontal pathogens, therefore, are of great interest and considerable attention has been devoted to the possibility of using antibiotics or antimicrobials in this respect. More recently, it has been suggested that high-power lasers, such as Nd/YAG laser, which emit light in the infrared region may be useful for destroying such organisms, presumably by a thermal effect [8]. However, the clinical use of such high-power lasers introduces problems from the point of view of thermal side effects on surrounding tissues [9]. An alternative approach using light in the visible region of the electromagnetic spectrum would be more attractive from the point of view of safety. Although most species of oral bacteria do not absorb visible light and so are largely unaffected by such radiation, assimilation or adsorption of a colored compound by these organisms can sensitize them to visible light [10]. It has been shown in in vitro studies that it is possible to kill oral bacteria with light from a low power laser, once they have been sensitized by various dyes such as toluidine blue O or methylene blue [10±16]. This implies that low power lasers, in conjunction with appropriate photosensitizers, may be a useful adjunct to mechanical debridement in the treatment of inflammatory periodontal diseases if a similar effectiveness can be achieved in vivo. To the best of our knowledge, no investigations evaluating the use of low power soft lasers in conjunction with topically applied photosensitizers in the treatment of periodontal diseases are available in the literature. Therefore, the purpose of this study was to examine the short-term effect of low power lasers on the microbiological and clinical parameters obtained by treatment with soft laser in conjunction with methylene blue and/or mechanical subgingival debridement in human periodontal disease.

Stud Design/Materials and Methods: Ten patients, in whom each dental quadrant was randomly designated to receive one of four types of treatment procedures, were included in the study. Groups of quadrants received: scaling/root planing (SRP); laser application (L); SRP combined with L (SRP/L); oral hygiene instructions (OH). Four single rooted teeth (one in each quadrant), having an interproximal site with a probing depth of 4 mm mesio-buccally, were selected in each patient. The selected teeth were first assessed for microbiological (one site/tooth) and then for clinical variables (six sites/tooth). Supragingival irrigation with methylene blue was performed prior to laser application. The microbiological (proportions of obligate anaerobes) and clinical measurements (plaque and gingival indices, bleeding on probing, probing pocket depth) were evaluated over a period of 32 days.

Results: Only the SRP/L and SRP groups provided significant reductions in the proportions of obligate anaerobes before and after treatments with no significant differences in between. Parallel to the microbiological changes, both SRP/L and SRP resulted in similar clinical improvements, whereas L alone revealed a limited effect similar to OH.

Conclusion: Within the limits of this study, methylene blue/soft laser therapy provided no additional microbiological and clinical benefits over conventional mechanical debridement. Lasers Surg. Med. 30:60±66, 2002.
soft laser therapy in conjunction with topical methylene blue and/or mechanical subgingival debridement on periodontal pockets with regard to the antimicrobial abilities and the improvement of periodontal condition.

MATERIALS AND METHODS

The study group comprised ten systemically healthy subjects with early to mild periodontitis who applied for treatment to the clinics of the Department of Periodontology at the Faculty of Dentistry, Marmara University and Yeditepe University. Patients who have taken antibiotics or received periodontal treatment within 6 months preceding the study were not included. They were instructed about the nature and purpose of the study and consents were obtained. Prior to any treatment procedure, oral hygiene instructions (OHI) were given. Each quadrant of the subjects was randomly assigned to one of the following groups: scaling and root planning combined with laser application (SRP/L), laser application (L) alone, scaling and root planning (SRP) alone, and OHI alone. Patients were asked to rinse with methylene blue (Buco blu 15 g, Koz Ilac San. Ve Tic. A.S.) for 1 minutes prior to laser application. Solutions were made up on a w/v basis (0.005%) [11].

Site Selection

Four single-rooted teeth (one in each quadrant) having an approximal site with a probing depth of 4 mm mesio-buccally were selected in each patient. To enhance the accuracy of measurement and simplify microbial sampling, mesio-buccal sites were chosen. The selected teeth were first assessed for microbiological (one site/tooth) and then for clinical variables (six sites/tooth). Clinical measurements were performed by a single examiner, whereas microbial culturing was done by another individual.

Microbiological Procedures

After superficial cleaning of the sites with cotton pellets and drying of the supragingival area with a stream of air, samples were taken by sterile paper points inserted into the depth of the pocket, left for 10 seconds and cultured as described by Noyan et al. [17] and Kuru et al. [18]. Briefly, each sample was aseptically transferred to 4.5 ml of phosphate buffered saline (PBS) and immediately dispersed using a vortex mixer at maximal setting for 60 seconds. The dispersed samples were serially diluted, and 0.2 ml portion of 10^1, 10^2, ..., 10^5 dilutions were spread on a solid agar medium using sterile bent glass rods.

