Periodontal Treatment with an Er:YAG Laser or Scaling and Root Planing. A 2-Year Follow-Up Split-Mouth Study

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Background: Non-surgical periodontal treatment with an Er:YAG laser has been shown to result in significant clinical attachment level gain; however, clinical results have not been established on a long-term basis following Er:YAG laser treatment. Therefore, the aim of the present study was to present the 2-year results following non-surgical periodontal treatment with an Er:YAG laser or scaling and root planing.

Methods: Twenty patients with moderate to advanced periodontal destruction were treated under local anesthesia, and the quadrants were randomly allocated in a split-mouth design to either 1) Er:YAG laser (ERL) using an energy level of 160 mJ/pulse and 10 Hz, or 2) scaling and root planing (SRP) using hand instruments. The following clinical parameters were evaluated at baseline and at 1 and 2 years after treatment: plaque index (PI), gingival index (GI), bleeding on probing (BOP), probing depth (PD), gingival recession (GR), and clinical attachment level (CAL). Subgingival plaque samples were taken at each appointment and analyzed using dark-field microscopy for the presence of cocci, non-motile rods, motile rods, and spirochetes. The primary outcome variable was CAL. No statistically significant differences between the groups were found at baseline. Power analysis to determine superiority of ERL treatment showed that the available sample size would yield 99% power to detect a 1 mm difference.

Results: The sites treated with ERL demonstrated mean CAL change from 6.3 ± 1.1 mm to 4.5 ± 0.4 mm (P <0.001) and to 4.9 ± 0.4 mm (P <0.001) at 1 and 2 years, respectively. No statistically significant differences were found between the CAL mean at 1 and 2 years postoperatively. The sites treated with SRP showed a mean CAL change from 6.5 ± 1.0 mm to 5.6 ± 0.4 mm (P <0.001) and to 5.8 ± 0.4 mm (P <0.001) at 1 and 2 years, respectively. The CAL change between 1 and 2 years did not present statistically significant differences. Both groups showed a significant increase of cocci and non-motile rods and a decrease in the amount of spirochetes. However, at the 1- and 2-year examination, the statistical analysis showed a significant difference for the CAL (P <0.001, respectively) between the 2 treatment groups.

Conclusion: It was concluded that the CAL gain obtained following non-surgical periodontal treatment with ERL or SRP can be maintained over a 2-year period. *J Periodontol 2003;74:590-596.*

KEY WORDS

Comparison studies; follow-up studies; lasers/therapeutic use; periodontal attachment; periodontal diseases/therapy; periodontal index; planing; scaling.

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The principal objective in the treatment of periodontitis is the complete removal of all calcified and bacterial deposits from the root surfaces in order to stop disease progression.[1,2] Today there is considerable evidence to support scaling and root planing (SRP) with hand instruments as one of the most commonly used procedures for the treatment of periodontal diseases. Numerous studies have reported beneficial results from this treatment modality in both clinical and microbial parameters.[3-8] In recent years, the therapeutic armamentarium has broadened with the introduction of ultrasonic scalers and air abrasives.[9-11]

In addition to these conventional tools, the use of lasers has been reported as an alternative therapy for root surface debridement.[12-16] Among all lasers used in dentistry, which include CO_2 (carbon dioxide), Nd:YAG (neodymium: yttrium, aluminum, and garnet), and diode lasers, the Er (erbium): YAG

laser has been reported to be the most promising laser for periodontal treatment. Its excellent ability to effectively ablate hard tissue and dental calculus without producing major thermal side effects to adjacent tissue has been demonstrated in numerous studies.[12,14,15,17-20] In contrast, the use of a CO_2 and Nd:YAG laser for root surface debridement resulted in extensive damage in root cementum and dentin, such as carbonization and melting.[19,21-24]

