Short-Term Clinical and Microbiologic Effects of Pocket Debridement With an Er:YAG Laser During Periodontal Maintenance

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Background: The erbium-doped:yttrium, aluminum, and garnet (Er:YAG) laser is considered a useful tool for subgingival debridement because the laser treatment creates minimal damage to the root surface and has potential antimicrobial effects. The aim of this randomized controlled clinical trial was to evaluate clinical and microbiologic effects of pocket debridement using an Er:YAG laser in patients during periodontal maintenance.

Methods: Twenty patients at a recall visit for maintenance were consecutively recruited if presenting at least four teeth with residual probing depth (PD) ≥5 mm. Two pockets in each of two jaw quadrants were randomly assigned to subgingival debridement using 1) an Er:YAG laser (test) or 2) an ultrasonic scaler (control). The laser beam was set at 160 mJ with a pulse frequency of 10 Hz. Clinical variables were recorded at baseline, 1 month, and 4 months after treatment. Primary clinical outcome variables were changes in PD and clinical attachment level (CAL). Microbiologic analysis of subgingival samples was performed at baseline, 2 days, and 30 days after treatment using a checkerboard DNA-DNA hybridization technique against 12 periodontal disease–associated species.

Results: The mean initial PD was 6.0 mm (SD: 1.2) in the test group and 5.8 mm (SD: 0.9) in the control group. At 1 month post-treatment, the PD reduction was significantly greater for test than control sites (0.9 versus 0.5 mm; $P<0.05$). The CAL gain also was significantly greater (0.5 versus 0.06 mm; $P<0.01$). At the 4-month examination, no significant differences were detected in PD reduction (1.1 versus 1.0 mm) or CAL gain (0.6 versus 0.4 mm). Both treatments resulted in reduction of the subgingival microflora. No significant differences in microbiologic composition were identified between the treatment groups at various time intervals. Degree of treatment discomfort scored significantly lower for the test than the control treatment modality.

Conclusion: The results of the trial failed to demonstrate any apparent advantage of using an Er:YAG laser for subgingival debridement, except less treatment discomfort perceived by the patients. *J Periodontol 2006;77:111-118.*

KEY WORDS

Chronic periodontitis; laser; maintenance; scaling.

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The introduction of laser devices with controlled penetration depth, and with power and wavelength suitable for ablation of soft and hard tissues, has increased the range of potential applications of lasers in dentistry. The potential use of erbium-doped:yttrium, aluminum, and garnet (Er:YAG) lasers as tools for non-surgical debridement of pathological periodontal pockets is related to their capacity for ablating soft and hard deposits on the root surface with minimal thermal side effects ,[1-3] particularly if water irrigation is used during the instrumentation.[4-6] Because the Er:YAG laser has a wavelength (2.94 μm) close to the peak of the absorption coefficient for water, absorption of the energy by water and hydrous organic components occurs rapidly, resulting in evaporation of water, microexplosive ablation, and reduced heat accumulation.[7-10] Further, the Er:YAG laser may possess bactericidal effects[11,12] and the potential to remove bacterial endotoxins from the root surface because of the high coefficient of absorption of the used light frequency by lipopolysaccharides.[13,14]

Data from controlled clinical trials revealed that the Er:YAG laser is as effective as hand instruments[15,16] or an ultrasonic device[17] for subgingival instrumentation in the treatment of

chronic periodontitis.[7,10,18] Calculus removal also could be achieved with an Er:YAG laser without obvious damage to the root structure.[2] In vitro studies, on the other hand, demonstrated minor damage to the root surface, e.g., grooves and increased surface roughness, after laser treatment,[19,20] but this potential damage was associated with the increased application angle of the laser tip against the root surface during instrumentation.[21]

The potential of the Er:YAG laser to ablate the root surface with minimal damage to the tooth could be of value in periodontal maintenance because frequently repeated root planing with mechanical instruments may lead to excessive removal of root substance.[22] The purpose of this randomized controlled trial was to evaluate clinical and microbiologic effects of pocket debridement using an Er:YAG laser compared to using an ultrasonic scaler in patients enrolled in a periodontal maintenance program.

