ORIGINAL PAPER

Efficacy of periodontal debridement using an Erbium YAG laser: A scanning electron microscopic study

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Abstract
The use of lasers during periodontal treatment was encouraged by their ability to remove hard-tissues, without any detrimental thermal effects on the adjacent soft tissues. Numerous studies had demonstrated its ability to ablate hard-tissues, without any detrimental thermal effects such as cracking or melting for the adjacent tissues. The aim of our paper is to compare using the images obtained on scanning electron microscopy, the in vitro effects of Er:YAG laser, sonic, ultrasonic and manual instruments on the root cement during scaling and root planning. We used extracted teeth, divided in four groups, based on the method used for scaling and root planning. The morphological alterations of the root cement were evaluated based on a specific scoring system. We observed noted unfavorable results after using Er:YAG laser, represented by craters and cracks of root cement. There was an increased amount of roughness on the radicular surface after using Er:YAg compared to manual, sonic and ultrasonic methods. Further clinical studies are needed in order to determine the final impact of laser therapy on the healing process of periodontal tissues.

Keywords: scaling and root planning, Erbium laser, root cement morphology.

Introduction

Current scientific research has focused on the incorporation of lasers as part of the therapy of periodontal disease. It was proved that the wavelength of different types of units might have a positive effect on both soft and hard tissues healing process consecutive periodontal treatment. Periodontal disease is a multifactorial condition characterized by a microbial etiology and also a host inflammatory component. The contribution of lasers to periodontal health is determined by their antimicrobial, debridement capacity and biostimulation effect [1-3]. The lasers were introduced in periodontology more than 50 years ago, based on the evidence that wounds heal more quickly after irradiation with low-intensity lasers, a process that might be influenced by the stimulation of growth factors. High-intensity lasers were used as part of the nonsurgical periodontal procedures, in comparison with the conventional therapy for cement and soft tissue debridement, especially in order to reduce dentinal hypersensitivity [4]. Laser light has three main characteristics: is monochromatic, directional and coherent. It can be delivered to a tissue area as continuous wave, running pulse mode or gated-pulse mode. The action of lasers on hard and soft dental tissues as well as microorganisms is influenced by the absorption of the laser by tissue chromophore as apatite minerals, water or pigmented substances found at the targeted site [5-7]. Soft tissue lasers proved to give good results in bacterial reduction and coagulation, with erbium group showing a bactericidal effect on Porphyromonas gingivalis and Aggregatibacter actinomycetem comitans. The aim of our study was to evaluate the effectiveness of an Er:YAG laser used during scaling and root planning. It will be compared with the conventional periodontal debridement methods, represented by sonic, ultrasonic and manual instruments and based on images obtained with the scanning electron microscopy, we intend to measure the in vitro effects of Er:YAG laser on the root cement.

Material and methods

We used 45 human teeth freshly extracted due to complications of dental caries or periodontal disease, which were stored in 4%

formalin solution at 4^{0}C. The study was conducted based on principles of the Declaration of Helsinki. As inclusion criteria we used the absence of caries, restorations and no history of periodontal treatment for 6 months prior to extraction.

The teeth were randomly included in one of the four groups and the debridement of the cervical area and coronal third of the root was done with different methods: Group A with ultrasonic instruments (Acteon Satelec®), Group B with sonic instruments (Sirona Siroair®, KaVo Sonicflex®), Group C with manual curettes (Gracey curettes Hu-Friedy® Chicago IL, USA) and Group D with an Erbium Yag Light Walker Laser device. The crowns were prepared for Scanning Electronic Microscopy (SEM) according to a specific protocol. The teeth were washed, dehydrated using increasing concentrations of ethyl alcohol from 70% to 100% and then dryed for 24 hours. They were mounted in copper rings with a diameter of 10 mm and fixed using a fotopolimerized composite resin. Prior to examination the dental surfaces were coated with a 30-40 nm of gold and afterwards evaluated by SEM. The cervical surface of each tooth was evaluated prior and after preparation using a microscope working at 5-10kV (JEOL 5200®, JOEL Corp. Tokyo, Japan) using different magnifications (35X, 100X, 200X, 1000X). The evaluation was carried based on the following a scoring system which measured the roughness and loss of dental hard tissue: 1-smooth radicular surface with no tissue lost or traces of scaling instruments; 2-mild abrasion or uneven spots on the root surface; 3-areas with cement loss; 4-a large part of dental hard tissue is lost and there are traces of debridement instruments. The collected data were statistically analyzed with the Graph Pad Prism® 7.03 and Mann-Whitney test, a value of $p < 0.05$ being considered statistically significant.

