Clinical Efficacy of Semiconductor Laser Application as an Adjunct to Conventional Scaling and Root Planing

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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 need of periodontal treatment (15 women, 7 men, mean age 45.0±10.8 years) with at least four teeth in all quadrants, were included. All of them 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 at 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 periodontitis 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

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TABLE 1. The Study was Performed by Two Clinicians (c1, c2)

Visit 1(c1, c2):	Patient recruitment, oral hygiene instructions, removal of supragingival calclus, and plaque
Visit 2 (c1):	Clinical measurements (baseline values)
Visit 3 (c2):	Subgingival scaling and root planing (two quadrants)
Visit 4 (c2):	Subgingival scaling and root planing (two quadrants)
Visit 5 (c2):	Laser treatment
Visit 6 (c1):	Clinical measurements

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 H_2O_2 (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 ligually. 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)

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.

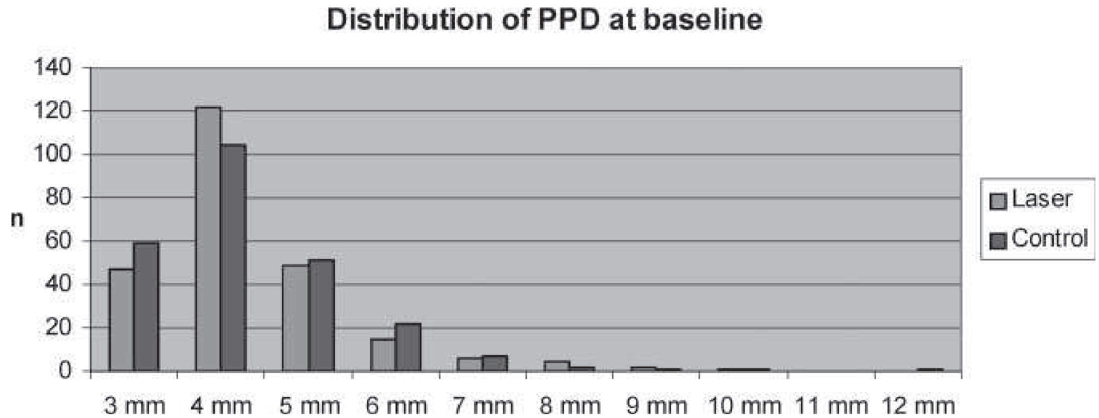

Fig. 2. Distribution of periodontal pocket depths at baseline. A mean PPD of 4 mm was predominant in both groups.

The distribution of the periodontal pocket depths in both groups at the beginning of the study is presented in Figure 2. In both groups, a mean periodontal pocket depth of 4 mm was predominant.

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® values (PT) were 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 ($P=0.019$) (Table 6).

The pocket depths (PD) were reduced from 4.2 mm (mean) to 2.4 mm in the laser and from 4.3 mm to 2.7 mm in the control group (Table 7).

The clinical attachment level (CAL) was reduced from 5.5 mm in both groups to 3.9 mm in the laser and 4.2 mm in the control group (Table 8). The differences in both the reduction of PPD and CAL between both groups were 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 Hatit 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 ± 0.6	−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 After Treatment in the Laser and the Control Group

SFFR	n	Baseline	12 weeks	Difference	*P*
Laser	246	3.0 ± 1.0	1.1 ± 0.3	−1.9	<0.001
Control	246	3.2 ± 1.2	1.5 ± 0.6	−1.7	<0.001
P-value		0.665	1.000	0.593	

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

TABLE 6. Periotest® Values (PT) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group

PT	n	Baseline	12 weeks	Difference	*P*
Laser	246	6.3 ± 8.9	3.1 ± 5.9	−3.2	<0.001
Control	246	6.4 ± 8.2	3.5 ± 6.2	−2.9	<0.001
P-value		0.257	0.224	0.019	

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, $P = 0.019$).

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].

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 5. Bleeding on Probing (BOP) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group

BOP	n	Baseline	12 weeks	Difference	*P*
Laser	246	70.7	32.8	−37.9	<0.001
Control	246	71.9	38.4	−33.5	<0.001
P-value		0.537	0.163	0.375	

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

TABLE 7. Periodontal Pocket Depth (PPD) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group

PPD	n	Baseline	12 weeks	Difference	*P*
Laser	246	4.2 ± 1.15	2.4 ± 0.67	−1.8	<0.001
Control	246	4.3 ± 1.26	2.7 ± 0.73	−1.6	<0.001
P-value		0.152	<0.001	<0.001	

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, $P < 0.001$).

TABLE 8. Clinical Attachment Loss (CAL) (Mean and Standard Deviation) at Baseline and 12 Weeks After Treatment in the Laser and the Control Group

CAL	n	Baseline	12 weeks	Difference	*P*
Laser	246	5.5 ± 1.42	3.9 ± 1.03	-1.6	<0.001
Control	246	5.5 ± 1.57	4.2 ± 1.04	-1.3	<0.001
P-value		0.748	<0.001	<0.001	

Both treatment modalities resulted in a significant reduction of the CAL values. The difference in the reduction of the values between both groups was significant (Wilcoxon test, $P < 0.001$).

TABLE 9. Gain in Clinical Attachmant (CAG) in Percent of the Treated Teeth

CAG	0 mm	1–2 mm	2–3 mm	> 3 mm
Laser	9%	55%	24%	12%
Control	11%	64%	18%	7%

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 planing.

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