Controlled clinical trials and case report studies have also indicated that non-surgical periodontal treatment with an Er:YAG laser leads to significant gain of clinical attachment.[16,25-27] Preliminary clinical results have also indicated that this minimally invasive device may allow instrumentation of very deep and narrow pockets without leading to major trauma of the hard and soft tissues; i.e., removal of tooth substance and increase in gingival recession.[16,26,27] Further in vitro studies on the antimicrobial effects of Er:YAG laser radiation provided clear evidence for bactericidal effects against periodontopathic bacteria.[13,28] However, no investigations are yet available evaluating the long-term clinical results of an Er:YAG laser for non-surgical periodontal treatment. Therefore, the purpose of this controlled clinical trial was to present the clinical results obtained at 2 years following treatment of advanced periodontal disease with an Er:YAG laser or scaling and root planing with hand instruments.

MATERIALS AND METHODS

Subject Selection

The study population and short-term results (6-month data) have been described previously.[16] Briefly, a total of 20 patients (14 females and 6 males) were included in the study based on signed informed consent. The study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 1983. The patient selection criteria were: 1) no periodontal treatment within the last 12 months; 2) no systemic diseases that could influence the outcome of therapy; 3) no pregnancy in women; and 4) no use of antibiotics for the 6 months prior to treatment.

Study Design

The study was performed according to a split-mouth design. A total of 34 maxillary and 21 mandibular pairs of contralateral single- and multirooted teeth were included (total, 660 sites). Each tooth of each contralateral pair had to exhibit gingival inflammation with a positive BOP, subgingival calculus, and a PD of >4 mm on at least one aspect of the tooth. In each contralateral pair, one tooth was randomly treated with subgingival scaling and root planing using hand instruments, while the other tooth was treated with an Er:YAG laser. The distribution of the 2 treatment modalities was equally divided between the right and left sides.

Oral Hygiene Program

For 4 weeks prior to treatment, all patients were enrolled in a hygiene program and received oral hygiene instructions at 2 to 4 appointments, as well as professional tooth cleaning according to individual needs. A supragingival professional tooth cleaning and reinforcement of oral hygiene were performed at baseline as well as 3, 6, 12, 18, and 24 months after treatment. A plaque index score (PI) <1[29] was chosen as the criterion for good oral hygiene.

Treatments

All operative procedures have been described previously.[16] Briefly, the mechanical subgingival instrumentation was performed using hand instruments (Gracey curet‖ No. 1/2, 3/4, 7/8, 11/12, and 13/14). An Er:YAG laser¶ was selected for laser treatment using an energy level of 160 mJ/pulse and a repetition rate of 10 Hz with water irrigation according to the manufacturer instructions. The fiber tips of 0.5 × 1.65 (136 mJ/pulse at the tip) and 0.5 × 1.1 (114 mJ/pulse at the tip) were chosen by the operator according to the situation. Instrumentation was performed from coronal to apical in parallel paths, with an inclination of the fiber tip of 15° to 20°[30] to the root surface. The instrumentation for both hand instruments and laser was performed until the operator felt that the root surfaces were adequately debrided and planed. The amount of time needed in the SRP group was, on average, 9 minutes for single-rooted teeth and 15 minutes for multirooted teeth. For the laser treatment, the averages were 5 minutes for single-rooted teeth and 10 minutes for multirooted teeth. All treatments were performed by the same operator (FS).

Clinical Measurements

At the baseline visit and 1 and 2 years following therapy, the following clinical parameters were assessed by the same blinded and previously calibrated investigator (AS): plaque (PI) and gingival index (GI),[29] bleeding on probing (BOP), probing depth (PD), gingival recession (GR), and clinical attachment level (CAL). Bleeding on probing was assessed simultaneously with the probing measurements, and the presence or absence of bleeding up to 30 seconds after probing was recorded. The measurements were made at 6 aspects per tooth: mesio-vestibular (mv), mid-vestibular (v), disto-vestibular (dv), mesio-lingual (ml), mid-lingual (l), and disto-lingual (dl) using a manual periodontal probe.#