MATERIALS AND METHODS

The trial was designed as a single-masked, split-mouth, randomized, and controlled test of 4-month duration. The study protocol was reviewed and approved by the regional Ethical Review Board, and an informed consent was obtained from all participating subjects.

Subjects

Twenty adult subjects (eight women) were consecutively recruited between January and February 2003 among patients treated for moderately advanced chronic periodontitis and presenting at a recall visit for periodontal maintenance at the Clinic of Periodontics, Department of Periodontology, Sahlgrenska Academy at Göteborg University, during a 3-month period. Patients in the study 1) had four teeth with probing depth (PD) ≥5 mm, bleeding on probing (BOP), and no signs of apical pathology; 2) were in good general health; 3) were not using anti-inflammatory drugs; and 4) had not used antibiotics in the previous 6 months. In addition, time elapsed since the last session of subgingival instrumentation had to be ≥6 months.

The mean age of the recruited patient sample was 56.2 years (range: 40 to 67 years). Fourteen patients were smokers. On average, the patients had been in a maintenance care program for 2.9 years (range: 1 to 10 years).

Treatment Procedures

In each patient, the two deepest non-adjacent pockets in each of two jaw quadrants were selected as experimental sites. After a baseline examination, the jaw quadrants were randomly assigned by use of a computer-generated table to either laser debridement (test) or ultrasonic instrumentation (control). The sequence of the procedures was randomized in a similar manner. Both test and control sites were treated at the same visit.

Before the start of the trial, the therapist (dental hygienist) performing the treatment procedures was educated and trained in the use of the laser unit and the ultrasonic device.

Test treatment. The Er:YAG laser unit[‡] was used with a chiseled tip with a rectangular end (1.1 × 0.5 mm). The power was set to 160 mJ and the pulse frequency to 10 Hz. The unit was equipped with a calculus detection system (feedback system) based on diode laser fluorescence spectroscopy.[23] The feedback system was calibrated before each treatment procedure.

The optical prism attached to the handpiece was inserted into the pocket, slightly angulated (~15°) against the root surface (Fig. 1), and then the laser was activated with a simultaneous supply of water spray and slow movement of the prism in the apical direction until the bottom of the pocket was reached. Several parallel tracks from the soft tissue margin to the bottom of the pocket were traced to cover the entire detached root surface. The instrumentation was terminated when the detection system indicated the absence of deposits on the root.

Control treatment. The periodontal pockets assigned to the control treatment were mechanically debrided using an ultrasonic scaler[§] with power set to 75% and water as coolant. The instrumentation was terminated when the operator judged the debridement to be adequately performed.

Time used for the instrumentation was recorded. No local anesthesia was used. All patients were prescribed 0.12% chlorhexidine mouthrinsing solution (twice daily for 1 minute) during the first week after treatment.

Supragingival cleaning was performed using a rubber cup and a low abrasive polishing paste before the initiation of the subgingival instrumentation and at a 1-month recall visit. In addition, self-performed plaque control measures were reinforced when indicated.

Clinical Assessments

Clinical data were collected before treatment (baseline) and at follow-up examinations after 1 and 4 months by an examiner (different from the therapist) masked with respect to treatment assignment. For probing measurements, a manual periodontal probe[‖] was used. The variables recorded were as follows:

Plaque: scored dichotomously as presence/absence of plaque at the cervical area of the tooth detected by running a probe along the surface.

‡ KEY 1243 with handpiece P2061, KaVo Dental GmbH, Warthausen, Germany.
§ Piezon Master 400 with Perio Slim tip, Electro Medical System, Nyon, Switzerland.
‖ PCP-15, Hu-Friedy, Leimen, Germany.