Results

Each group of teeth received surface examined by SEM received a score according to the scoring system described and the median value for each group was measured The evaluation of dental surfaces from group A, where ultrasonic instruments were used, gave a mean score of 2.31, meaning that there was a complete removal of dental calculus, localized uneven surface and mild abrasion and (figure 1) in group B we used sonic instruments and the mean score after SEM examination was 2.63. There were more pronounced morphological alterations compared with group A, we observed areas with cement loss and remnants of dental deposits (figure 2). The mean score for group C was 1.75, the lowest value recorded in our study. Most aspects were characterized by smooth appearance of the radicular cement, without traces of instruments or tissue loss (figure 3). The last group was treated with an Er:YAG laser and showed the formation of cavities on the radicular surface, with a mean score of 2.52 (figure 4).

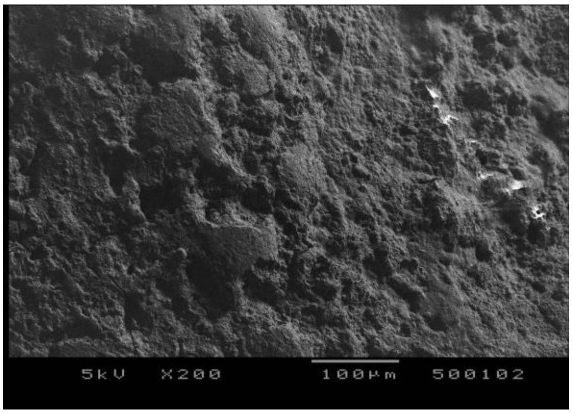

Figure 1. Specimen from group A. Debridement with ultrasonic instruments; uneven radicular surface and mild abrasion of the root cement.

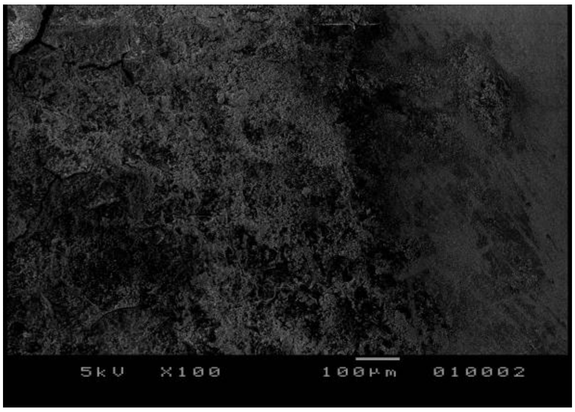

Figure 2. Specimen from group B. The use of sonic instruments created areas with cement loss and remnants of dental deposits

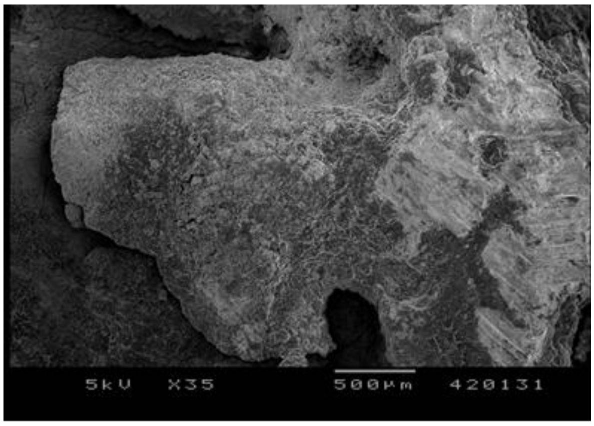

Figure 3. Specimen from group C. Smooth appearance of the radicular cement, but rests of dental calculus is visible in the cervical areas.

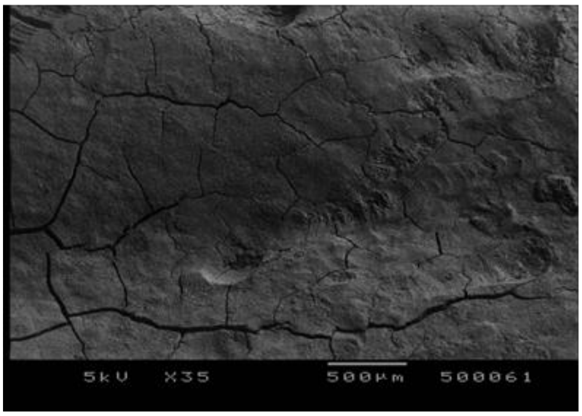

Figure 4. In group D the debridement was performed with an Er:YAG laser; it showed the formation of small cavities on the cement surface

The statistical evaluation of the scores attributed to each group showed significant differences between group A and B, but no differences between group B and D. Statistically significant differences we also noted between group C compared to A, B and D (Table 1).

