Original Article

Scanning Electron Microscope (SEM) Evaluation of Tooth Surface Irradiated by Different Parameters of Erbium: Yttrium Aluminium Garnet (Er:YAG) Laser

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Abstract:

Introduction: The aim of this study was to investigate the Scanning Electron Microscope (SEM) analysis of tooth surface irradiated by different parameters of Er:YAG laser.
Methods: 15 caries-free extracted human third molars were used in this study. The teeth were put into 5 groups for laser irradiation as follows: Group 1 (power: 2.5 W, Energy: 250 mJ); Group 2(power: 3 W, Energy: 300 mJ); Group 3 (power: 3.5 W, Energy: 350 mJ); Group 4 (power: 4 W, Energy: 400 mJ); Group 5 (power: 4.5 W, Energy: 450 mJ). All samples were prepared by repetition rate of 10 Hz. Then, the samples were prepared for SEM examination.
Results: The SEM images showed cleaned ablated surface and exposed dentinal tubules, without production of smear layer.
Conclusion: It can be concluded that Er:YAG laser can be an alternative technique for surface treatment and can be considered as safe as the conventional methods, like turbine and bur.
Keywords: dentinal tubules; laser; scanning electron microscopy.

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Introduction

The main goal in restorative dentistry is to find the best procedure for caries removal to provide conservative treatments (1, 2).

Presence of pain, vibration, and especially application of local anesthesia account for disadvantages of conventional caries removal methods. To eliminate all unfavorable conditions, new technologies, such as administration of laser is recommended (3).

Among different lasers used in dentistry, Erbium lasers are considered as the best option for caries removal and cavity preparation. This family has two wavelengths including Er:YAG laser (2940 nm) and Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) laser (2780 nm)(4).

The mechanism of dental hard tissue ablation by erbium laser is called water-mediated ablation. Laser energy which is absorbed in water causes vaporization of the water segment and hydrated components leading to explosive destruction of inorganic substances which forms hydrokinetic forces that will result in ablation of dental hard tissue (5, 6).

It is still needed to determine the property of surface prepared by laser in order to use appropriate restorative materials best interacted with this surface (7).

The aim of this study was to evaluate the dentin surface prepared by different parameters of Er:YAG laser.

Methods

15 extracted human impacted third molars were selected for this study. Teeth showed no caries, restoration and fracture. They were washed under tap water and then stored in distilled water containing 0.4% thymol to prevent microbial growth. Then, the teeth were divided into 5 groups as follows:

Group 1: power: 2.5 W, Energy: 250 mJ,
Group 2: power: 3 W, Energy: 300 mJ,
Group 3: power: 3.5 W, Energy: 350 mJ,
Group 4: power: 4 W, Energy: 400 mJ,
Group 5: power: 4.5 W, Energy: 450 mJ.

All samples were prepared by repetition rate of 10 Hz with pulse duration of 450 μ sec.

The laser was used in non-contact mode with spot size of 1mm with distance of 5 mm above the tooth surface.

For Scanning Electron Microscope (SEM) analysis, samples were fixed in 2.5% Glutaraldeheyde for 12 hours (4°C), and then dehydrated in ascending grades of ethanol (25%, 50%, 75%, 90% and 100%). After that, the samples were dried and sputter-coated with gold. Finally, all 4 surfaces were analyzed with a scanning electron microscope at ×500, ×1000, ×5000 magnification.

Results

Under SEM evaluation in the laser group with output power of 2.5, 3 and 3.5 W cleaned ablated surfaced with no smear layer production could be seen. Also, exposed dentinal tubules, scaly and chalky surfaces were shown (Figures 1-6).

The surface which was prepared by output power of 4 and 4.5W showed some cracks and melting area (Figures 7-9).

