Er:YAG Laser in Defocused Mode for Scaling of Periodontally Involved Root Surfaces: An In Vitro Pilot Study

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Background: The Er:YAG laser may be used on periodontally involved teeth in combination with conventional periodontal therapy in order to improve the efficacy of root instrumentation. The aim of this study was to compare the effect of hand instrumentation on root surfaces of periodontally involved teeth with Er:YAG laser application.

Methods: Thirty freshly extracted, non-carious, single-rooted, periodontally diseased human teeth from adult humans with advanced periodontal disease were used in this study. The teeth were divided into three groups of 10 specimens each. Group A was treated with scaling and root planing (SRP) with curets only (control). In group B, the root surfaces were scaled with curets and then lased with an Er:YAG laser (wavelength 2.94 µm). A handpiece with a water spray was used in non-contact mode (defocused) at a distance of 1 cm from root surface. Laser parameters were set at energy of 100 to 200 mJ/pulse, with 10 Hz of frequency. In group C, the root surfaces were lased only with power settings 250 to 300 mJ/pulse and 10 Hz frequency. An epon-araldite plastic embedding technique was used for light microscopic investigation.

Results: Histologic findings showed significant differences between the test and control sites. In control sites, after hand instrumentation, the surface was smooth, without a cementum layer, and the dentin layer presented opened tubules. Defects on the dentin layer were also present along root surfaces. In the test sites (B, C) root surfaces revealed no thermal damage; no cracking or tissue carbonization were observed. The superficial layers of lased surfaces appeared smooth and melted without alterations.

Conclusion: Based on these findings, it appears that it may be feasible to use the Er:YAG laser for root instrumentation without prior root planing if the proper parameters are followed. J Periodontol 2005;76:686-690.

KEY WORDS
Comparison studies; lasers/therapeutic use; periodontal diseases/therapy; planing; scaling; tooth root.

In recent years the use of Er:YAG laser radiation on periodontally involved root surfaces has been suggested as an alternative tool to the conventional periodontal mechanical therapy for root debridement.1-3 Scanning electron microscopy (SEM) studies on root surfaces treated with Er:YAG laser radiation showed very small alterations due to thermal damage,4 since the Er:YAG laser beam with a 2.94 µm wavelength is absorbed by water efficiently. Good results2,4 have been shown in removing subgingival calculus and layers of infected cementum in periodontally involved teeth, since this laser beam may avoid extensive thermal damage to root surfaces,5 increase efficiency in root debridement by providing a smoother surface,6 and improve detoxification effects of periodontal bacterial flora distributed on periodontally involved root surfaces.7 However, Frentzen et al.8 using an Er:YAG laser with a P2056 handpiece in combination with either a 1.10 or a 1.65 application tip, both of which have comparable energy profiles, observed craters significantly deeper than those following treatment with hand instruments. The purpose of the present in vitro study was to histologically determine the effects of an Er:YAG laser in defocused mode both with hand instrumentation and alone, on diseased, calculus-covered root surfaces using light microscopic evaluation.

MATERIALS AND METHODS
Samples
Thirty freshly extracted, non-carious, single-rooted, periodontally diseased human
teeth from adult patients with advanced periodontal disease were used in this study. The teeth had deep pockets and bone loss more than two-thirds of their root length. The hopeless teeth were extracted before any periodontal treatment. After extraction, samples were stored in sterile saline solution (NaCl 0.9%) until treatment was carried out. Specimens were divided into three groups of 10 each. Two clinicians treated the teeth (N = five in each group). Group A teeth were treated by scaling and root planing (SRP) with Gracey curets 1/2 and 3/4 only (control). Group B teeth also received hand instrumentation and then were randomly assigned to two subgroups of five each for laser treatment. Five teeth (group B1) were lased with an energy of 100 mJ/pulse and five (group B2) at 200 mJ/pulse. Group C teeth were lased only, five (C1) at 250 mJ/pulse and five (C2) at 300 mJ/pulse. The same laser device, with a wavelength of 2,940 nm and 10 Hz frequency and a handpiece in a defocused mode, was used on all 20 lased teeth. The tip of the handpiece was applied perpendicularly to the surface and a water spray was used. Each tooth was scaled with the curet for 1 minute (approximately 20 times). Results were evaluated with a probe.

**Histological Examination**
Following treatment, root samples were immediately immersed in phosphate-buffered 10% formalin. The specimens were post-fixed in osmic acid and embedded in Epon. The sections were ground down to 10 to 15 µm thickness using a grinding and polishing machine. The unstained specimens were examined by light microscope in Nomarsky differential interference contrast. The cross sections were evaluated histologically at ×400 magnification. The following parameters were recorded for all sections: remaining calculus (yes/no); craters (yes/no); mean depth of craters; and cracks (yes/no).

