Original Article

Effect of Hand, Ultrasonic Scaler and Erbium-Doped Yttrium Aluminum Garnet (Er: YAG) Laser on the Morphology of Root Surfaces with Periodontitis: a Comparative in Vitro Scanning Electron Microscopy Study

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Abstract:

Introduction: The main purpose of the present study was to describe the ultra structural changes which happened after treatment of the root surfaces with ultrasonic and hand devices followed by Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser irradiation.
Methods: Sixty single-rooted maxillary and mandibular teeth which had been extracted due to periodontal problems were collected. Crown and apical parts of the root were cut off using a diamond bur. The specimens were mounted on an acrylic resin in order to make a plain surface of the root accessible. The samples were assigned as following: group1: samples were root planed using conventional hand curette, group2: were prepared by ultrasonic device, group3: roots after scaling by hand instrumentation were treated by Er:YAG laser with 50 mJ/pulse and frequency of 10 Hz, group4: roots were prepared by ultrasonic scaler and consequently were treated by laser. Furthermore, the teeth were dried, sputter-coated with gold, and monitored with scanning electron microscope (SEM).
Results: Photomicrographs from ten samples of root surfaces which were taken at magnifications up to 500X revealed that there were not any severe morphologic changes, such as melting and charring, in any group. However, the samples treated by laser irradiation showed more irregularities and distortions.
Conclusion: Er:YAG laser setting at 50mj/pulse, as an adjunctive to traditional scaling and root planning, did not induce severe damages to root surfaces, although root surface irregularities were more pronounced in laser treated groups compare to hand instruments.
Keywords: Er YAG lasers; root surface; scanning electron microscopy.

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Introduction

The aim of non-surgical periodontal treatments (NSPTs) is to eliminate bacterial deposits and create a relatively smooth root surface in order to accelerate the cell adhesion and proliferation. Scaling is a prerequisite for every periodontal treatment, and smooth root surfaces has been considered as the ultimate goal of the initial phase of all periodontal treatments (1). Traditionally, hand curette and ultrasonic instrumentation were used

for root surface debridement. Some clinicians believe that manual instrumentation leads to meticulous root surface removal and the others stated that ultrasonic devices may have harmful effects on the root surfaces (2). Since last two decades, using different dental lasers in dentistry has been more popular. The well documented benefits of different wavelengths of lasers including: antibacterial activity (3), soft tissue curettage and de-epithelialization (4), bio stimulation with low level of energy (5), and root surface modification (6).

Although it has been showed that the Erbium family lasers have the potential of taking the hard bacterial deposits away, using dental lasers as mono therapy for NSPTs has not been recommended. For complete removal of calculus, the clinician must use the high level of energy which may have some side effects such as over heating and producing cracks, deep pits, and fissures (7). De Mendonca et al. reported that in spite of less roughening of root surface following treatment by Erbium-Doped Yttrium Aluminum Garnet Lasers (Er:YAG) with 120 mj/pulse compared with manual instrumentation, there is still some degrees of unevenness and roughness on the root surface (8). Therefore, some investigators suggest the lower levels of laser's energy to reduce mechanical and chemical side effects like melting and charring (9).

Application of lasers in periodontal pockets as an adjunctive to traditional scaling and root planning have been discussed recently and some studies suggest that lasers may improve the root surface compatibility and facilitate adhesion of fibroblast cells(10). One of the major explanations of this effect is root bio modification that occurre after laser irradiation. Erbium lasers in particular may have some physical and chemical effects on root. There are two main methods to evaluate the surface changes including: a) quantitative analysis of the root roughness, and b) qualitative evaluation of ultra structural view of the surface by scanning electron microscopy (SEM) (11).

Qualitative assessment of root surfaces following laser treatment has been seen in some literatures, although the protocols used for treating the samples were not similar to routine clinical practice. Meta-analysis data showed that Erbium lasers should be used as an adjunctive rather than mono therapy during scaling (12). The aim of present study was to analyze the resulting morphological alterations of the root with periodontitis treated with conventional and laser-assisted procedures by means of scanning electron microscopy.

Methods

Sixty single-rooted maxillary and mandibular teeth with more than 5mm loss of attachment which had been extracted because of periodontal problem were collected. The whole crown and apical part of the root were cut off using a diamond bur and water coolant and stored in phosphate buffered saline at room temperature until treatment was carried out. The specimens were mounted on an acrylic resin in order to make a plain surface of the root accessible. The samples were assigned as four groups: group1: roots were scaled and root planed using manual curette #7,8 (Nordent Co, USA). The treatment continued till reaching a surface which in probing by the operator was smooth; group2: roots were prepared by ultrasonic scaler (Juya Elec., Iran) adjusted in moderate power and high water irrigation with 0-20 degrees tip angulation using the same protocol; group3: the samples were treated with hand instruments followed by laser irradiation via Smart 1240D plus laser device (DEKA, Italy). The laser used in this study was Er:YAG laser with a wavelength of 2940 nm, energy of 50 mj/pulse, and pulse repetition of 10 Hz, in "very short pulse" mode (pulse length:230 micro second), 50%-50% air/ water coolant, swiping motion, and maximum tip angulation at 20°; group4: roots were prepared by ultrasonic scaler and consequently were treated by Er:YAG laser as the same protocol. Each specimen was assessed by a profilometer (MahrSurf M300+ RD18C system, Germany) with a probe with 2.5µm tip. Ten samples which showed the median roughness selected from different groups for SEM analysis.

