SEM Evaluation of Root Surface Roughness Following Scaling Using Er:YAG, Ultrasonic, and Hand Instruments

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Purpose: The aim of this investigation was to compare the root surface roughness following scaling by Er:YAG laser with the conventional ultrasonic and hand instruments.

Materials and Methods: This in vitro investigation was performed on 15 premolars which had been freshly extracted due to existing periodontal problems. Scaling was performed either by an ultrasound system, hand instrument or Er:YAG laser. Each tooth was sectioned into halves, of which a second sectioning was performed to provide four samples of the same tooth for best possible comparison. Overall, 45 root surface sections with calculus and debris were grouped into three in a randomized selection manner. Scanning electron microscopy (SEM) was employed for surface assessment at 50X, 400X, and 750X magnification. Data were analyzed using Kruskal Wallis and ANOVA tests.

Results: There was a noticeable difference in surface roughness of samples with the three different approaches. Intergroup comparison of samples showed a significant difference between laser and hand instruments, and ultrasonic and hand instruments. The hand instrument group had the least surface roughness among all groups.

Conclusion: A minimal surface roughness was observed under SEM in samples treated by Er:YAG. Laser use was not superior to the other two methods of ultrasonic and hand instrumentation.

Keywords: scaling, polishing, Er:YAG laser, surface roughness, ultrasonic, SEM.

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Periodontal disease is widely acknowledged as one of the most common causes of tooth loss. Elimination of calculus and bacterial microflora has been proven to be critically important in treating such diseased tissue. To date, several approaches have been introduced to achieve complete elimination of calculus, plaque, and necrotic cementum. Hand instrumentation has long been considered as the most effective and convenient method of plaque removal, with some limitations in its ability to completely remove calculus, causing recurrence of the periodontal problem.[1] The use of ultrasonic scalers has also been shown to be effective in removing calculus; however, a more damaged, rougher surface is seen afterwards. In addition, its use is restricted in certain cases.[2-5] More recently, research has been done on calculus removal with CO_2, Nd:YAG, and Er:YAG lasers, to name the most frequent energies used. The Er:YAG laser is believed to be the most effective of all, due to its absorption capacity by water.[6] It has been shown that Er:YAG laser is capable of removing calculus with a reasonable root surface roughness remaining and little to no side effects.[7] Its superior, minimally destructive effect over hand instrumentation has also been confirmed.[8] Nevertheless, conflicting reports exist on the effects of Er:YAG laser on root surface roughness.[9-14] This study was therefore designed to look at the differences between root surface roughness produced following laser, ultrasonic and hand instrumentation for calculus removal.

MATERIALS AND METHODS

This in vitro investigation was performed on 15 freshly extracted human premolars following their presentation with periodontal pocket depths of over 5 mm on interproximal surfaces and with less than 1 mm of attached gingivae. The sample teeth were kept in saline solution prior to and after each experimental step. Matching was performed in groups to avoid initial roughness differences at the root surfaces for sites exposed to oral cavity and those covered with periodontal ligament. This was to eliminate the chance of surface cover effect. Each tooth was then mounted in a stone plaster mold from the coronal part leaving the root surface exposed and accessible. Each sample tooth was then longitudinally sectioned into halves using a conventional carbide disk mounted in a handpiece. Each half was marked into two separate halves for each experiment. The overall 45 marked surfaces were put into three separate groups for each test. The sample halves were randomly allocated into groups. The first group was then randomly assigned for surface treatment using Er:YAG laser (Fidelis Twin Laser, Fotona; Ljubljana, Slovenia) with energy settings of 120 mJ at 12 Hz in VSP mode with water cooling for 2 min each. The second group was treated by an ultrasonic device (JE-3025, Juya Electronics; Iran) using a TFI 10 handpiece and power of 25 Hz. The third group was subjected to surface treatment by hand instrumentation using a sharp new curette (Colombia 5RL, Hu Friedy; Chicago, IL, USA). Comparisons were made on the same tooth as all three methods were applied on different halves of the same tooth. The Er:YAG laser (Fidelis Plus, Fotona) was employed at an energy of 120 mJ/pulse, 12 Hz frequency, and 75-100 ms pulse rate (VSP mode and Ro7 handpiece).[8] Each procedure was performed for 120 s by a trained operator (periodontist) calibrated in a preliminary study.[10]

After surface treatment, a thin cutting disk was used to separate the differently prepared surfaces, which were then subjected to a gold coating process in preparation for SEM examination. Each prepared surface was then photographed at 50X, 400X, and 750X magnification. Micrographs were then used to score the degree of roughness as mild, moderate, or severe, based on the depth of craters on similar magnified pictures. A Kruskal Wallis test was used to analyse the data.

RESULTS

The overall surface roughness varied based on the method used, with very little (mild) roughness seen in laser irradiated group. The degree of surface roughness found following SEM assessment of the sample surfaces showed significant differences ($p = 0.034$). Comparing the two groups of hand instrument and laser, there was a significant difference seen between the two in terms of the surface roughness level measured ($\alpha = 0.05$). The same results were achieved when the surface roughness of the ultrasonically treated group was compared to that of the hand instrument group ($\alpha = 0.05$). However, the difference was not significant when ultrasonic and laser groups were compared ($p = 0.12$). Overall, surface roughness had a lower value in the hand instrument group. Based on SEM results achieved from samples observed, there was no clear indication of the difference between groups when 50X and 400X magnifications were used. However, differences appeared to be significant and clear with 750X magnification (Figs 1 to 3).