Examiner Calibration

Five patients, each with 2 pairs of contralateral teeth (single- and multirooted) with probing depths >6 mm

‖ Hu-Friedy Co., Chicago, IL.
¶ KEYII, KaVo, Biberach, Germany.
# PCP 12, Hu-Friedy Co.

on at least one aspect of each tooth, were used to calibrate the examiner. The examiner evaluated the patients on 2 separate occasions, 48 hours apart. Calibration was accepted if measurements at baseline and at 48 hours were similar to the millimeter at a >90% level.

Microbiological Evaluation

The bacterial samples were obtained as follows. After professional supragingival tooth cleaning, a sterile paper point was introduced through the sulcus as far apically as possible. It was withdrawn after 30 seconds and then suspended in a sterile 0.9% sodium chloride solution. Within 15 minutes, the samples were evaluated using dark-field microscopy by classifying cocci, spirochetes, motile, and non-motile rods from 100 to 150 bacteria from fields selected at random.[31]

Statistical Analysis

A software package was used for the statistical analysis.** The paired *t* test was used to compare the mean scores of all investigated clinical parameters from the baseline to those after 1 and 2 years for each treatment group. Comparisons between the treatment groups at baseline and after 1 and 2 years were also accomplished with the paired *t* test. The alpha error was set at 0.05. The power of the study, given 1 mm as a significant difference between groups, was calculated to be 0.99, which justified the sample size of 20 patients.

Table 1.

Mean Scores of Clinical Parameters (±SD) at Baseline and 1 and 2 Years (N = 20 patients)

Index/Treatment	Baseline	1 Year	*P* Value	2 Years	*P* Value
PI					
Laser	1.0 ± 0.6	0.6 ± 0.4	NS	1.3 ± 0.6	NS
SRP	1.0 ± 0.6	0.7 ± 0.5	NS	1.2 ± 0.6	NS
P value	NS	NS	NS	NS	NS
GI					
Laser	1.9 ± 0.6	0.4 ± 0.3	<0.001	1.0 ± 0.6	<0.001
SRP	1.9 ± 0.6	0.5 ± 0.3	<0.001	1.1 ± 0.6	<0.001
P value	NS	NS		NS	
BOP					
Laser	56%	14%	<0.001	20%	<0.001
SRP	52%	26%	<0.001	28%	<0.001
P value	NS	<0.05		<0.05	
PD					
Laser	4.9 ± 0.7	3.0 ± 0.8	<0.001	3.3 ± 0.9	<0.001
SRP	5.0 ± 0.6	3.5 ± 1.3	<0.001	3.7 ± 0.7	<0.001
P value	NS	<0.01		<0.01	
GR					
Laser	1.4 ± 0.8	1.5 ± 0.7	NS	1.6 ± 0.7	NS
SRP	1.5 ± 0.8	2.1 ± 0.7	<0.001	2.1 ± 0.7	<0.001
P value	NS	<0.001		<0.001	
CAL					
Laser	6.3 ± 1.1	4.5 ± 1.3	<0.001	4.9 ± 1.0	<0.001
SRP	6.5 ± 1.0	5.6 ± 1.4	<0.001	5.8 ± 1.0	<0.001
P value	NS	<0.001		<0.001	

Significance of differences within and between the groups at different time points by *t* test: $P < 0.05$.

RESULTS

Clinical Measurements

The observations on early postoperative healing and the short-term results have been described elsewhere.[16] Briefly, the postoperative healing was uneventful in all cases. No complications such as abscesses or infections were observed throughout the study period. At the baseline examination, there were no statistically significant differences in any of the investigated parameters (Table 1). The PI, GI, and BOP for both treatment groups at baseline and after 1 and 2 years are summarized in Table 1. There was no statistically significant difference in mean PI between the 2 groups at baseline or after 1 and 2 years. Although PI increased slightly in the laser and SRP groups at 2 years, this difference was not found to be statistically significant compared to baseline or to the 1-year results. A statistically significant difference was observed in both treatment groups when comparing the 1- and 2-year GI and BOP to the baseline values ($P < 0.001$, respectively); however, the reduction of the BOP score was significantly higher in the laser group than in the SRP group at the 1- and 2-year observation ($P < 0.05$, respectively) (Table 1).