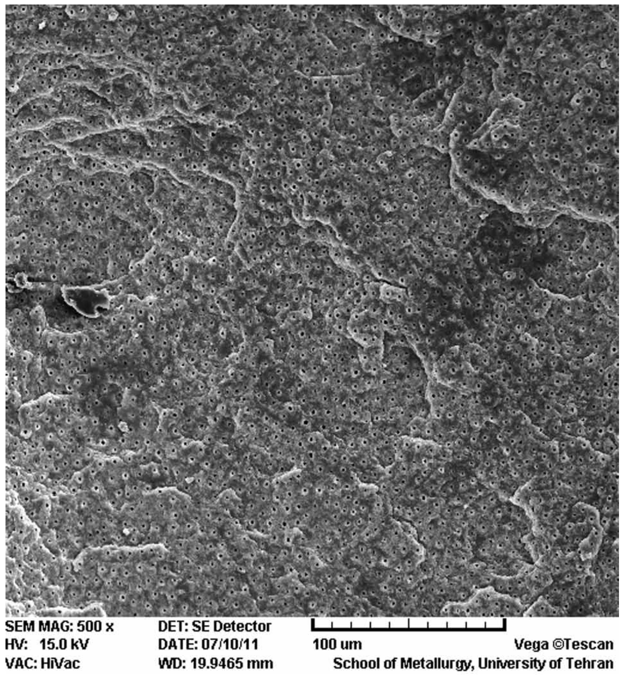

Figure 1. Surface treated by Er:YAG with power 2.5 W. Open dentinal tubules, no smear layer, scaly and flake surface (Original magnification ×500, bar=100μm)

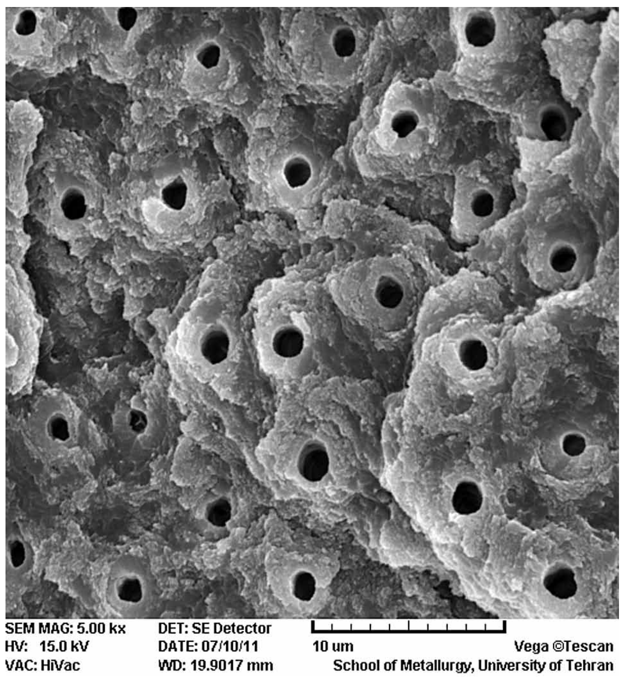

Figure 2. Surface treated by Er:YAGwith power 2.5 W showing open dentanl tubules (Original magnification ×5000, bar=10μm)

Discussion

In recent years, the application of new technology such as laser has gained special attention for cavity preparation (9). The aim of this study was to compare the surfaces irradiated by Er:YAG laser with different output powers. The result of this study showed that surfaces irradiated by output power below 4 W was free of smear layer with open dentinal tubules, but the surfaces irradiated by output power of 4 and 4.5 W demonstrated