**RESULTS**
The laser-treated root surfaces revealed no major thermal damage. No cracking or carbonization was observed along irradiated root surfaces; there were no steep grooves or crater walls. Three characteristic changes were observed in all lased root surfaces compared to SRP specimens: 1) calculus and microbial flora were eliminated from the superficial layer of the lased-root surfaces; 2) cementum was ablated through to the dentin in different thicknesses; and 3) structural dentin alteration processes were visible in the different subgroups examined.

**Group A (SRP only)**
In the control specimens the root surface was smooth, with absence of cementum layers and open tubules in the dentin.

**Group B (SRP ± laser)**
In subgroup B1 (power setting at 100 mJ/pulse), there was no thermal damage or cracking or tissue carbonization along root surfaces (Fig. 1). The superficial layers of cementum were present in different thickness since it was not completely removed. In subgroup B2 (200 mJ/pulse power), the cementum layer was completely removed without damage or cracks (Fig. 2). The surface outline of the samples appeared flat, with no damages, cracks, grooves, or carbonizations. Two different modifications were present within the lased root surfaces. The superficial layer showed histological modifications with structural rough layer of 5 to 10 µm.
10 μm width. There was a second deeper zone, with a thickness of 150 to 200 μm (Fig. 3).

**Group C (laser only)**

In subgroup C1 (energy of 250 mJ/pulse), the cementum layer was removed completely, without root damage, carbonization, or cracking (Fig. 4). A superficial rough layer 15 μm thick and structural dentin alteration processes immediately beneath the superficial margin were observed (Fig. 5). This layer was 170 to 210 μm thick. In subgroup C2 (power of 300 mJ/pulse), the root surface presented large and deep grooves (Fig. 6). The bottom of the grooves presented with a similar histological aspect observed in subgroup C1, with a superficial rough layer of 15 μm and an underlying structural modification of dentin (Fig. 7). The maximum number of craters was observed in this subgroup.

**DISCUSSION**

As expected, calculus removal was observed in group B, hand instrumentation plus Er:YAG laser, as well as group C, where the teeth were only lased, since Er:YAG laser radiation can remove significant amounts of root cementum even at lower energy levels.10 In group B, where the teeth had been previously scaled conventionally by curets, the power setting of Er:YAG laser was set at 100 mJ/pulse and 200 mJ/pulse, while in group C the same histological results were obtained only by increasing the power setting by 50 mJ to
According to Folwaczny et al., another important histological feature is the presence of roughness in all lasered root surfaces presented by Frentzen et al. Keller and Hibst reported the roughness of root surfaces treated with Er:YAG laser as 20 to 25 µm thick. This roughness seems to be compatible with healing results, as the micromorphology of Er:YAG laser treated root surfaces is quite comparable to the surface structure achieved by conventional treatment and conditioning with citric acid or EDTA. According to other authors, the surface morphology obtained with Er:YAG laser might, in theory, also promote the colonization of fibroblasts. None of the histological sections in the present study had any sign of thermal side effects (e.g., charring, melting, necrosis, or fusion) as have been reported on tooth surfaces irradiated with Nd:YAG laser, which caused severe thermal damage. Some authors observed fissuring, carbonization, cracking, melting, and resolidification of amorphic sheets and globules as indicators of thermal alterations. In contrast, other authors observed dramatic changes of the root surface after Nd:YAG laser irradiation using high power settings. After the use of low power settings (1.5 to 2.0 watts) there is no significant change of the surface pattern. Frentzen et al. compared the control site root surfaces treated either with scaling and root planing or with an ultrasonic instrument with test site root surfaces cleaned by Er:YAG laser using the 1.10 tip and observed the maximum number of craters in the laser group ($P < 0.05$, Kruskal-Wallis). These craters were significantly deeper than those following treatment with hand instruments, the ultrasonic device, and the 1.65 application tip. Grooves were found in all cross-sections. The crater walls treated with the 1.10 application tip were steeper, and some signs of melting processes in the superficial layer were visible under scanning electron microscope examination.

In a clinical study, Sculean et al. showed no statistical difference between pockets after treatment with an Er:YAG laser alone or ultrasonic device in a non-surgical treatment. In our study, where the Er:YAG laser beam was used in the defocused mode, only in subgroup C2 (power of 300 mJ/pulse) did the root surfaces present large and shallow grooves and have a rough surface in their bottom. The maximum number of craters was observed in this subgroup. In conclusion, the results seem to indicate that calculus removal can be selectively done using the Er:YAG laser at lower irradiation energy levels only. Considering the favorable histological results, the routine use of the Er:YAG laser in periodontal therapy may be practical in the future in clinical practice.

REFERENCES


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