At 1 and 2 years, the CAL improvement was highly statistically significant in both treatment groups compared to baseline ($P < 0.001$, respectively) (Table 1 and Figs. 1 through 3). At the 1- and 2-year examination, the statistical analysis showed a significant difference for PD ($P < 0.01$, respectively), GR ($P < 0.001$, respectively), and CAL ($P < 0.001$, respectively) between the

** SPSS version 9.0, SPSS Inc., Chicago, IL.

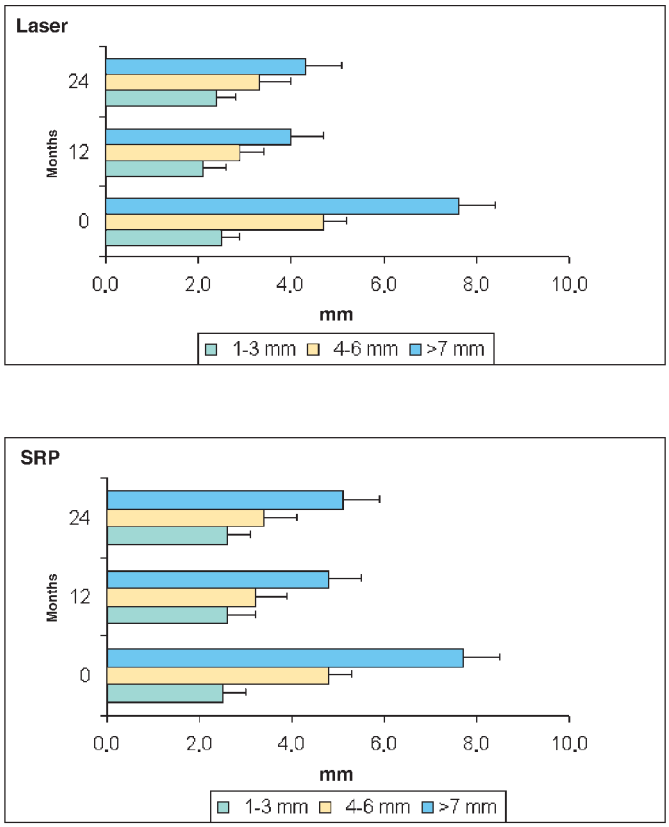

Figure 1.
Plot of mean probing depth at baseline and 1 and 2 years at sites with initial probing depths of 1-3, 4-6, and >7 mm (n = 20).