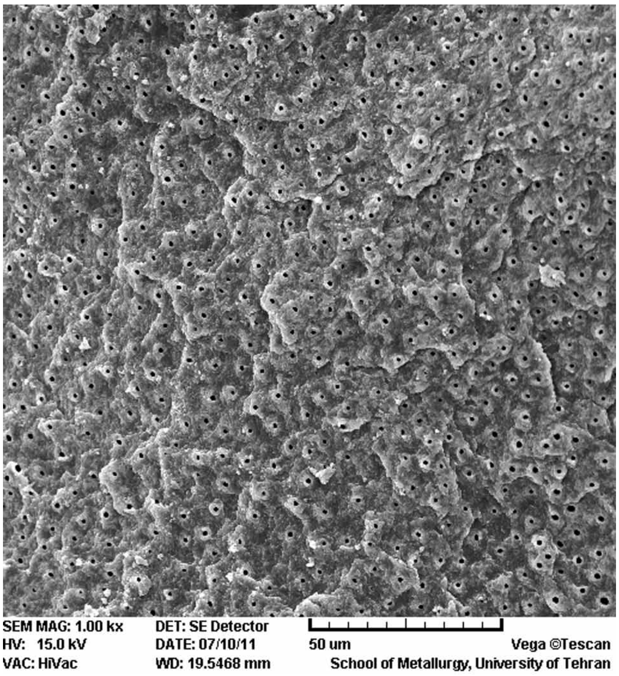

Figure 3. Surface treated by Er:YAGwith power 3 W. Open dentinal tubules, no smear layer, scaly and flake surface (Original magnification ×1000, bar=50μm)

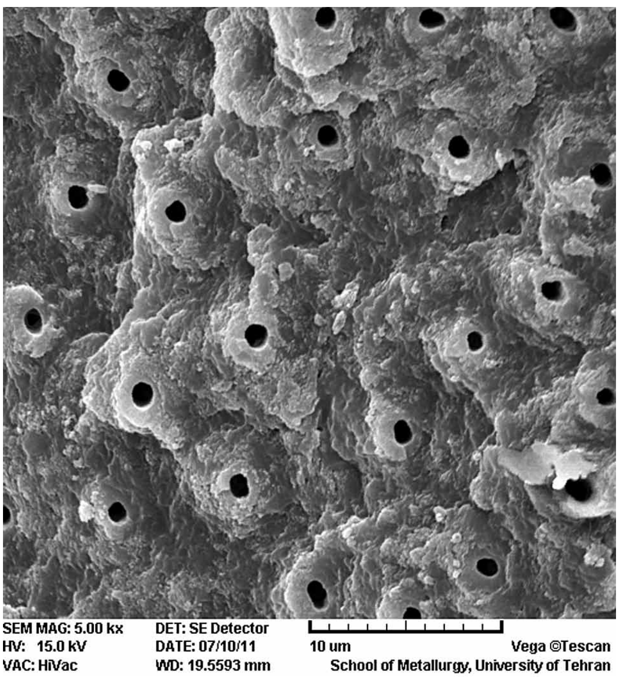

Figure 4. Surface treated by Er:YAGwith power 3 W. open dentinal tubules (Original magnification ×5000, bar=10μm)

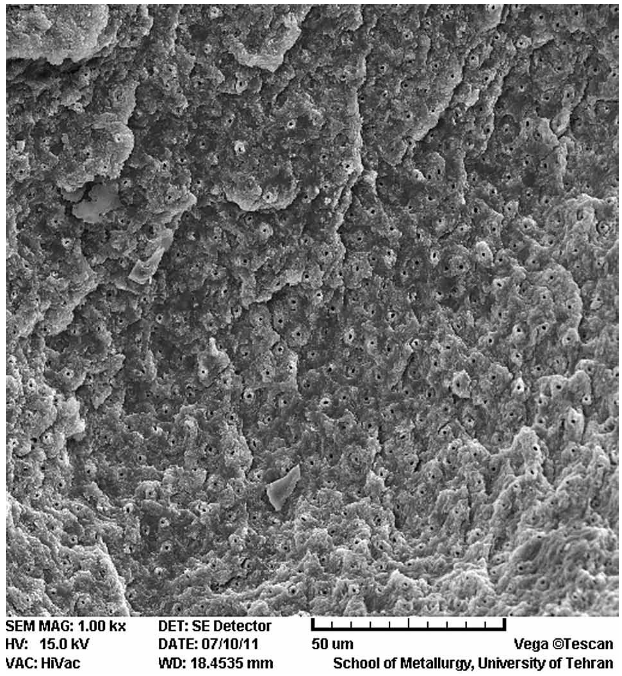

Figure 5. Surface treated by Er:YAGwith power 3.5 W. open dentinal tubules (Original magnification ×1000, bar=50μm)