Trypticase soy agar plate (Oxoid Ltd.; Hamsphire, England) enriched with 0.0005% hemin (Sigma Chemical Co.; St. Louis, MO, USA), 0.00005% menadione (Sigma), and 5% defibrinated sheep blood, was inoculated for non-selective bacterial growth [19]. Furthermore, trypticase soy agar plate enriched with 5% defibrinated sheep blood was used for cultivation for facultative anaerobic microorganisms.

After 7 days of incubation of the supplemented trypticase soy agar plates in Gas Pak jars (Gas generating kit, Oxoid) in an atmosphere of 95% H₂ and 5% CO₂ at 378C, the total viable count (TVC) was determined from the dilution giving 30±300 colonies. TVC was expressed in terms of milliliter of transport medium. Colonies were identified by the analysis of colony morphology, aerotolerance, pigmentation, Gram staining procedures, motility, catalase and oxidase activity, and using API 20 A strips (BioMerieux, France). After 5 days of incubation of a trypticase soy agar plate in air and 10% CO₂ at 378C, the total number of facultative anaerobes was determined.

All the microbiologic data were transformed into colony forming units/milliliter (CFU/ml). Obligate anaerobic bacteria was calculated as the total counts of anaerobically cultivable bacteria (TVC) minus the total counts of facultatively anaerobic bacteria and expressed as a percentage of TVC.

Clinical Parameters

Clinical measurements were performed at the selected teeth that were assessed for microbiological variables. The measurements included plaque index (PI) [20], gingival index (GI) [21], bleeding on probing (BOP), and probing pocket depth (PPD) to the nearest mm using a calibrated manual probe (PQ-OW Chicago, IL, USA, Hu-Friedy Instrument Co.).

Laser

The laser used was a Gallium-Arsenide diode laser (BTL-2000 Prague, Check, Rep., BTL Co., Check Rep.) operating at a frequency of 5.0 Hz and delivering a 30 mW continuous wave output at 685 nm with a power density of 1.6 J/cm². Patients received 1.11 minutes treatment three times a week over each papillary region as recommended by the manufacturer. During application, protective eyeglasses were worn both by the operator and the patient.

Study Design

The study design is presented in Table 1. Seven days before commencement of the experimental procedures, oral hygiene instructions were given. The day when microbiological samples and clinical records were taken was designated as the day 0. On the days 1 and 7, the mechanical subgingival debridement was undertaken using the ultrasonic and hand instruments for the SRP/L and SRP groups. This procedure was followed immediately by soft laser application for the SRP/L group as well as the L group. On the days 2, 4, 9, and 11, the soft laser was applied to the SRP/L and L groups. Methylene blue was applied as a mouth rinse prior to laser application. The OHI group received neither mechanical debridement nor laser application. Three weeks after therapy procedures, microbiological samples were obtained and clinical measurements were repeated.

After completion of the experimental period, the quadrants which received laser application alone and OHI alone were subjected to further mechanical subgingival debridement.

Statistics

Differences between the pre- and post-treatment values within each group and differences between the changes of
the pre- and post-treatment values among groups were compared using the Wilcoxon matched-pairs signed rank test [22] using the NCSS statistics package program on an IBM compatible computer. The probability value for statistical significance was set at $P \leq 0.05$.

RESULTS

There were no complaints such as discomfort, sensitivity or pain from subjects immediately after laser irradiation as well as 3 weeks post-therapy. The approach of patients appeared to be positive toward laser.

Microbiological Assessments

TVC (total anaerobically grown) and obligate anaerobic micro-organisms (total viable counts of anaerobically cultivable bacteria minus the total counts of facultatively anaerobic bacteria determined using parallel sets of aerobically and anaerobically incubated agar plates) expressed as a percentage of TVC in subgingival samples before and after different treatments, are given in Tables 2

Following subgingival mechanical debridement combined with laser application (SRP/L), a decrease in TVC from the mean baseline value of 19.08 $\pm$ 18.62 to 15.31 $\pm$ 20.67 was noted. However, this reduction along with minor fluctuations in other groups was not significant (Table 2).

Table 3 demonstrates the differences from baseline in percent obligate anaerobes of TVC in four test groups. The proportions of obligate anaerobes decreased notably in all groups. However, only the SRP/L and SRP groups provided significant changes from baseline to 32 days post-therapy values (from 50.54 $\pm$ 27.29 to 16.36 $\pm$ 22.28, and from 47.66 $\pm$ 26.62 to 16.06 $\pm$ 17.54, respectively) ($P \leq 0.05$). When changes in the proportions of obligate anaerobes between the four groups were compared, as shown in Table 4, the differences between the SRP/L and L, SRP/L and OHI, and SRP and OHI were found to be significant ($P \leq 0.05$).