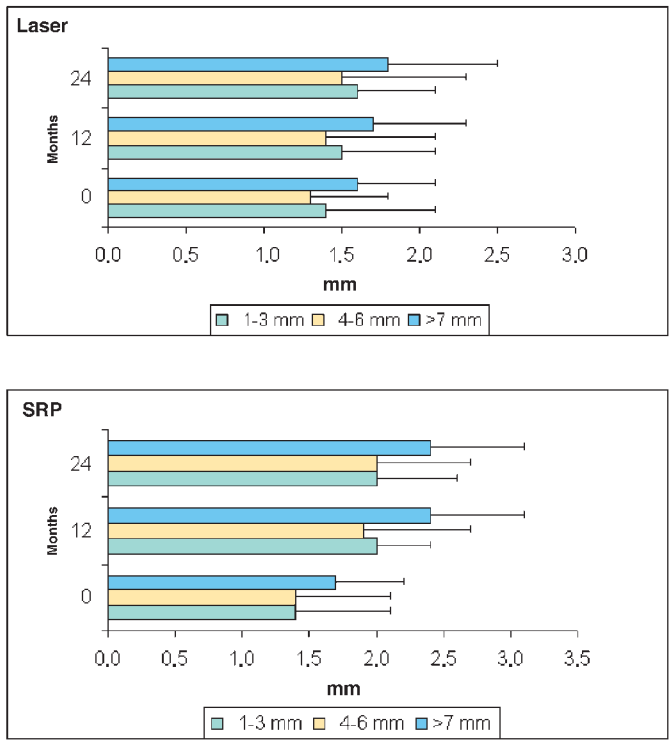

Figure 2.
Plot of mean gingival recession at baseline and 1 and 2 years at sites with initial probing depths of 1-3, 4-6, and >7 mm (n = 20).

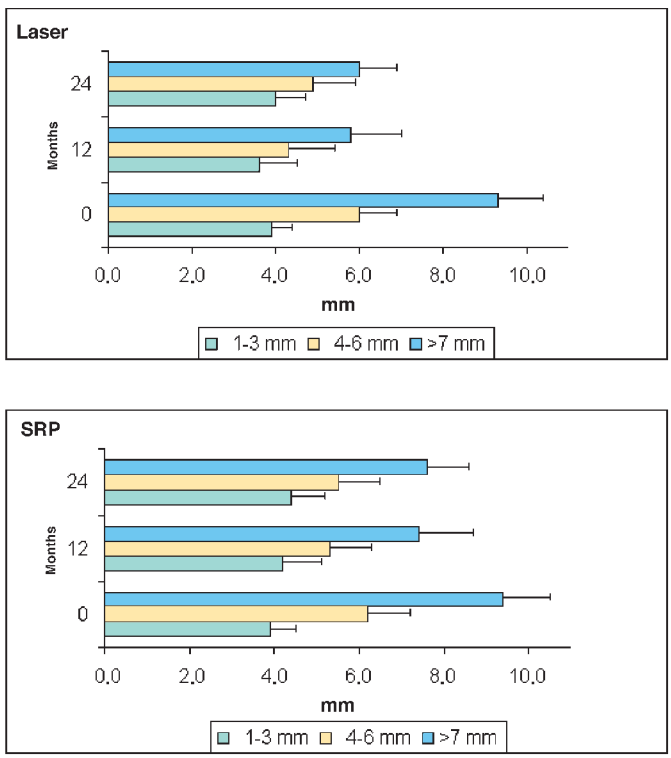

Figure 3.
Plot of mean clinical attachment level at baseline and 1 and 2 years at sites with initial probing depths of 1-3, 4-6, and >7 mm (n = 20).

2 treatment groups. The effect of ERL and SRP at different initial probing depths is shown in Figures 1 through 3. Initially deeper pockets (>7mm) showed the greatest changes in PD, GR, and CAL. Moderately deep pockets (4 to 6 mm) showed moderate improvements, while shallow sites exhibited the least amount of changes. In particular, sites with initially deep probing depths showed more GR, more CAL gain, and deeper residual PD at the 1- and 2-year examination than sites with initial moderate or shallow PD. In the ERL group, at 2 years, there was a mean loss of CAL of 0.1 mm for shallow sites, in contrast to a 1.1 mm mean gain for moderately deep sites, and a 3.3 mm mean gain for deep sites. In the SRP group, at 2 years, there was a mean loss of CAL of 0.7 mm for shallow sites, in contrast to a 0.8 mm mean gain for moderately deep sites, and a 1.9 mm mean gain for deep sites (Fig. 3). The difference between laser and hand instrumentation was much more significant in initially deep pockets ($P < 0.001$) than in moderate or shallow pockets ($P < 0.01$, $P < 0.05$, respectively).

