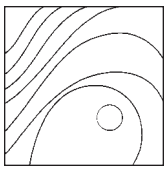
Comparing Efficiency and Root Surface Morphology After Scaling with Er:YAG and Er,Cr:YSGG Lasers



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The purpose of this study was to investigate the root morphology of teeth and efficiency of scaling after using Er:YAG and Er,Cr:YSGG lasers. Thirty-two periodontally hopeless teeth were extracted. The border of an appropriate calculus was marked using a diamond bur on each tooth, and the calculus was divided into two almost equal parts. An Er,Cr:YSGG laser with pulse energy of 50 mJ, power of 1 W, and energy density of 17.7 J/cm² and an Er:YAG laser with pulse energy of 200 mJ, power of 2.4 W, and energy density of 21 J/cm² were used to remove the calculus. The time for scaling was recorded for each group, and using stereomicroscopic analysis, the calculus remnant, carbonization, and number of craters were investigated. The mean time required for calculus removal in the Er,Cr:YSGG and Er:YAG laser groups was 15.22 ± 6.18 seconds and 7.12 ± 4.11 seconds, respectively. The efficiency of calculus removal in the Er:YAG laser group was significantly higher than in the Er,Cr:YSGG laser group. Under stereomicroscope examination, no carbonization or remaining calculus was found in samples from either group, but all samples had craters. The number of craters in the Er,Cr:YSGG laser group was significantly higher than in the Er:YAG laser group. According to the parameters used and limitations of this study, there was no significant difference in efficiency per power for calculus removal between the two groups. (Int J Periodontics Restorative Dent 2013;33:e140–e144. doi: 10.11607/prd.1765)

Pathogenic bacteria located in the subgingival area can cause periodontal diseases, gingivitis, and periodontitis. These bacterial species stick to the root surfaces and are found in a complex structure called dental plaque, which is a form of biofilm. Dental plaque, where appropriate oral hygiene is lacking, may become calcified, thereby creating calculus mainly formed from crystalline. The porous surface of calculus can be considered a suitable retentive area. The mechanical removal of these retentive parts from the root surface is called scaling and is currently the main goal of therapy in the management of these diseases.

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Scaling may be done by hand or powered instruments. Sonic and ultrasonic scalers were first made for the removal of supragingival calculus and extrinsic stains. Subsequently, these instruments transformed into devices with smaller and longer tips, allowing better access to subgingival areas. Ultrasonic scaling is as effective as hand instrumentation in plaque removal.[1] Regarding the specific properties of laser radiation, such as its hemostatic effects, selective calculus removal, and bactericidal efficacy, an appropriate laser application could represent an alternative to mechanical or powered root debridement.[2] The lasers most commonly used in periodontics are diode lasers: the Nd:YAG laser, the Er:YAG laser, the Er,Cr:YSGG laser, and the CO_2 laser. However, several studies have shown thermal side effects, such as melting, cracking, or carbonization, when CO_2 or Nd:YAG lasers are applied directly to root surfaces.[2,3] Er:YAG and Er,Cr:YSGG lasers have been used to remove calculus and, due to their high absorption in water, provide the ability to completely ablate calculus from periodontally diseased areas without causing thermal side effects to the root.[4–7] Based on current evidence, Er:YAG and Er,Cr:YSGG lasers may be similar to hand instruments, scaling, or ultrasonic scaling devices in reducing probing depth and subgingival bacteria.[8–11] Hence, laser scaling reduces patient trauma, postscaling complications, and healing time. Yet, evidence is lacking as to which is the best laser for periodontitis treatment and scaling with minimal side effects and less time.

The purpose of this study was to investigate the root morphology of teeth and efficiency of scaling after using Er:YAG and Er,Cr:YSGG lasers.

Method and materials

Thirty-two extracted teeth that were periodontally hopeless and had calculus on their root surfaces were selected for this study. Samples with caries, fillings, root fractures, or previous root canal therapy were excluded. All samples were kept in saline solution after extraction until use.

The border of the calculus was marked using a small diamond bur (D&Z). Using a knife edge bur (D&Z), the calculus was divided into two almost equal segments and a hole was randomly made on top of one part of the calculus. The segment beneath the hole was prepared for scaling with the Er:YAG laser and the other part with the Er,Cr:YSGG laser (Fig 1).

A digital photograph (IXUS 130, Canon), perpendicular to the calculus surface, was taken of each tooth with a caliper beside it. Using AutoCAD 2010 software, the calculus surface area in each part was calculated.

Laser scaling and settings

The dotted side was scaled using the Er:YAG laser (Fotona Fidelis Plus III), and the parameters were as follows: pulse energy, 200 mJ; power, 2.4 W; pulse repetition rate, 12 Hz; pulse duration, 100 µs; tip diameter, 1.1 mm; tip length, 6 mm; 60% water, 40% air; and energy density of 21 J/cm^2.