Clinical Assessments

Improvements with respect to clinical parameters occurred in all groups between the baseline and post-therapy measurements. The analysis of the PI (Fig. 1) and GI (Fig. 2) parameters indicated significant reductions from baseline to day 32 for all groups ($P \leq 0.05$). With respect to the BOP, significant reductions were observed in the SRP/L and SRP groups ($P \leq 0.05$), whereas the reductions in this parameter of the L and OHI groups were found insignificant (Fig. 3). Similarly, PPD declined significantly in the SRP/L and SRP groups after treatment.

---

**TABLE 2. Total Viable Counts ($\times 10^3$ CFU/ml) of Subgingival Samples at the Baseline and 3 Weeks After Treatment**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>SRP and laser</th>
<th>Laser</th>
<th>SRP</th>
<th>OHI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>19.08 ($\pm$ 18.62)</td>
<td>15.69 ($\pm$ 8.92)</td>
<td>10.57 ($\pm$ 7.19)</td>
<td>12.60 ($\pm$ 8.32)</td>
</tr>
<tr>
<td>Post-therapy</td>
<td>15.31 ($\pm$ 20.67)</td>
<td>15.89 ($\pm$ 9.40)</td>
<td>8.41 ($\pm$ 7.40)</td>
<td>11.04 ($\pm$ 8.36)</td>
</tr>
<tr>
<td>Z</td>
<td>1.27</td>
<td>0.05</td>
<td>0.56</td>
<td>0.36</td>
</tr>
<tr>
<td>$P$</td>
<td>0.20&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>0.96&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>0.58&lt;sup&gt;NS&lt;/sup&gt;</td>
<td>0.72&lt;sup&gt;NS&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Data are presented as the mean values and the numbers in brackets are the standard deviations.

SRP, scaling and root planning; OHI, oral hygiene instruction; NS, not significant.
procedures (P < 0.05), as shown in Figure 4. Although the PPD score also tended to decrease in the L and OHI groups, these reductions were not significant.

Comparisons of the changes in the clinical parameters before and after therapy among the groups are shown in Table 5. Similar changes were observed in the SRP/L and SRP groups and the differences between these two groups in all clinical parameters were not statistically significant. In contrast, the L group demonstrated significantly less reductions in the PI, BOP, and PPD measurements compared to the SRP/L group (P < 0.05) except the GI parameter. In addition, no significant differences were noted between the L and OHI groups.

Taking the changes in all microbiological and clinical parameters into consideration, the mechanical subgingival debridement alone or in combination with laser application was observed to be more effective as compared to laser application alone.

DISCUSSION

Laser technology originated in 1960 and has developed since then. Recently the use of laser therapy has appeared with increasing frequency in the dental literature. It should be emphasized that there are different theories on the effects of laser and still many questions concerning its therapeutic value are unanswered. At the present time, the antimicrobial effects of low power lasers have not been substantiated. In assessing the potential antimicrobial effects of low power laser irradiation, a number of investigations to date has been done. Moritz et al. in their studies suggested that irradiation with the diode laser with a wavelength of 805 nm facilitates bacterial elimination from periodontal pockets [23,24]. On the other hand, in vitro studies pointed out that in the absence of an appropriate photosensitizer, exposure to low power laser light had no significant effect on the viability of the pure cultures of suspected periodontal pathogens such as Porphyromonas gingivalis, Actinobacillus actinomycetemcomitans, and Fusobacterium nucleatum [10±12]. It is also reported that oral bacterial species most of which do not absorb visible light and so are unaffected by such irradiation can be killed by red light from a helium/neon laser following sensitization with various dyes, especially toluidine blue O and methylene blue [10±13]. Haas et al. in another in vitro study found that dye/laser treatment resulted in the destruction of bacterial cells on different implant surfaces [14]. In a recent study, Dortbudak et al. evaluated the laser effect on peri-implantitis-associated bacteria in vivo [25]. Although the complete elimination of bacteria was not achieved in this study, authors confirmed the bactericidal effect of toluidine blue O/laser treatment when the dye applied topically on implant surfaces.