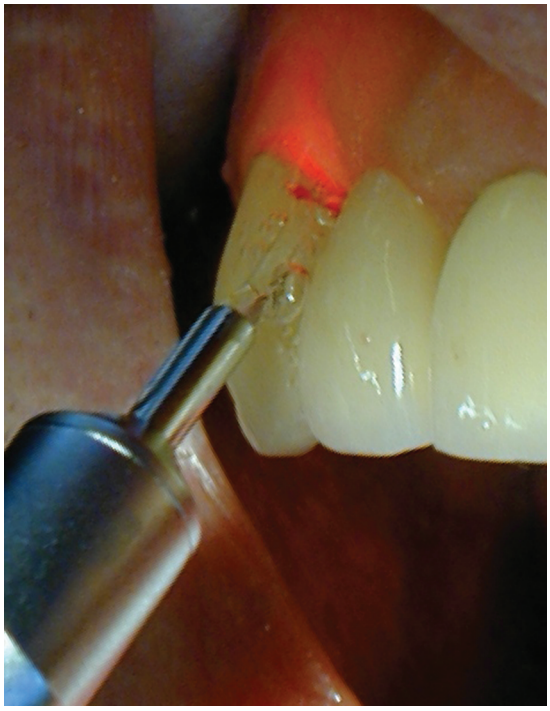

Figure 1.
Pocket debridement with the Er:YAG laser device (the red color originates from the diode laser feedback system).

PD: the distance in millimeters from the gingival margin to the bottom of the probeable pocket.

BOP: scored dichotomously as presence/absence of bleeding within 15 seconds after pocket probing.

Clinical attachment level (CAL): distance in millimeters from a fixed reference point (cemento-enamel junction or the border of a restoration) to the bottom of the probeable pocket.

Dentin sensitivity: recorded (yes/no) after 5 seconds of air-blast stimuli while protecting neighboring teeth with gloved fingers.

In addition, the degree of discomfort experienced during treatment and during the post-treatment phase (1-month examination), respectively, was graded by the patient using a 10-cm visual analog scale (VAS) with "none" and "unbearable" as verbal endpoints.

Microbiologic Assessments

After cleaning the marginal portion of the tooth surface, a subgingival plaque sample was collected from the deepest test and control sites using a sterile curet. Samples were obtained immediately before treatment and at 2 days and 1 month after pocket instrumentation. The same sites were sampled at all time intervals.

The samples were analyzed for the detection of *Porphyromonas gingivalis*, *Prevotella intermedia*, *Prevotella nigrescens*, *Tannerella forsythensis*, *Actinobacillus actinomycetemcomitans*, *Fusobacterium nucleatum*, *Treponema denticola*, *Peptostreptococcus micros*, *Campylobacter rectus*, *Eikenella corrodens*, *Selenomonas noxia*, and *Streptococcus intermedius* using the checkerboard DNA-DNA hybridization technique and with whole genomic probes.[24,25] The samples were transferred to a tube containing 100 μl TE buffer (10 mM Tris-HCL and 1 mM EDTA; pH: 7.6), and 100 μl 0.5 M NaOH was added and the suspensions boiled for 5 minutes. After cooling, 800 μl 5 M ammonium acetate was added to each tube, and the samples were further processed according to standardized procedures. The hybrids formed between the bacterial DNA and the probes were detected by application of an antidigoxigenin antibody conjugated with alkaline phosphatase and incubation with a chemiluminescent substrate (disodium-3-(4-methoxyspiro{1, 2-dioxetane-3,2′-(5′-chloro)tricyclo[3.3.1.1^{3,7}]decan}-4yl)phenyl phosphate)¶. Evaluation of the chemiluminescent signal was performed at a workstation# by comparing the obtained signals with those of pooled standard samples containing 10^6 or 10^5 of each of the 12 studied microorganisms. The obtained chemiluminescent units were transformed into a scale of scores from 0 to 5 according to Papapanou et al.,[25] related to the low and high standard, respectively. In addition, the specificity of each bacterial probe was tested against species of the panel. A 10% overlap was noticed between *P. intermedia* and *P. nigrescens*. A site was considered positive for the various microorganisms at a concentration $\geq 10^5$ (score 2 and above).