Microbiological Evaluation

Both treatments led to a significant reduction of spirochetes and a significant increase of cocci and nonmotile rods at the 1-year observation (Fig. 4). However,

the total count of the motile rods at the 1- and 2-year examinations was almost identical to the baseline score in both treatment groups. After 2 years, increasing percentages of spirochetes and decreasing percentages of cocci and non-motile rods could be observed in both groups. No significant differences were observed between the laser and SRP groups (Fig. 4).

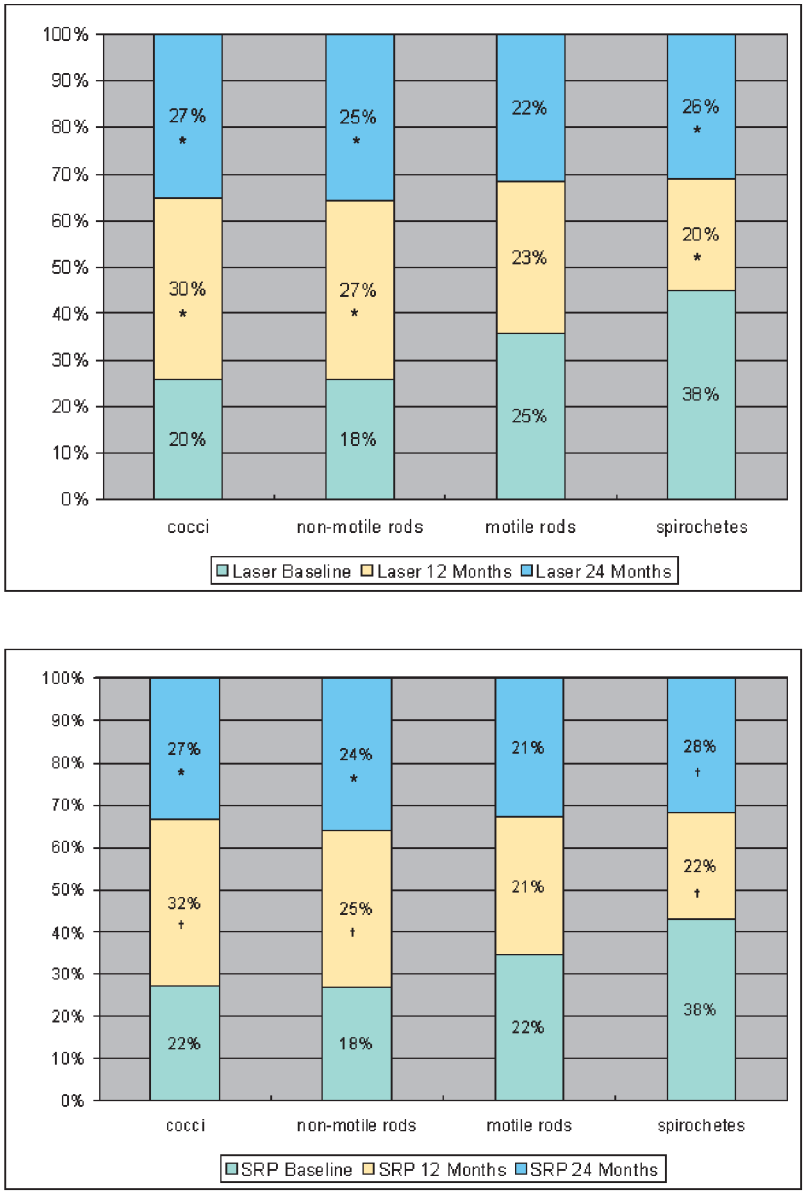

Figure 4.
*Distribution of bacteria at baseline and 1 and 2 years (laser, n = 12,344; SRP, n = 12,587). Significance of differences at different time points compared to baseline by the t test (*P <0.01; †P <0.001).*