Given the problems in extrapolating irradiation parameters and findings from in vitro research to human practice, trials in humans are essential. The use of dye/soft lasers in periodontal treatment in terms of their bactericidal effects has not been investigated in vivo. It is observed that higher doses are required to produce in vivo clinical effects than those commonly used for in vitro research [26]. One of the major problems in evaluating the laser efficacy is the determination of the optimal dosage and treatment schedule. With low power lasers, this remains an area of controversy both in medicine and dentistry. Although there is some guidance from other experiments, the choices remains discouragingly wide. Furthermore, there are great differences in the published literature in terms of experimental and assessment methods and irradiation conditions. The laser used for therapy in this study was a Gallium±Arsenide diode laser operating at a frequency of 5.0 Hz and delivering a 30 mW continuous wave output at 685 nm with a power density of 1.6 J/cm². Patients received 1.11 minutes treatment three times a week over each papillary region as recommended by the manufacturer. In the present well-controlled split-mouth study providing a comparison by eliminating subject-based differences, topical methylene blue/laser
treatment produced no significant antimicrobial effects at the aforementioned settings.

Methylene blue was used as the photosensitizer and applied as a mouth rinse prior to laser irradiation, since it is expected that agents in mouth rinses during supragingival irrigation can be projected into pockets less than 5 mm in depth and access to subgingival plaque can be achieved [27,28]. No significant reductions in the proportions of subgingival obligate anaerobes were detected before and after laser treatment alone. Within SRP and SRP/L groups, significant reductions in the proportions of obligate anaerobes were observed before and after treatments. However, intergroup comparison revealed no significant differences in between the groups SRP and SRP/L.

Clinical results of this study showed improvements when parameters recorded at the baseline and 3 weeks after procedure were compared. All treatment groups showed decreases in the PI, GI, BOP, and PPD parameters. However, significant reductions in PPD and BOP were observed only in the groups where mechanical subgingival debridement was performed (the SRP/L and SRP groups). This is consistent with the other studies in the related literature confirming the importance of mechanical debridement as the cornerstone for control and prevention of periodontal disease [1,17,29,30]. On the contrary, laser application without elimination of local aetiological factors resulted in insignificant reductions in PPD and BOP similar to oral hygiene regimens [31,32]. Supragingival plaque removal alone is unlikely to be sufficient to control periodontal diseases as also demonstrated by Listgarten et al. [3] and Beltrami et al. [33]. However, some shrinkage of the gingival tissues with some reduction of inflammation may occur [17,32,34]. L and OHI groups seem to have the least favorable clinical results when compared to SRP/L and SRP alone. This may indicate the unfavorable healing at the base of the pocket due to the lack of any subgingival treatment.

Periodontal diseases are bacterial infections and therefore the aim of the periodontal therapy is to eliminate or control the periodontopathic bacteria. Direct subgingival delivery of methylene blue in different concentrations should be performed to further investigate the potential antimicrobial effect of soft lasers in human periodontal disease. Dosimetric factors are also of critical importance [15,35]. The essential question is whether soft laser can provide equal or improved treatment over conventional methods in terms of antimicrobial effects.

We do feel that more research is required to effectively determine optimal treatment parameters/regimens for the significance of applying a new treatment method which is low cost, not painful, apparently harmless, and technically
an easy treatment to perform should not be overlooked. If the in vitro bactericidal effectiveness of dye/soft laser can be achieved in vivo, low power lasers in conjunction with photosensitizer may be useful in the treatment of in amnatory periodontal diseases.

ACKNOWLEDGMENTS

We would like to thank the BTL Company for providing the BTL 2000 device.

REFERENCES

25. Dortbudak O, Haas R, Bernhart T, Mailath-Pokorny G. Lethal photosensitization for decontamination of implant


Treatment of Periodontal Pockets With A Diode Laser

Andreas Moritz, MD, DDS, Ulrich Schoop, MD, Kawe Goharkhay, MD, Petra Schauer, MD, Orhun Doertbudak, MD, Johann Wernisch, DTSc, and Wolfgang Sperr, MD, DDS, PhD

1Department of Conservative Dentistry, Dental School of the University of Vienna, A-1090 Vienna, Austria
2Institute of Applied and Technical Physics, Technical University of Vienna, A-1040 Vienna, Austria

Background and Objective: The aim of this study is to examine the long-term effect of diode laser therapy on periodontal pockets with regard to its bactericidal abilities and the improvement of periodontal condition.

Study Design/Materials and Methods: Fifty patients were randomly subdivided into two groups (laser-group and control-group) and microbiologic samples were collected. There have been six appointments for 6 months following an exact treatment scheme. After evaluating periodontal indices (bleeding on probing, Quigley-Hein) including pocket depths and instruction of patients in oral hygiene and scaling therapy of all patients, the deepest pockets of each quadrant of the laser-group’s patients were microbiologically examined. Afterwards, all teeth were treated with the diode laser. The control-group received the same treatment but instead of laser therapy were rinsed with H2O2. Each appointment also included a hygienic check-up. After 6 months the final values of the periodontal indices and further microbiologic samples were measured. The total bacterial count as well as specific bacteria, such as Actinobacillus actinomycetemcomitans, Prevotella intermedia, and Porphyromonas gingivalis, were assessed semiquantitatively.