Data Analysis

Primary clinical outcome variables were changes in PD and CAL. The power calculation for paired comparison gave a sample size of 20 subjects resulting in a power of 80% with α set to 0.05, detecting a difference of 0.5 mm (considered clinically significant) with a common SD of 0.6 mm.

Mean values and SDs for the clinical variables were calculated for each treatment and time interval based on the subject as the statistical unit. The χ^2 McNemar test was used to test the null hypothesis of no difference between the two treatments for categorical variables. Student t test was employed for continuous variables after confirming normality of the data distribution. The Wilcoxon signed rank test was used when the normality could not be confirmed.

RESULTS

All enrolled patients completed the 4-month study. The mean time used for instrumentation of the two experimental sites was 3.6 minutes (SD: 1.3) for the laser and 4.0 minutes (SD: 1.1) for the ultrasonic scaler.

¶ CSPD, Lumilmager, Boehringer-Mannheim, Mannheim, Germany.
# Lumilmager, Boehringer-Mannheim.

Clinical Assessments

Supragingival plaque was present on 10% of the test and 22% of the control teeth at baseline. At 1 month, ~10% of the teeth in both treatment groups harbored plaque, whereas at 4 months the corresponding figure was 20% to 25%.

The BOP score was reduced from 92% at baseline to 60% at 1 month and to about 40% at 4 months in the laser- and ultrasonic-treated groups (Fig. 2).

Alterations in PD and CAL are illustrated in Figure 3. The mean initial PD was 6.0 mm (SD: 1.2; range: 5 to 10.5) in the laser group and 5.8 mm (SD: 0.9; range: 5 to 9) in the ultrasonic treatment group. The 1-month examination revealed a significant reduction in PD for both treatment groups (P <0.01) and a significant CAL gain (P <0.01) for the test group. The comparison between treatment groups revealed a significantly greater mean PD reduction (0.9 versus 0.5 mm; P <0.05) and a significantly greater CAL gain (0.5 versus 0.06 mm; P<0.01) for the laser treatment than for the ultrasonic instrumentation.

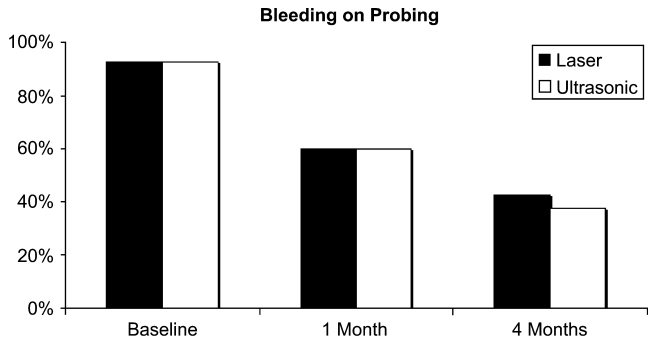

Figure 2.
Proportion (%) of sites with bleeding after probing at the various examinations.

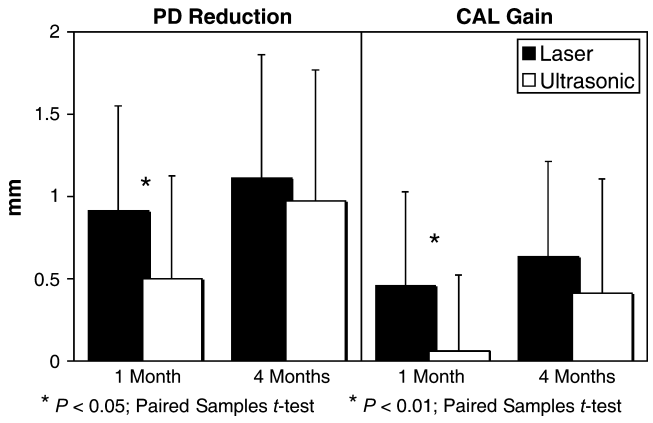

Figure 3.
Mean PD reduction and CAL gain at the various examination intervals with regard to treatment modality.