For SEM analysis, the samples were fixed in 2.5% glutaraldehyde in phosphate buffer for 24 hours. The specimens were washed and then dehydrated. They were dried, sputter-coated with gold, and examined through SEM. Photomicrographs from the root surfaces were taken at the magnifications of 50×, 100×, and 500×.

Results

Ten root surface samples treated with four different procedures were evaluated morphologically by scanning electron microscopy. Photomicrographs showed that all treatment modalities could remove dental calculus completely. There were not any signs of major thermal changes such as melting and carbonization in any laser-treated samples of group 3

and 4 (Figure 1). Hardly any dentinal tubule exposure was observed as a result of treatment of root.

While efficient calculus removal was observed, the samples treated with ultrasonic devices showed rougher surfaces with few depth and laser irradiated samples in both groups 3 and 4 represented the most irregular appearances. There were small islands which were separated with well organized furrows (Figure 2).

The surface in the hand instrumented samples (group 1) was smoother than other three groups. However, surface irregularities with low depth and some debris were observed in the hand instrumentation group at higher magnification scale at 500× (Figure 3).

Ultrasonic instrumentation and Er:YAG irradiation produced more rugged root surfaces than the use of curettes. Moreover, laser adjunct to ultrasonic instrument represented the most irregular and significant morphological changes at all of three magnification levels. Generally, there were not any signs of fusion and resolidification of the superficial layer of cementum.

Discussion

The root surfaces which were affected with periodontal pathogens showed great changes on the chemical and physical characteristics. On the other hand, reducing the pocket depth and removing the ecological niches can be achieved through clinical new connective tissue attachment. The whole procedure done in non surgical periodontal treatments must create a biocompatible root surface and establish a favorite base for gingival fibroblast re-attachment (13). There are various instruments and clinical protocols to removing bacterial deposits and necrotic cementum during NSPTs. The conventional approach using hand

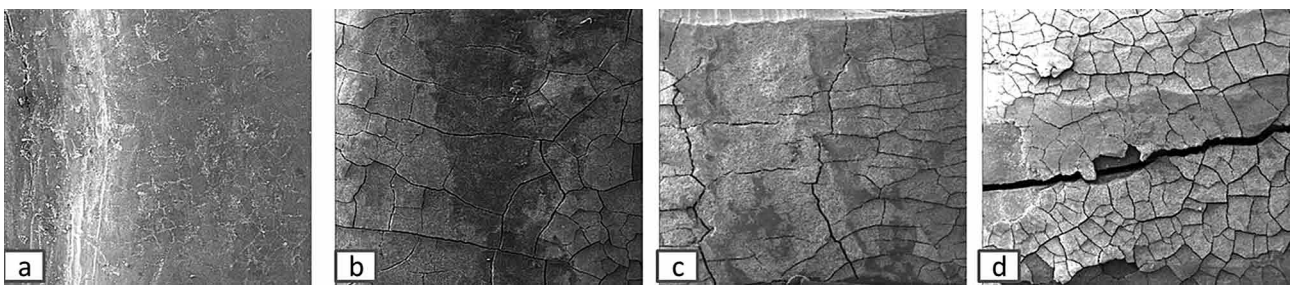

Figure1. SEM of root surfaces after scaling with a) hand instruments, b) ultrasonic device, c) hand curette followed by laser irradiation, and d) ultrasonic with laser treated. (bar =500 microns, original magnification 50×).

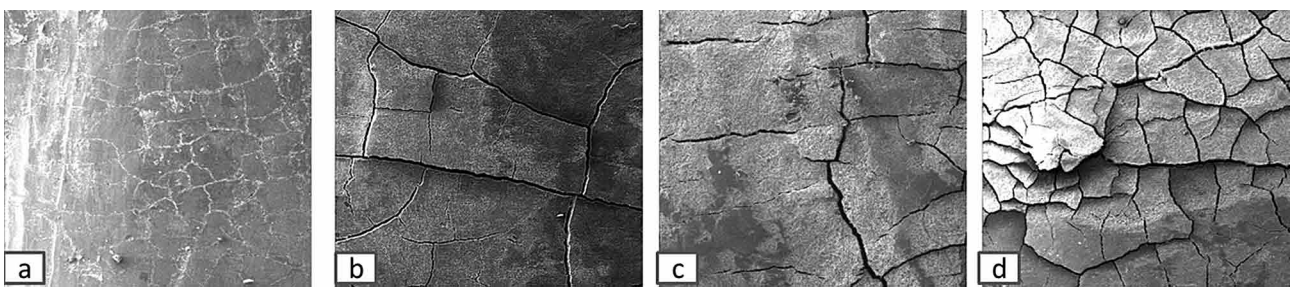

Figure2. SEM of root surfaces after treatment. a) group1, b) group2, c) group3, and d) group4. (bar =200 microns, original magnification 100×).