Results: The bacterial reduction with diode laser therapy was significantly better than in the control group. The index of bleeding on probing improved in 96.9% in the laser-group, whereas only 66.7% in the control group. Pocket depths could be more reduced in the laser group than in the control group.


© 1998 Wiley-Liss, Inc.

Key words: root; scaling; microbiology

INTRODUCTION

This study examines the long-term effect of combined periodontal treatment with diode laser and scaling, evaluates bacterial reduction in periodontal pockets, and documents changes in periodontal pocket depth prior to, and following, treatment.

So far, conventional methods for treatment of periodontal disease have not been equally effective in eliminating all types of bacteria. Actinobacillus actinomycetemcomitans, especially,

*Correspondence to: Andreas Moritz, MD, DDS, Dental School, University of Vienna, Waehringerstrasse 25a, A-1090 Vienna, Austria.

Accepted 2 March 1998

© 1998 Wiley-Liss, Inc.
Diode Laser Therapy on Periodontal Pockets

TABLE 1. Treatment Scheme

<table>
<thead>
<tr>
<th>Appointment No.</th>
<th>Lased group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 1</td>
<td>Selection of patients on the basis of periodontal pocket depth; evaluation of periodontal indices; instruction in oral hygiene and tooth brushing; scaling of all teeth.</td>
<td>Selection of patients on the basis of periodontal pocket depth; evaluation of periodontal indices; instruction in oral hygiene and tooth brushing; scaling of all teeth.</td>
</tr>
<tr>
<td>No. 2 after 1</td>
<td>Hygienic check-up; microbiologic examination; LASER.</td>
<td>Hygienic check-up; microbiologic examination; rinsing with H₂O₂.</td>
</tr>
<tr>
<td>No. 3 after 2</td>
<td>Microbiologic examination</td>
<td>Microbiologic examination</td>
</tr>
<tr>
<td>No. 4 after 2</td>
<td>Hygienic check-up; LASER.</td>
<td>Hygienic check-up; rinsing with H₂O₂.</td>
</tr>
<tr>
<td>No. 5 after 4</td>
<td>Hygienic check-up; LASER.</td>
<td>Hygienic check-up; rinsing with H₂O₂.</td>
</tr>
<tr>
<td>No. 6 after 6</td>
<td>Microbiologic examination; measurements of periodontal pocket depth.</td>
<td>Microbiologic examination; measurements of periodontal indices; measurements of periodontal pocket depth.</td>
</tr>
</tbody>
</table>

plays a causative role in the development of periodontal disease that has shown to be difficult to eliminate [1].

Since a pilot study on diode laser treatment yielded very favorable results regarding bacterial reduction of Actinobacillus actinomycetemcomitans, Porphyromonas gingivalis, and Prevotella intermedia, this long-term study was carried out to evaluate the bacterial counts in periodontal pockets irradiated with the diode laser over a 6 month period.

Changes in periodontal pocket depth and papillary bleeding index were used as significant parameters in the evaluation of the success of treatment.

MATERIALS AND METHODS

The patients were randomly subdivided into two groups. Thirty-seven patients were assigned to the group that underwent laser treatment; however, three of them could not be considered in the final evaluation because of inadequate oral hygiene. Thirteen patients were used as controls, one patient dropped out due to illness.

Table 1 illustrates the treatment scheme that determined the different examination and treatment steps. The criterion for inclusion in this study was that at least one periodontal pocket with a depth of at least 4 mm had to be present in each of the four quadrants. All patients were completely dentate. When wisdom teeth were present, they were included in the treatment but excluded from the evaluation.

Measurements of the periodontal indices were carried out. The papillary bleeding index (PBI) and the plaque index according to Quigley and Hein were assessed and the depth of all periodontal pockets were measured using a special periodontal probe (Ash Parodontic 25G). All measurements were carried out by the same examiner.

To create comparable conditions, the patients were asked to brush their teeth twice daily after meals with a specific toothpaste (Blend-a-med, Procter & Gamble, Schwalbach, Germany) and were instructed in proper oral hygiene. Furthermore, all patients underwent scaling at the first appointment. They were recalled 1 week later for microbiologic sampling. One sample per patient was obtained from the deepest approximal periodontal pocket. The microbiologic samples were obtained using sterile paper tips that were introduced into the periodontal pocket for 10 seconds. The subgingival portion of the paper tip was cut off with a sterile pair of scissors and put into a transport jar containing 1 ml reduced transport fluid without EDTA.

In the lased group, 29.4% of the samples from maxillary periodontal pockets were obtained from the molar region, 11.8% from the premolar region, and 11.8% from the anterior region.