At the 4-month reexamination, further improvements with respect to PD and CAL were observed in the ultrasonic group, whereas the changes in the laser group were minute. There were no statistical differences between the test and control treatments at the 4-month follow-up examination.

At 1 month, pocket closure, i.e., PD ≤4 mm, was observed at a frequency of 35% in laser-treated sites and 30% in ultrasonic-treated sites (P >0.05). At 4 months, the corresponding figure was 50% for laser-treated sites and 42% for ultrasonic-treated sites (P >0.05).

Microbiologic Assessments

The number of sites positive to microbial testing (concentration ≥10^5) for each of the analyzed species is presented in Figure 4. For three of the species, *C. rectus*, *E.*

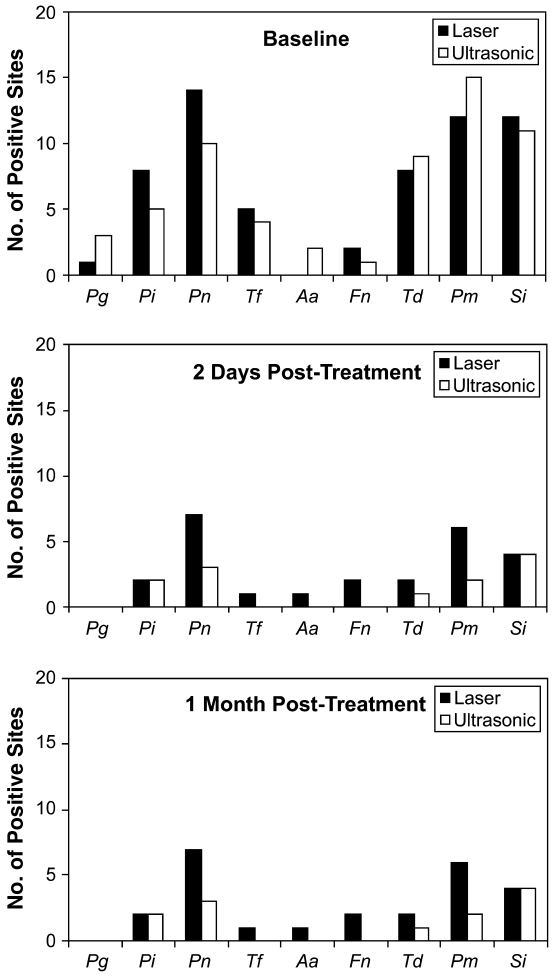

Figure 4.
Number of sites positive to microbial testing for P. gingivalis *(Pg),* P. intermedia *(Pi),* P. nigrescens *(Pn),* T. forsythensis *(Tf),* A. actinomycetemcomitans *(Aa),* F. nucleatum *(Fn),* T. denticola *(Td),* P. micros *(Pm), and* Streptococcus intermedius *(Si) categorized by treatment at baseline, 2 days, and 1 month.*

corrodens, and *S. noxia*, no positive sites were detected at any of the examination time points. At baseline and the post-treatment examinations, no significant differences were observed between the two treatment groups. A reduction in the prevalence of all bacterial species was recorded in both treatment groups 2 days after treatment; a reduction was also evident at the 1-month follow-up examination.

Considering only the presence of bacteria belonging to the "red complex" (*P. gingivalis*, *T. forsythensis*, and *T. denticola*) and "orange complex" (*P. intermedia*, *P. nigrescens*, *F. nucleatum*, *P. micros*, and *C. rectus*) as defined by Socransky,[26] a significant effect ($P < 0.05$) of subgingival treatment was detected in both treatment groups 2 days post-treatment (Fig. 5). A tendency for relapse was seen for the red complex bacteria at 1 month. However, no significant difference was detected between the two treatment groups.

Subjective Assessments

A tendency for an increased prevalence of dentin sensitivity was observed in both groups as a consequence of the treatment (Fig. 6), but no significant difference was found between treatments at any of the time intervals.