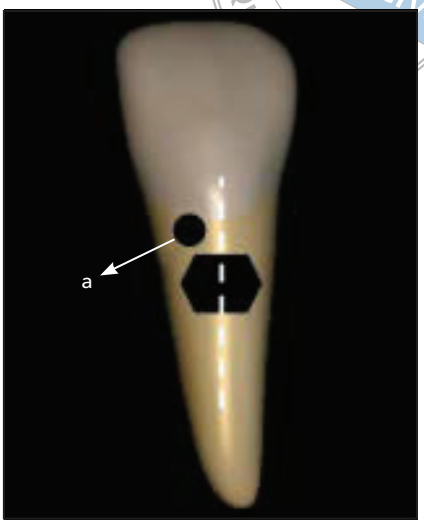

Fig 1 *The hexagon shows the calculus area, and the black dot* (a) *shows the part scaled using the Er:YAG laser.*

The Er,Cr:YSGG laser (Waterlase, Biolase) was used for the other side with the following settings: pulse energy, 50 mJ; power, 1 W; pulse repetition rate, 20 Hz; pulse duration, 140 µs; tip diameter, 600 µm; tip length, 4 mm; 55% water, 65% air; and energy density of 17.7 J/cm^2.

In both groups, irradiation was done by an expert periodontist (AE) about 2 mm in distance from the root surface and at a 30-degree angle. The laser handpiece was continuously moved during irradiation over the entire surface. The time for scaling each part was recorded. The parameters used for the Er,Cr:YSGG laser were the same as in the authors' previous study.[9]

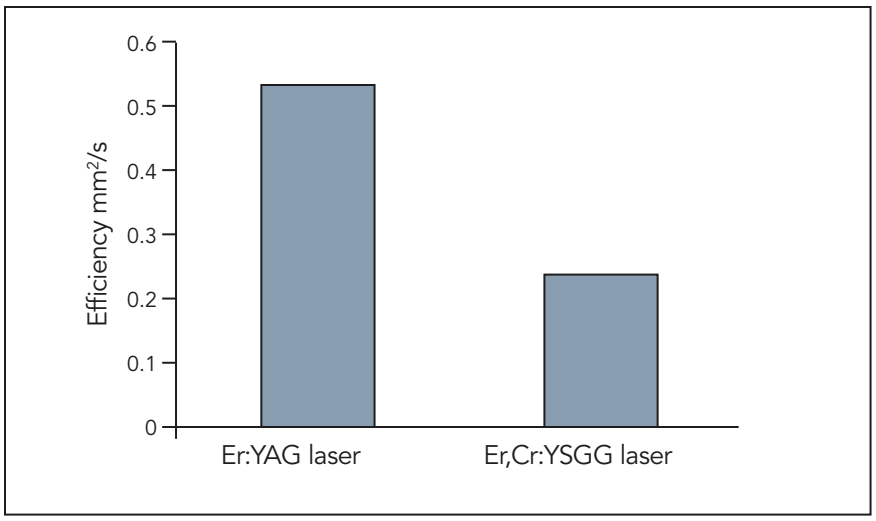

Fig 2 *Efficiency comparison of the two groups.*

Fig 3 *Stereomicroscope image of the calculus site. The area below the dot* (a) *was scaled using the Er:YAG laser and the other side with the Er,Cr:YSGG laser.*

Table 1 **Different variables in the Er:YAG and Er,Cr:YSGG laser groups**

	Er:YAG laser (mean ± SD)	Er,Cr:YSGG laser (mean ± SD)
Amount of calculus (mm^2)	3.52 ± 1.97	3.53 ± 1.85
Time of procedure (s)	7.12 ± 4.11	15.22 ± 6.18
Efficiency (mm^2/s)	0.53 ± 0.05	0.24 ± 0.12
Efficiency per power ($mm^2/s/W$)	0.22	0.24
No. of craters	7.47 ± 4.181	13.13 ± 5.96

The efficiency (the proportion of calculus area to total time of its removal) was assessed.

In stereomicroscopic analysis (FZX9, Olympus-Stereo), images with ×20 magnification were taken (TK-C1380E, JVC). All stereomicroscopic photographs were blind-analyzed by an oral pathologist to investigate the remnants of calculus and carbonization as well as the number of craters. The data were analyzed using the *t* test in SPSS statistical software version 16.

Results

The mean and SD of the amount of calculus prior to scaling was 3.53 ± 1.85 mm^2 for the Er,Cr:YSGG group and 3.52 ± 1.97 mm^2 for the Er:YAG group. The mean time required for calculus removal in the Er,Cr:YSGG group was 15.22 ± 6.18 seconds (range, 6.52 to 29.79 seconds) and for the Er:YAG laser, 7.12 ± 4.11 seconds (range, 2.90 to 19.10 seconds). According to these findings, the mean and SD of efficiency of calculus removal in the Er:YAG group (0.53 ± 0.05 mm^2/s) was significantly higher than in the Er,Cr:YSGG group (0.24 ± 0.12 mm^2/s) (P = .001) (Fig 2).