Of the samples from mandibular periodontal pockets 17.6% were obtained from the molar region, 20.6% from the premolar region, and 8.8% from the anterior region.

In the control group, 33.4% of the maxillary samples were obtained from the molar region, 8.3% from the premolar region, and 16.7% from the anterior region, while 25% of the mandibular
samples were taken from the molar region, 8.8% from the premolar region, and 8.3% from the anterior region.

Microbiologic Evaluation

The total bacterial counts as well as specific bacteria, such as Actinobacillus actinomycetemcomitans, Prevotella intermedia, and Porphyromonas gingivalis, were assessed semiquantitatively.

Microbiologic Examinations

The samples were first shaken by vortexing for 30 seconds and then diluted 1:100 and 1:1,000 in RTF. One-hundred l of the undiluted suspension, 100 l of the suspension diluted 1:100 RTF, and 100 l of the suspension diluted 1:1,000 RTF were inoculated on ETSA (enriched trypticase soy agar), TSBV, and KVLB (kanamycin 75 g/ml, vancomycin 2 mg/ml) agar, respectively. ETSA and KVLB agars were incubated with mixed gas (80% N₂, 10% H₂, 10% CO₂) in anaerobic jars for 7 days at 37°C using the evacuation replacement method. TSBV agar was incubated with 10% CO₂ for 5 days at 37°C.

Actinobacillus actinomycetemcomitans was identified using gram staining, colony morphology, and positive catalase reaction. Prevotella intermedia and Porphyromonas gingivalis were identified using gram staining, incubation in 5% CO₂, BA-NA hydrolytic activity, -glucosidase activity, esculin hydrolysis, and Indole test.

The lased group underwent irradiation with the diode laser at the second appointment. Lasing was carried out with a diode laser by Dentek Laser System (Dentek, Gaisfeld, Austria) that has a thin flexible light guide with a diameter of 0.4 mm and a wavelength of 805 nm. All periodontal pockets of all patients of this group were lased at an output power of 2.5 W, a pulse duration of 10 ms, and a frequency of 50 Hz.

Each tooth was subdivided into four quadrants, each of which was lased separately as follows: The light guide was introduced into the periodontal pocket and moved from apical to coronal, parallel along the root surface, in a sweeping fashion. This procedure was carried out in all four quadrants, i.e., buccally, lingually, palatally, and approximally. All teeth were lasered at an output power of 2.5 W, a pulse duration of 50 ms, and a frequency of 50 Hz. The duration of lasing depended on the depth of the respective periodontal pocket. The pocket depth in mm corresponded to the exposure time in seconds. 3-mm-deep pockets were lasered for 3 seconds, 4-mm-deep pockets for 4 seconds, 5-mm-deep pockets for 5 seconds, and so on.

The control group underwent rinsing with H₂O₂ at the second appointment, following the microbiologic examination.

At the third appointment after two weeks, the patients of both groups underwent another microbiologic examination, the procedure used being the same as above. The microbiologic samples were obtained from the same periodontal pockets as in the first examination.

At the fourth appointment after 2 months, both groups again underwent an evaluation of the hygienic index. The patients of the lased group again underwent lasering of all teeth as described above.

At the fifth appointment after 4 months comprised the same treatment and examination procedures as the fourth appointment.

At the last recall appointment after 6 months, microbiologic samples were again obtained from the same periodontal pockets as before using the same procedure. Furthermore, the same examiner carried out measurements of all periodontal indices and periodontal pocket depth in both groups.

As mentioned previously, some of the patients did not meet minimum oral hygiene requirements (Quigley-Hein Index 1) and had to be excluded from the evaluation.

RESULTS

Changes in the Bacterial Counts Following Treatment of Both Groups

Table 2 shows a comparison between the initial and the final findings. As far as the total bac-

<table>
<thead>
<tr>
<th>TABLE 2. Comparison Between Initial and Final Findings*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group</td>
</tr>
<tr>
<td>-------</td>
</tr>
<tr>
<td>Lased group</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Control group</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

*TC, Total bacterial count; AAC, Actinobacillus actinomycetemcomitans; Pi, Prevotella intermedia; Pg, Porphyromonas gingivalis.
terial count is concerned, long-term bacterial reduction was achieved in the 100% of the lasered patients, whereas 58.4% of the controls showed an improvement of the values, i.e., bacterial reduction, 8.3% a deterioration of the results, i.e., an increase in bacteria in the periodontal pockets, and 33.3% consistent results, i.e., the initial and final values were the same.