DISCUSSION

The aim of the present study was to compare the long-term clinical results following non-surgical periodontal treatment with an Er:YAG laser or scaling and root planing using hand instruments. The results have demonstrated that non-surgical periodontal treatment with both treatment modalities results in significant reductions in PD and gains of CAL that can be maintained over 2 years. However, at the 1- and 2-year evaluation, the laser group showed a significantly higher reduction of BOP ($P<0.05$, respectively) and CAL gain ($P<0.001$, respectively) compared to the SRP group. The results also have shown that in both groups, a slight, statistically insignificant loss of mean CAL was observed between the 1- and 2-year evaluation period. This change might be explained in both treatment groups by the higher values of PI, which were higher than the baseline values. Although at 2 years the increase in PI, GI, and BOP did not reach statistical significance compared to baseline and to the 1-year scores, it is impossible to estimate to what extent the plaque accumulation might have led to inflammation and subsequently a loss of CAL. Recently, results from controlled clinical studies have shown that the stability of gained clinical attachment following conventional and regenerative periodontal treatment is dependent upon stringent oral hygiene.[32,33] Furthermore, it should be pointed out that in the present study, the difference between treatment groups was more significant in deeper pockets than in moderate or shallow pockets (Figs. 1 through 3). Results from previous studies demonstrated that subjects with a high percentage of residual deep pockets (>6 mm) following treatment run a greater risk of additional attachment loss than subjects with a small percentage of such residual pockets.[34,35]

The finding that non-surgical periodontal treatment with an Er:YAG laser may result on a short-term basis in statistically significant improvements in PD and CAL compared to baseline is in agreement with previously reported data.[16,25-27] To the best of our knowledge, there are no other data from controlled clinical studies reporting the outcome of non-surgical periodontal treatment with an Er:YAG laser up to 2 years. The present results obtained in the SRP group are in agreement with those reported in a number of clinical studies that described the effectiveness of non-surgical periodontal therapy.[3-5,7,8]

Furthermore, the results of the present study have demonstrated that both treatments led to a significant reduction of spirochetes and a significant increase of cocci and non-motile rods at the 1-year observa-

tion. However, the total count of the motile rods at the 1- and 2-year examinations was almost identical to the baseline score in both treatment groups. After 2 years, increasing percentages of spirochetes and decreasing percentages of cocci and non-motile rods could be observed in both groups. These findings are in accordance with results from previous studies which have shown that bacterial recolonization occurs after 3 months.[36,37]

Although periodontal treatment with an Er:YAG laser offers some interesting perspectives to the clinician, some questions still remain and need to be resolved. One of these questions concerns the extent of root surface damage after laser application. Histological and scanning electron microscopy examination showed that the Er:YAG laser ablated not only the calculus, but also the superficial portion of the underlying cementum.[12,14,15,20,38] However, this microstructured root surface showed no thermal effects such as melting or carbonization after CO_2 and Nd:YAG laser irradiation.[19,22,24] In the debridement of the diseased root surface, the removal of calculus and the contaminated cementum is required.[39,40] Therefore, a certain amount of cementum ablation during calculus removal using the Er:YAG laser may be clinically acceptable. The usefulness of additional treatment to remove the superficially changed layer of the lased root surface using root planing via hand instruments has been demonstrated in vitro.[41] In this context, it is important to point to the results of a previous clinical study which has shown that the combined treatment of Er:YAG laser and SRP did not seem to additionally improve the outcome of the therapy compared to laser treatment alone.[27] Furthermore, it should be pointed out that only a slight increase of gingival recession, which is a common complication of periodontal treatment with hand instruments, could be observed following treatment with an Er:YAG laser.[16,26,27,35,42] This fact, coupled with the finding that both treatments have been shown to result in comparable clinical results, suggests from a clinical point of view that the Er:YAG laser may represent an alternative to SRP.

In conclusion, within their limits, the present results indicate that the CAL gain following non-surgical periodontal treatment with an Er:YAG laser or SRP with hand instruments can be maintained over a 2-year period.

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