Table 1. Mean values for the roughness and root cement loss scores for each study group

Group	Number of specimens	Mean index value	Comparison between groups	P value
A	14	2.31	A-D	p>0.05
B	12	2.63	A-B	p<0.05*
C	12	1.75	B-C	p<0.05*
D	12	2.52	C-D	p<0.05*

*statistically significant differences (p<0.05)

Discussion

During the treatment for periodontal disease, the mechanical procedures were conventionally considered of outmost importance, although a complete elimination of periodontal etiologic factors represented by microorganism and the optimal healing cannot be obtained only through this treatment option [8]. The clean, smooth radicular surface favors the healing process and the regeneration of tooth supporting tissues.

Alongside with chemotherapy and anti-inflammatory drugs, phototherapy by using light-emitting diodes and lasers has been combined with other scaling and root planning procedures, for a proper debridement and decontamination; furthermore, to promote wound healing and tissue stimulation. Most of these pathogens are gram-negative anaerobes and the immune response to these local agents and their toxins is a hyperactive inflammatory reaction [9-11]. This will destroy the epithelial attachment and connective tissue, leading in time to tooth loss. The nonsurgical treatment option is represented by periodontal debridement, aiming to remove microbial biofilm and dental calculus from supra- and subgingival dental surfaces and thus decreasing the inflammatory reactions. Previous studies regarding the use of Er:YAG laser for periodontal debridement had negative results, with the formation of small craters on the root cement [12-15]. We noticed the same aspect, probably due to insufficient water cooling.

Another explanation could be the micro explosions of vapors which increase the pressure inside dental hard tissues. We used extracted teeth, which had less water than natural teeth, a factor that has to be taken into consideration regarding the result of small cavities after laser debridement.

There were no significant differences between group D compared to group A and B, but we noticed an important difference between group A and D. In a SEM study made by Frentzen et al (2002) the amount of cement removed represented up to 22.5% in a group of teeth treated by laser, in comparison to 12.5% in a group of teeth treated by conventional methods [11]. The authors noted a larger volume of cement loss and root roughness when the periodontal debridement was done with Er:YAG laser alone, compared to manual and ultrasonic instruments. These side-effects were seen when the energy was over 50mJ/pulse, even under copious water irrigation. In a study conducted by Ratka-Kruger et al the use of Er:YAG was compared with sound debridement and no significant differences regarding clinical and microbiological parameters between the study groups were found [9]. On the contrary, Yilmaz et al observed that there were important differences in the values of clinical attachment level and reduction of pocket depth in sites treated with Er:YAG laser in addition to scaling and root planning, compared to sites treated only by conventional debridement therapy [3].

A study on extracted teeth conducted by Aoki et al [4] compared different power settings of Er:YAG lasers used during periodontal debridement and observed that removal of dental tissue was restricted to the root cement, which supports the idea of using this instrument during clinical procedures. The total removal of cement in the coronal third of the root could lead the invasion of the underlying dentin by oral microorganisms, with consecutive hypersensitivity or irreversible dental pulp inflammation. Many studies observed that the use of both hand curettes and ultrasonic instrumentation could completely remove the necrotic cement and allow proper decontamination of the periodontal pockets. In ultrasonic scalers, the tip of the instrument has an elliptical motion being unlikely to remove the calculus uniformly. The defects produced by hand instruments depend on the applied force that can be adjusted by the specialist [14-17]. Compared with the conventional debridement techniques, the Er:YAG laser is one of the most versatile instruments and can be effectively used in periodontal therapy or maintenance phase. The complete mechanical debridement of the periodontal pockets cannot be achieved with conventional instruments; lasers can improve the removal of calculus, granulation tissue and lining epithelium, offering better local healing conditions. The use of laser systems in combination with conventional debridement therapy could be a better future solution for periodontal therapy.

Conclusions

Even though the favorable results obtained after periodontal treatment promote the use of lasers, we consider that further studies are necessary in order to determine in which moment of the therapy these methods are best suitable and appropriate. Despite the use of copious water cooling, we noted unfavorable results on the root cement after using Er:YAG laser as craters and cracks induced by heat. There was a greater amount of roughness on the root surface after Er:YAG was used for scaling and root planning compared to manual, sonic and ultrasonic methods.

Conflict of interest: None to declare.

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