The long-term bactericidal effect of the diode laser on Actinobacillus actinomycetemcomitans (AAC) is of interest as well. Bacterial reduction of AAC was achieved in 73.5% of the lasered patients; the remaining 26.5% had not been contaminated with this bacterium from the start. In contrast, 33.3% of the controls showed bacterial reduction, 16.7% consistent values, and 8.3% an increase in bacteria. More than 41% of the controls had not shown contamination with AAC from the start.

A reduction in Prevotella intermedia (Pi) was achieved in 85.3% of the lasered patients and 58.35% of the controls.

Similar results were obtained for Porphyromonas gingivalis (Pg) and are shown in Table 2.

Figure 1 shows a comparison of the reduction in total bacterial counts by logarithmic steps between the lased group and the control group. It can be seen that 58.8% of the lasered patients underwent bacterial reduction by one log step, i.e., by one power of ten, 26.5% by two log steps, and 14.7% by three log steps. 33.3% of the controls underwent bacterial reduction by one log step, 16.8% by two log steps, and 8.3% by three log steps. In the control group, 33.3% showed consistent results and 8.3% an increase in the total bacterial count by one log step.

Figure 2 shows the changes in the bacterial counts of AAC. A noticeable finding was that 58.8% of the lasered patients showed bacterial reduction by one log step. In comparison, 25% of the controls showed an improvement of the values by one log step. While none of the lasered patients showed worsening of the results, the values of 8.3% of the controls deteriorated by one log step.

As far as Pi is concerned, 41.2% of the lasered patients underwent bacterial reduction by one log step, 35.3% by two log steps, 5.9% by three log steps, and 2.9% by four log steps. Over 58% of the controls showed an improvement of the results by one log step (Fig. 3).

Figure 4 shows the changes in the bacterial counts of Pg. 47.1% of the lasered patients underwent a reduction in the bacterial count by one log step, 26.5% by two log steps, and 14.7% by three log steps, whereas 41.6% of the controls showed a reduction in Pg by one log step and 16.7% by two log steps.
log steps. Consistent results were seen in 16.7% and in 8.3%, a deterioration of the results by two log steps.

Figure 5 illustrates the changes in the papillary bleeding index (PBI). The values improved in 96.9% of the lased patients and remained the same in 3.1%. PBI improved in 66.7% of the controls and remained consistent in 33.3%.
Figure 6 shows the changes in the depth of all approximal periodontal pockets for both the lased and the control groups. The teeth were subdivided into anterior teeth, premolars and molars to facilitate a better comparison. Figure 6 clearly shows that the number of periodontal pockets whose depth decreased in comparison to the initial value was markedly greater in the lased group.
group than in the control group. The control group, on the other hand, showed more periodontal pockets with an increased pocket depth than did the lased group.

Figure 7 allows a comparison of the mean periodontal pocket depths, showing the initial and final values separately for the anterior, premolar, and molar regions, as well as a comparison between the lased group and the control group.

In the lased group, the mean periodontal pocket depth decreased from 3.9 mm to 2.6 mm, especially in the molar region. Furthermore, the mean periodontal pocket depth in the premolar region decreased by 1 mm in this group. In the anterior region, the values decreased from 2.5 mm to 1.6 mm.

In the control group, the mean initial periodontal pocket depth in the molar region was around 3 mm and decreased to 2.6 mm after 6 months. The periodontal pocket depth in the premolar and molar regions was reduced by 0.1 mm and 0.2 mm, respectively.

DISCUSSION

Most publications dealing with laser treatment of periodontal tissues cover the usage of the Nd:YAG laser. However, we expect the diode laser to have similar properties as the Nd:YAG laser that emits radiation within the infrared range at a very similar wavelength.

The effect of laser irradiation on certain tissues depends on both the wavelength of the laser and the absorbing capacity of the lased tissue. A study by Gold et al. [3] demonstrated that the application of the Nd:YAG laser for curettage of the pocket epithelium does not cause damage to the underlying tissue layers. Histologic sections revealed complete removal of the pocket epithelium without necrosis and carbonization of the connective tissue structures in 83% of the cases.

A theoretical paper by Rastegar et al. [4] comparing the application of a high-power diode laser (810 nm) and a Nd:YAG laser (1,064 nm) for tissue coagulation showed that both lasers had similar effects.

However, the heat building up at a depth of 0.2 cm in the prostatic tissue of a dog during irradiation with a diode laser was almost 1.5 times that caused by the Nd:YAG laser. This means that the diode laser radiation was absorbed mainly by the superficial prostatic layers.

