Effect of Er:YAG Laser on Diseased Root Surfaces: An In Vivo Study

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Background: The aim of the present study was to observe in vivo the effects of two different power settings of an Er:YAG laser on pockets of periodontally involved root surfaces using a scanning electron microscope (SEM).

Methods: Thirty-two teeth with severe periodontal disease scheduled for extraction were divided into three groups: group A was irradiated with an energy of 140 mJ, 10 Hz; group B with 160 mJ 10 Hz; group C was used as controls. Morphological changes on the treated root surfaces were evaluated using SEM observations to assess laser-induced ultrastructural changes.

Results: All surfaces treated in both groups showed a homogeneous and smooth root surface morphology. The surface alterations were very similar with both energy values used.

Conclusion: Er:YAG laser irradiation performed with two different power settings of root surfaces in vivo showed at the SEM observation a complete absence of debris and smooth root surfaces. J Periodontol 2005;76:1386-1390.

KEY WORDS
Lasers/therapeutic use; periodontal pockets/surgery; scaling; tooth root/surgery.

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calculus and plaque elimination. As a contrast, during in vivo Er:YAG laser root debridement in periodontal pockets, many variants may interfere with the process such as water irrigation, change of working tip angulation on root surfaces, fiber velocity during strokes, and ability of the operator to move the laser tip into the entire perimeter of the periodontal pocket.

The purpose of the present study was to examine the morphologic changes on root surfaces of periodontally involved teeth following root treatment by Er:YAG laser tip in periodontal pockets in vivo using SEM observations.

**MATERIALS AND METHODS**

**Teeth**

Thirty-two patients, each presenting with one study tooth, were selected for this study. The 32 teeth, 11 canines and 21 incisors, were affected by severe periodontal disease showing probing depth >6 mm, clinical attachment loss >8 mm, and scheduled for extraction.

The patients were informed of the laser treatment and oral and written consent was obtained.

Patients had not received any periodontal treatment in the previous 6 months. Professional tooth cleaning was performed on all teeth to remove supragingival plaque and calculus. Test teeth were divided randomly into two groups of 15 specimens each for laser treatment at different radiation energy; the remaining two teeth were not lased and served as controls.

**Laser Radiation and Delivery System**

An Er:YAG laser system† (wave length 2.94 µm) was used at 140 mJ/pulse energy level (group A) and 160 mJ/pulse (group B), both at 10 Hz equivalent to the energy densities of 83, 94 J/cm²/pulse.

The Er:YAG laser beam was delivered into the periodontal pockets using a chisel-shaped fiber quartz tip with handpiece in contact mode under water irrigation. The laser beam was transmitted in focused mode along the 10 mm vertical axis of the quartz tip with a diameter of 400 µm.

Group A teeth were irradiated at a radiation energy of 140 mJ/10 Hz; in group B the samples were irradiated at 160 mJ/10 Hz. The laser fiber was applied at the bottom of periodontal pockets around teeth and used with apico-coronal movements in a parallel direction along the root surface with an angulation of 30°.

The working time required was 5 minutes for each tooth. Teeth were immediately extracted after irradiation, the crowns were cut at the cemento-enamel junction, and the lased roots fixed with a 2% glutaraldehyde solution in phosphate buffered saline (PBS).

**Scanning Electron Microscopical Analysis (SEM)**

Fixed specimens were then dehydrated in an ascending order of ethanol for 30 minutes. After dehydration in hexamethyldisiloxane for 30 minutes, the specimens were sputter coated with gold before SEM examination. All specimens were then examined and photographed with SEM. All thirty-two specimens were examined in different areas using SEM‡ analysis.

**RESULTS**

At both energy levels used in this study the Er:YAG laser beam transmitted was able to remove subgingival calculus and bacterial flora from root surfaces in all teeth in the two examined groups compared with the control group, in which the untreated root surfaces still presented calculus and bacterial flora (Fig. 1). Although the Er:YAG laser was able to remove subgingival calculus and plaque from all test root surfaces, different degrees of morphological changes could be observed in the investigated energy levels. In group A, the laser tip at an energy level of 140 mJ and 10 Hz eliminated tooth substance with a homogeneous and smooth surface of the treated roots into the pocket (Fig. 2); however, this surface presented some superficial irregularities (Fig. 3).