However, the efficiency per power was 0.22 $mm^2/s/W$ for the Er:YAG laser, which is almost equal to the 0.24 $mm^2/s/W$ for the Er,Cr:YSGG laser.

In the stereomicroscopic examination, there were no cracks in either group, but all samples had craters. The number of craters in the Er,Cr:YSGG group was significantly higher than in the Er:YAG group (P = .001). The mean and SD of the number of craters was 13.13 ± 5.96 and 7.47 ± 4.181 in the Er,Cr:YSGG and Er:YAG laser groups, respectively (Table 1). After examining root surfaces with the stereomicroscope, no carbonization or remaining calculus was observed for either group (Fig 3).

Discussion

Recently, several laser devices have been suggested as alternatives/coadjutants to conventional hand instruments. It was reported that Er:YAG and Er,Cr:YSGG lasers could provide sufficient removal of subgingival calculus without thermal side effects at levels similar to those provided by ultrasonic scaler and hand instruments.[12–14] It was shown that Erbium family lasers produce fewer cracks compared with ultrasonic scalers with an outcome more similar to the intact root.[9] This study compared the efficiency of Er:YAG and Er,Cr:YSGG lasers in calculus removal and measured the remaining calculus and craters after laser treatment. Several studies have reported that nonsurgical periodontal therapy with lasers leads to significant improvements in clinical parameters, including Gingival Index, probing depth, and clinical attachment level.[9,14–16] In addition, the laser application has an antibacterial benefit and reduces the bacterial load.[17]

According to the current findings, the Er:YAG laser showed a significant difference in efficiency of calculus removal compared with the Er,Cr:YSGG laser. These findings are in accordance with results from previous in vitro studies, which have shown that the Er:YAG laser is able to effectively remove subgingival calculus from the root surface.[13,18] Calculus removal by laser devices depends on the power output and the angulation of the working tip.[7] Ting et al[19] compared different power outputs (0.5 W, 1 W, 1.5 W, and 2 W) of Er,Cr:YSGG laser by examining the efficiency of calculus removal. They reported that laser application with an output power of 2 W was much more efficient in calculus removal. Their study suggested that the Er,Cr:YSGG laser had acceptable efficiency to remove calculus. Hakki et al[15] concluded that the Er,Cr:YSGG laser with a short-pulse setting was more appropriate for the removal of calculus. Eberhard et al[16] compared the effectiveness of hand instrumentation and laser irradiation and revealed that the lack of cementum removal in contrast to scaling and root planing may qualify the laser as an alternative approach during supportive periodontal therapy.

Stereomicroscopic observation showed higher crater numbers in the Er,Cr:YSGG laser group. Frentzen et al[20] showed maximum crater numbers in all laser group samples compared with the ultrasound group. Also, Crespi et al[14] observed a maximum crater with vast and narrow grooves in energy of 300 mJ/pulse from the Er:YAG laser. Laser devices can produce surface irregularities in the root surface; on the other hand, they do not leave a smooth microscopic surface on the cementum.[8,17,21] Therefore, laser irradiation associated with conventional scaling and root planing can be more effective in removing irritants from the root surface.[22] Noori et al[9] concluded that the application of Er,Cr:YSGG for scaling and root planing compared to an ultrasound procedure produced more craters. They reported that the number of cracks decreased in the laser group due to a lack of vibration that exists in ultrasonic scalers. On the contrary, Schwarz et al[23] demonstrated that the use of the Er:YAG laser resulted in a smooth surface even at higher energy settings.

Root surface examination with the stereomicroscope did not reveal any carbonization or calculus remaining in the two groups. In agreement with this study, Herrero et al concluded that the capacity of the Er:YAG laser to remove calculus is comparable to ultrasonic scaling without any modification of the root surface.[24] The carbonization after calculus removal by laser irradiation causes no tissue attachment in the root surface.[25]

The results of this study indicated that laser application led to the creation of craters in the root surface. De Mendonça et al[26] reported that all instruments (Er:YAG laser, ultrasonic system, and curette) increased the roughness of the dentin root surface after treatment. Surface irregularities and smear layer production may be unfavorable in providing a good root structure to form periodontal attachment.[15]

There is no statistical difference in efficiency per power for both lasers, but the difference in the number of craters would be attributed to the different tip diameters that were used. More in vitro and clinical studies are needed to clarify the effectiveness of laser application for calculus removal.

Conclusion

Within the limitations of this study, the Er:YAG laser group appears to have an advantage in terms of time and efficiency of calculus removal and crater formation compared with the Er,Cr:YSGG group. For more precise results, another study with the same power and the same tip diameter is recommended.

Acknowledgments

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