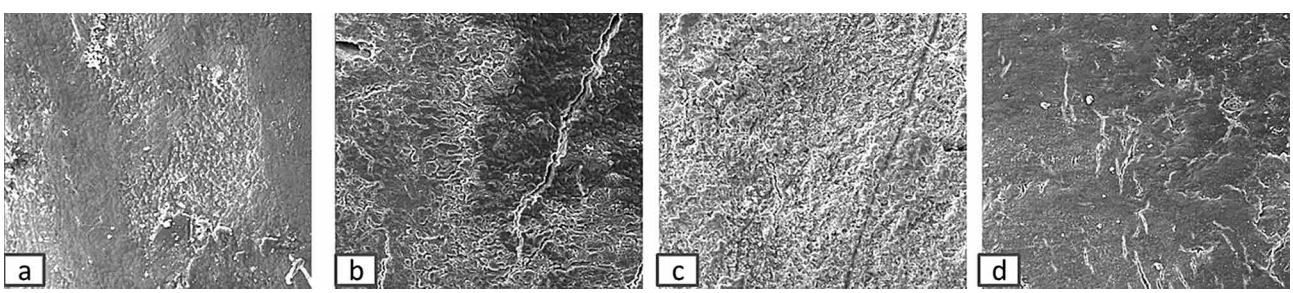

Figure3. Photomicrographs of treated root surfaces. (bar =50 microns, original magnification 500×).

curettes and ultrasonic devices has been routinely used in clinic. Some authors reported that adjunctive use of Nd:YAG, Er:YAG, Er,Cr:YSGG, and diode lasers has some additional effect on clinical outcomes (14), while others stated that laser assisted NSPTs did not show any significant improvement (15).

In order to understand the cell response following root surface treatment, we decided to analyze the ultra-structural morphologic changes after root surface debridement. SEM analysis of the irradiated specimens revealed various degrees of alterations on the root surfaces. Our findings are comparable to the results reported by de Oliveira et al. Their morphological analysis disclosed that all root surfaces irradiated by Er,Cr:YSGG laser were rougher than surfaces that were not irradiated (16).

There are some parameters of laser irradiation which can be effective on the morphological changes. Ting et al. compared different power outputs (0.5 W, 1 W, 1.5 W and 2 W) of Er,Cr:YSGG laser by examining the morphological alterations of root surfaces and the efficiency of calculus removal. They reported that a 1 W power output was appropriate for root scaling and that a 2 W power output was much more efficient in calculus removal but resulted in significant morphologic alteration to the root surface (17). On the other hand, Hakki et al. reported that there was a difference between laser groups regarding roughness of the root surfaces and it may be speculated that the reason for this different roughness could be related to pulse duration (13). The laser type is another major factor which affected the results. Among different kinds of lasers that were available in dental clinics, we selected Er:YAG. Results of several studies have suggested that recruitment of Er:YAG laser for Scaling and root planing is more suitable than other types of laser although, controversy still exists (18,19).

Within all limitation of the present study, it was clear that, at least morphologically, laser irradiation produced rougher root surfaces than treatment by hand instruments. However, it does not mean that it will interfere with the adhesion of blood components or fibroblasts to the root surfaces. Some authors used roughness as a physical character of root to explain the biocompatibility as well as the cell response of different treatments (20). Surface irregularities and smear layer may be disadvantageous in providing a suitable structure to form new connective tissue attachment during the healing phase. However, morphological analysis and roughness measurement reported by Bolortuya et al. showed that dentin surfaces treated with Er:YAG laser irradiation were rougher and subsequently exhibited the greatest number of attached fibroblasts among all experimental and control groups after 12 and 24 h (21). Tsurumaki Jdo et al. also reported that in spite of the fact that ultrasonic instrumentation and Er,Cr:YSGG irradiation produced rougher root surfaces than the use of curettes, there were no differences among treatments with respect to the adhesion of blood components (22).

Although we did not show the roughness analysis, unpublished data calculated by the authors represented some interesting quantitative findings through profilometer which has not been showed here. Regarding surface roughness (Ra) and surface distortion (Rz), we found out significant differences in each group before and after treatment. The highest values of reduction in roughness reported in groups 1 and 2 with P=0.000, and the least belonged to group3 (1.40±1.45, P=0.002). However, no statistical significant differences were observed among the four groups with P values of 0.966 and 0.629 for Ra and Rz, respectively. The comparison between manual and ultrasonic instrumentation indicates that hand instrumentation produce smoother surface than ultrasonic device but it was not statistically significant.

Conclusion

Er:YAG laser setting at 50 mj/pulse as an adjunctive therapy to traditional scaling and root planing can reduce the root surface roughness in compare to untreated surfaces. However, the morphological data showed more irregularities in compare to hand instrumentation. In order to achieve a conclusion for clinical recommendation, we should combine the results of physical examinations with the data obtained from cell adhesion tests.

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