The mean VAS score recorded immediately after the completion of test and control treatment procedures (Fig. 7) showed a significant difference ($P < 0.01$) in terms of discomfort perceived by the patients between laser (1.7) and ultrasonic treatment (5.2). The degree of discomfort experienced during the post-treatment phase (1 month) was low, and there was no difference between the two treatments.

DISCUSSION

The results of the present study failed to demonstrate any obvious advantage of using an Er:YAG laser for subgingival debridement, except less treatment discomfort perceived by the patients. Hence, no differences were detected between the two evaluated treatment modalities in terms of changes in microbiologic parameters or in clinical outcome variables at 4 months post-treatment. These findings are in accordance with data reported in the literature on the use of lasers for non-surgical treatment of periodontally untreated patients,[16,17] showing no statistically significant differences in clinical outcomes compared to hand or ultrasonic instrumentation. Interestingly, however, a significantly greater PD reduction and CAL gain was noted in the current study at the 1-month follow-up examination. The earlier detection of clinical improvement after subgingival debridement with an Er:YAG laser may be ascribed to its effects on the soft tissues adjacent to the pocket. Due to the laser's ablating action, the epithelium lining the soft tissue wall of the pocket and the adjacent inflammatory cell infiltrate may have been removed.[10,15] In addition, the low-dose radiation that scatters into the surrounding tissues may possess a beneficial effect on the healing process. A recent meta-analysis of studies in animals and humans indicated that low-level laser

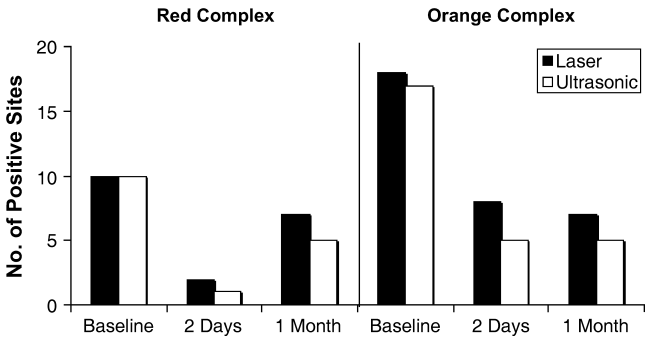

Figure 5.
Number of sites positive to microbial testing categorized by treatment and microbial complex (red and orange; see text) at baseline, 2 days, and 1 month.

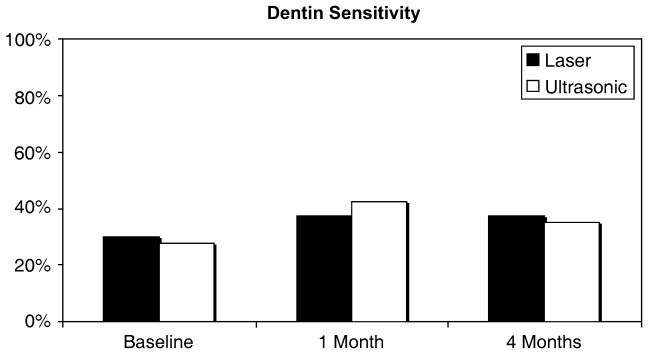

Figure 6.
Proportion (%) of sites that scored positive for dentin sensitivity at the 1- and 4-month examinations with regard to treatment modality.

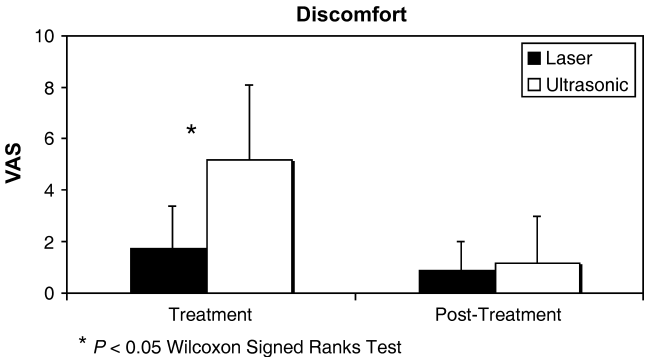

Figure 7.
Mean VAS (SD) for perceived discomfort during treatment and during the post-treatment phase with regard to treatment modality.