In group B, at energy levels of 160 mJ and 10 Hz, the laser tip induced a homogeneous and smooth aspect of treated surface without any alterations or thermal damage. At the bottom of the pocket, the difference between the lased root surface of the pocket and cell remains showed evident signs of treatment borders (Figs. 4 and 5). Figure 6 shows the treatment border between the lased surface, with a smooth aspect without smear layer, and non-treated root surface, with periodontal cell remains. Laser scaling appeared more

† HOYA CordBio, Fremont, CA.
‡ LEO 420, Electron microscopy Ltd., Cambridge, U.K.
effective at the higher power setting since the surface appeared more homogeneous with slight superficial modifications (Fig. 7).

**DISCUSSION**

The results of the present study indicate that the clinical use of Er:YAG laser beam delivered by a tip into periodontal pocket removed calculus and bacterial
cells, providing smooth root surfaces without smear layer. Laser scaling was effective along all perimeters of treated root surfaces, with a good demarcation at the bottom of the pocket where the laser tip was positioned. With the increasing energy level at 160 mJ and 10 Hz, the efficiency of laser scaling increased, providing homogeneous, smooth root surfaces, biologically compatible with periodontal wound healing.11,12

The same results were obtained by Schwarz et al.10 by SEM observation of 80 laser scaled surfaces. The root surface morphology was homogeneous with some slight superficial alterations localized to cementum with no visible traces of the used fiber tip. Moreover, Theodoro et al.,13 in an electronic micrograph in vitro study after Er:YAG irradiation of root surfaces at 100 mJ/10 Hz energy level, showed an absence of significant morphological changes and did not detect high pulpal temperatures. In addition, Frenzen et al.14 considered areas of subgingival calculus on 40 freshly extracted human teeth. Each of these areas was randomly divided into two equal parts. The control site was treated either with scaling and root planing or with an ultrasonic instrument. The test site was cleaned using an Er:YAG laser at 160 mJ/pulse with a 1.10 mm tip and 120 mJ using a 1.65 mm tip.

Clinically and histologically, the mechanical treatment in the control group resulted in smooth root surfaces. The test sites treated with Er:YAG laser showed an increased removal of tissue and roughened surfaces, according to the results obtained by Yamaguchi et al. who, moreover, pointed out the ability of Er:YAG laser in removing the lipopolysaccharide (LPS) from root surfaces.15 Feist et al.16 analyzed the biocompatibility of root surfaces treated by Er:YAG laser, comparing adhesion and growth of cultured human gingival fibroblasts on root surfaces treated by either irradiation with Er:YAG laser or curet. Results indicated the surfaces treated with 60 mJ/pulse Er:YAG laser irradiation promoted faster adhesion and growth than surfaces treated with either root planing or 100 mJ/pulse Er:YAG laser irradiation. In contrast to previous SEM studies, Folwaczny et al.17 observed thermal changes on root surfaces following Er:YAG laser irradiation in situ using histological sections. Periodontal pockets in jaws of human corpses were irradiated at 60 mJ, 100 mJ, and 180 mJ energy levels. Following laser treatment, the tooth, gingiva, and alveolar bone were removed and histological examination revealed two kinds of thermal changes: a superficial layer 5 to 10 µm in width with ultrastructural irregularities and a semicircular, more deeply stained area close to the apical end of the scaling track beneath the irradiated cementum. This layer had a depth of 255 to 611 µm and appeared to be independent of the radiation energy.

Earlier, Folwaczny et al.18 attempted to determine the amount of cementum and/or dentin removal with Er:YAG laser radiation based on the angulation of a specially developed application tip. The results provided clear evidence that not only physical radiation parameters, but also clinical handling parameters, in particular the angulation of the application tip, had a strong influence on the amount of root substance removal using Er:YAG laser radiation.

In conclusion, following irradiation in vivo of periodontal pockets with the Er:YAG laser at 160 mJ and
10 Hz, a smooth root surface morphology was found using the SEM analysis. However, further studies should be carried out to examine the effect of this treatment on periodontal wound healing.

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