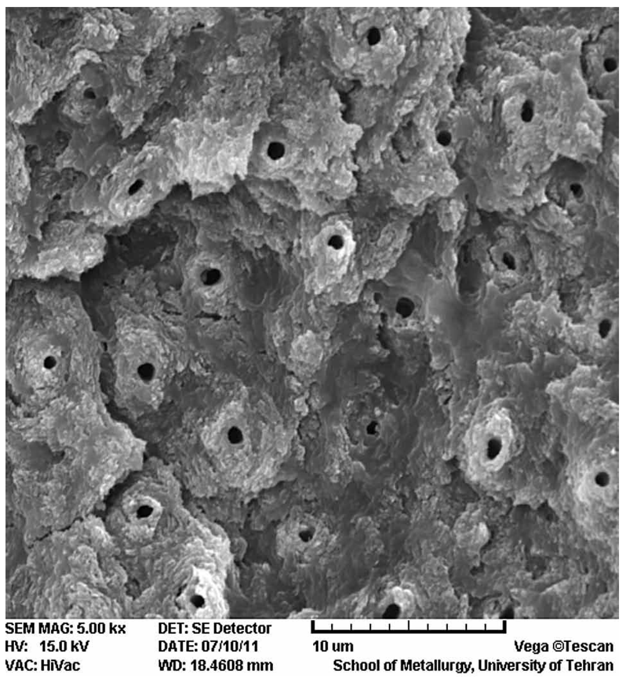

Figure 6. Surface treated by Er:YAGwith power 3.5 W. protruding area around dentinal tubules. (Original magnification ×5000, bar=10μm)

cracks and melting areas.

This result was in agreement with Freites at al who indicated that different parameters of Er:YAG laser produced irregular and micro-retentive morphological pattern without production of smear layer that makes these surfaces more suitable for

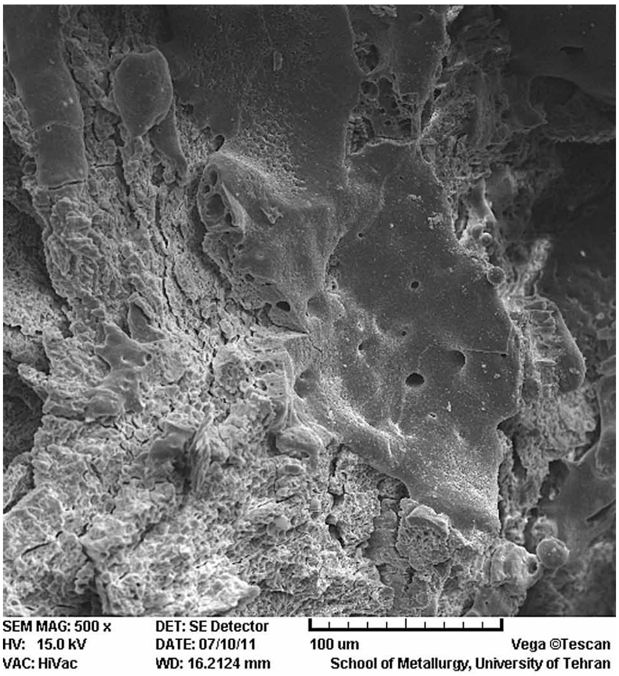

Figure 7. Surface treated by Er:YAGwith power 4 W. cracks and melting area can be observed (Original magnification ×500, bar=100μm)