therapy positively influenced several indices of tissue repair, e.g., acceleration of inflammation, wound tensile strength, reduction of wound size, healing time, and collagen synthesis,[27] supporting the existence of what is called a photoeffect of "biostimulation."[28] A beneficial effect of the Er:YAG laser on surgical wound healing has been reported in dermatologic studies in which the Er:YAG laser therapy was compared to other methods for skin resurfacing.[29,30] A faster healing response compared to incision methods resulted from use of the Er:YAG laser for frenum removal[31] and implant-abutment connection surgery.[32] A proposed explanation of the observed accelerated healing is the thermal effect on the tissues that induces a heat-shock response (HSR) with release of heat-shock proteins (HSPs), suggested to play a role in the expression of growth factors like transforming growth factor (TGF)-β.[33] Furthermore, it has been reported that Er:YAG laser therapy may result in improved proliferation of fibroblasts and their adhesion to root surfaces.[34,35]

The patients participating in the current study scored differently the degree of discomfort attributed to the treatment, indicating a preference for the laser treatment. Since no anesthetics were used during instrumentation, one may assume that pain sensation was the major contributing factor to perceived treatment discomfort. However, it should be recalled that the patients were not masked with respect to the modality of treatment, and that the attitude toward a novel instrument could have affected the patient's judgment. On the other hand, pain experience during laser therapy for gingivectomy procedures was reported as negligible and not requiring use of anesthetics.[36]

For the microbiologic analysis in the present study, the checkerboard DNA-DNA hybridization technique was used. Since cross-reactions between whole genomic probes and related species have been shown,[37] the specificity was checked for species in the test panel of 12 strains. Cross-hybridization was noticed between *P. intermedia* and *P. nigrescens*. It is also possible that cross-reactions occurred between the probes and other bacterial species not included in the panel; however, this disturbing factor would have a similar effect on all samples and might not interfere with the overall result. The prevalence data based on a cut-off point of 1 may lead to an overestimation due to occasionally interfering background. This occurred specifically for the species *P. nigrescens* but also to a lesser degree for *P. micros* and *T. denticola*, and was explained by the presence of proteins tightly bound to the membrane (or the DNA) that could not be diminished by washing steps. This makes it difficult to read the membranes using the computer program, which cannot distinguish between the background and true signals of hybridization. Consequently, in the present study, the membranes also were evaluated by the naked eye to avoid the risk of overestimation of these three species. In addition, we included only scores 2 and above in the analysis of the microbiologic data to ensure an unambiguous bacterial level of detection.

Previous studies have demonstrated that the Er:YAG laser has antimicrobial effects[11,38,39] and detoxification properties[13,14] because of a wavelength that is well absorbed by water and lipopolysaccharides. However, in the present study, no significant differences in quality and quantity of subgingival microbiota between the test and control treatments were found. There are several potential explanations for this divergent finding. Since our study included patients enrolled in a periodontal maintenance care program, the sites were not highly infected at baseline, which hence limits the possibility to detect potential differences in antimicrobial effect of the treatments. Further, both treatment modalities included water cooling with a possible effect of pocket flushing on the subgingival microflora. Also, the ultrasonic instrumentation performed in control sites may possess antibacterial properties due to cavitation effects,[40,41] even if there are contradicting reports in this respect.[42] Finally, the DNA probe technique used for analysis of the bacterial samples provided information on the genetic material of bacterial origin contained in the pocket, not living cells. A culturing technique might have allowed a more accurate evaluation of the actual suppression in numbers of bacteria, although no difference between the two methods of analysis was evident in a study in which both techniques were used to evaluate the microbial changes.[3]

CONCLUSION

The results of the present trial failed to demonstrate any apparent advantage of the use of an Er:YAG laser for subgingival debridement during maintenance therapy, except less treatment discomfort perceived by the patients.

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