Because desmodontal tissue is very well sup-
plied with blood, it is of interest to see to what extent diode laser radiation is absorbed by blood. Rastegar et al. [4] examined the absorption of laser radiation by oxygenated and deoxygenated blood and found an absorption of 4.5 cm\(^{-1}\) and a penetration of 2.2 mm in both. A comparison of the absorption values of other tissues examined in that study (liver, heart, prostate) revealed that the greatest absorption occurs in oxygenated and deoxygenated blood. It can thus be concluded that tissue that is very well supplied with blood too shows a high absorbing capacity.

Morlock et al. [5] observed melted and resolidified porous globules consisting of root mineral substance at the root surface following Nd:YAG laser treatment. The impressions in the root cementum had a mean depth of 20-30 μm. Infrared spectroscopic examinations carried out by Spencer et al. [6] revealed a decrease in the protein/mineral ratio of the root surface following Nd:YAG laser treatment. Cobb et al. [7] reported a significant reduction in periodontopathic bacteria. However, the cementum surface was damaged by the high energy levels of 1.75 W and higher in vivo. Ineffective and patchy removal of deposits on the root surface was observed that was associated with areas of cratering and melt-down. Wilder-Smith et al. [8] were able to eliminate the smear layer on root-planed surfaces without inducing hard tissue microstructural damage. The intra-pulpal temperature increased to 22°C and the surface temperature to 36°C. Zach and Cohen [9] found that a temperature rise as small as 5.5°C can damage pulpal vitality.

Horton and Lin [10] indicated that subgingival application of the pulsed Nd:YAG laser should be at least equally effective in reducing recolonization of specific bacterial species as scaling and root planing, less effective in removing calculus, and without any difference regarding measurements of probing depth and attachment loss.

According to Radvar et al. [11], Nd:YAG-laser-induced damage to the root surface also depends on the treatment method used. Only when the laser beam is guided parallel to the root surface does it not cause damage to the root, whereas perpendicularly applied laser radiation damages the root surface.

As far as bacterial reduction in periodontal pockets is concerned, the diode laser is expected to have a disinfecting thermal effect on bacteria that is basically limited to the root surface. The thermal effect of the laser beam is based on the absorption of radiation by tissue and subsequent transformation of laser energy into heat. Tissue absorbs a certain amount of laser radiation per volume and transforms it into a certain amount of energy, depending on the exposure time used. The
amount of energy absorbed depends on the type of tissue irradiated and the wavelength of the laser.

The diode laser is not expected to cause damage to the pulp when operated in pulsed mode and at an output power of 2.5 W since White et al. [12] described only a negligible temperature rise within the pulp during irradiation with a Nd:YAG laser.

Laser light is supposed not only to eliminate bacteria but also to inactivate bacterial toxins diffused within root cementum [13].

However, recent studies by Radvar et al. [10] examining the irradiation of periodontal pockets with the Nd:YAG laser at a pulse energy of 80 mJ and 50 mJ revealed no significant bacterial reduction in periodontal pockets following laser treatment. Tseng and Liew [14] observed a significant reduction in bacterial counts; complete inhibition of all anaerobes was observed in teeth lasered at output powers greater than 1 W and 20 pps.

The wavelength of their lasers ranged around 1,064 nm. Although the Nd:YAG laser is similar to the diode laser, it leads to a temperature rise in markedly deeper tissue layers, whereas most of the diode laser radiation is absorbed by superficial layers, thus having a better effect on sites affected by periodontal disease. However, the actual mechanisms of all possible laser bacteria interactions still have to be scrutinized.

The effectiveness of scaling and root planing in the treatment of periodontal disease to reduce bacterial plaque on the root surface is universally accepted [15]. Sbardone et al. [16] reported that diseased sites treated with a single episode of scaling and root planing exhibited a microflora similar to that in healthy sites at 7 days after treatment. However, the treated sites were repopulating with potentially pathogenic microbes at 21 days after treatment. Lin et al. [17] indicated that subgingival treatment with the Nd:YAG laser without anesthesia is more effective in reducing or inhibiting recolonisation of Actinomyces for up to 28 days than is root planing.

In the present study, the diode laser was used as supplementary treatment aimed to reduce or eliminate bacteria but not for calculus removal or pocket curettage. Observations at 7 days after laser treatment without scaling and root planing showed early recolonization by a variety of microbial morphotypes [7]. Lin et al. [18] showed that subgingival use of the Nd:YAG laser is less effective in removing calculus than is root planing.

Because the effects of laser treatment on periodontal tissue basically depend on the wave length, pulse energy, frequency, and spot size used, we consider the diode laser an interesting alternative to conventional IR lasers in periodontal treatment. Furthermore, lasing is a treatment modality that is finding very good acceptance with patients because it involves minimal pain.

REFERENCES

13. Pick RM, Pecaro BC, Silberman CJ. The laser gingivec-
Diode Laser Therapy on Periodontal Pockets