DISCUSSION

There have been only a few reports on the use of different laser wavelengths in removing calculus.[15-19] However, there is more agreement on the Er:YAG energy effect on this topic compared to other wavelengths. There are also conflicting reports on the level of Er:YAG laser energy efficacy on root surface preparation.[9-14,20-23] SEM evaluation of cases in the current investigation revealed a smoother surface achieved by the use of hand instruments in comparison to the use of the ultrasonic system, which is similar to findings reported earlier.[24-28] Despite the fact that laser energy has not been proved to be superior to hand instruments,[8,18,29,30] some investigators believe that laser scaling and root planing can be as effective as or

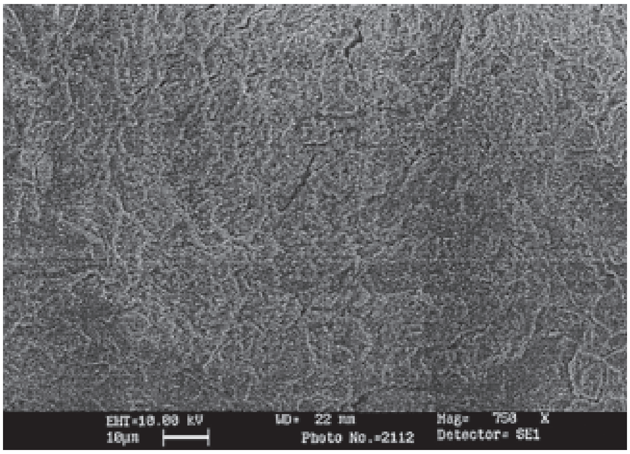

Fig 1 SEM image of laser-treated root surface, 750X magnification. Note the homogenicity of the surface.

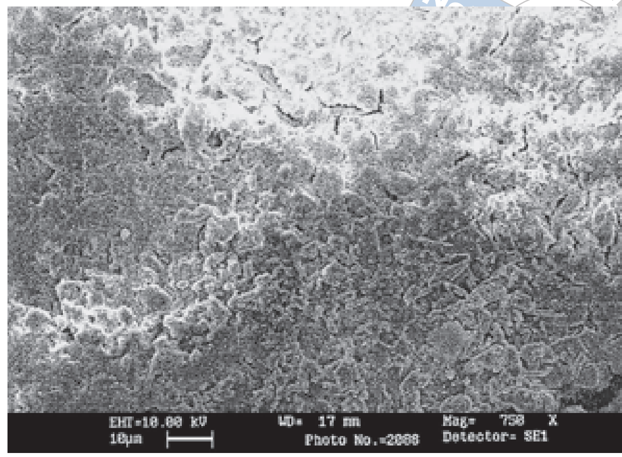

Fig 2 SEM image of ultrasonically treated root surface, 750X magnification. Note the cracks on this surface.

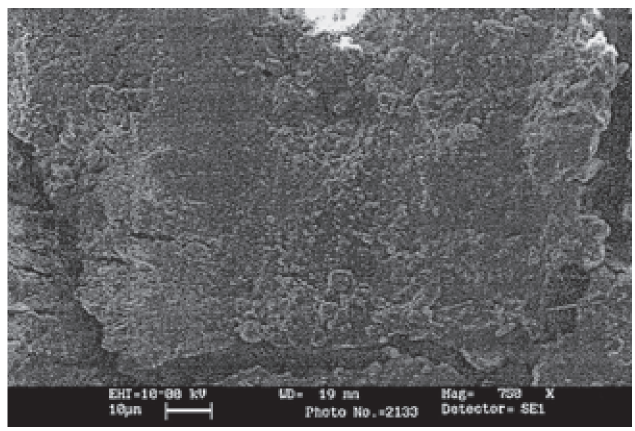

Fig 3 Root surface treated by hand instrumentation, 750X magnification. Note the undesirable wide cracks on this surface.

even superior to the conventional methods.[20,31] Based on the results of this in vitro assessment, there were no significant differences observed between laser and ultrasonic groups. An earlier report suggested that dried surfaces of the root treated by Er:YAG laser appear to be opaque, compared to the shiny surfaces resulting from ultrasonic treatment.[32] Similar findings were observed on laser treated surfaces of the cases examined in this study. Thermal ablation occurs following laser irradiation of the root surfaces, resulting in crater formation and surface roughness. The extent of such roughness is directly related to the laser energy, its pulse rate and duration. An estimated 60% of laser-treated cases showed some degree of surface roughness as seen and judged by 5 independent observers. No report of crater production was made from laser-treated cases. This favored tissue healing through ingress of fibroblasts, as they tend to adhere to such rough surfaces with a much higher rate than normal.[16,36,34] Clinical application of such laser energies, therefore, could enhance the healing process over the use of conventional methods.[35] The presence of craters has often been reported following the use of higher power laser energies, resulting in delayed and defective periodontal tissue healing.[10] As different surface roughness could only be detected at 750X magnification, it is therefore recommended to use this magnification in future studies of the same nature. The use of longer tipped fibers with a chisel cutting end and short pulses of 50 µs and less could improve the resultant surface texture considerably when Er:YAG laser is employed.[36]

Table 1 Mean value of surface roughness after three different preparation methods of scaling and root planing

Preparation method	Laser (%)	Hand instrument (%)	Ultrasonic (%)	Total No (%)
Smooth surface	27.3	38	24.3	29.5
Rough surface without crater	33.6	42	28.7	34.5
Rough surface with shallow crater	27.3	19	37.4	28.3
Rough surface with deep crater	11.8	1	9.6	7.7
Mean (SD)	2.236 (0.985)	1.831 (0.766)	2.321 (0.950)	2.141 (0.932)

CONCLUSION

The use of Er:YAG laser energy to remove calculus and perform root planing is shown to produce little surface roughness based on the laser settings employed in this investigation. The results of laser use, however, were not found to be superior to those obtained with ultrasonic or hand instrumentation.

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