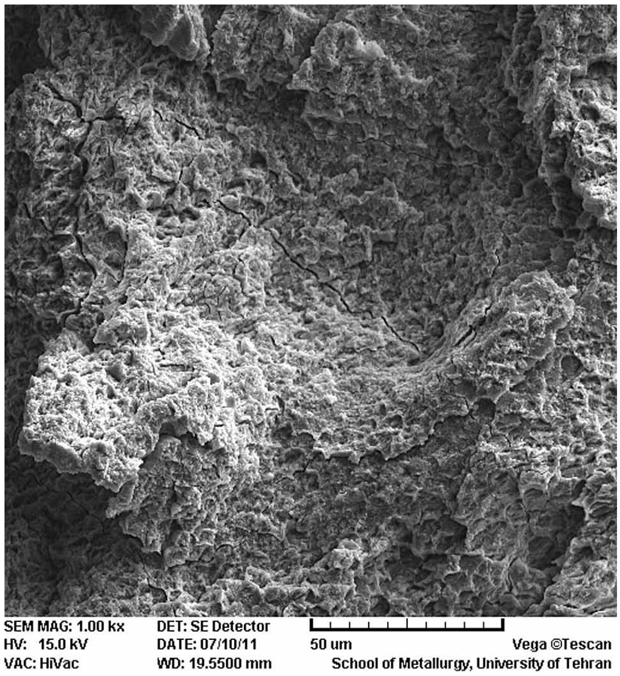

Figure 9. Surface treated by Er:YAGwith power 4.5 W. crack can be observed (Original magnification ×1000, bar=50μm)

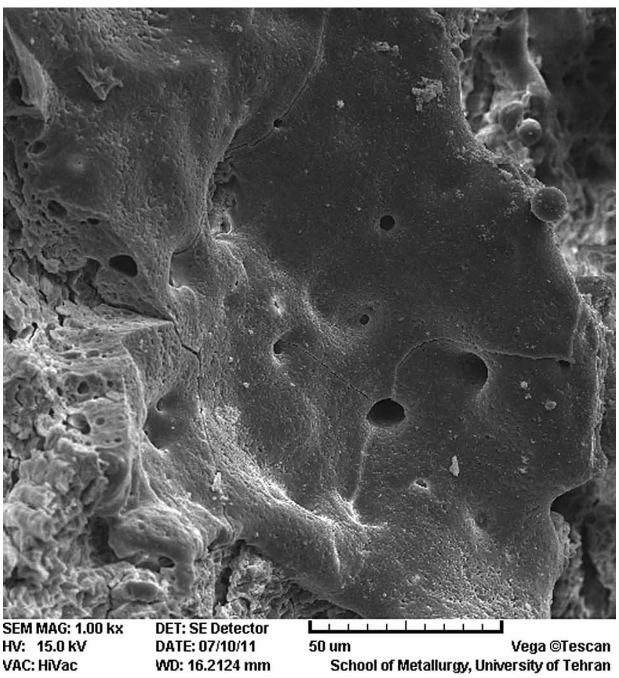

Figure 8. Surface treated by Er:YAGwith power 4 W. cracks around dentinal tubules can be observed. (Original magnification ×1000, bar=50μm)

resin composite restoration(10).

Also, Ceballos et al in analyzing the Er:YAG laser treated surfaces showed open dentinal tubules which allowed the development of resin tags(11).

The cracks formed by output power above 4 W is related directly to the amount of power used because more cracks and melting areas are produced by application of higher powers (12).

One of the main concerns during the cavity preparation is assessing thermal changes in the pulp. Evaluation of pulpal temperature rise during cavity preparation by Er:YAG laser indicated that the temperature would not rise more than 3º C which is lower than threshold temperature of 5.5º C indicated by Zach and Cohen (13). Since the highest amount of laser energy is used for ablation process, only a small part of energy is used to cause heat in surrounding tissue (14).

While using laser for cavity preparation, it's important to apply the minimum energy to cause the safe ablation of the tissue without unfavorable side effects (15).

The SEM images showed protruding dentinal tubules due to more ablation of inter-tubular dentin compared to peritubular dentin, because inter-tubular dentin is composed of large amount of collagen matrix which mainly contains water which is suitable for Erbium laser absorption (16).

In addition to comfort and reduced noise and vibration, erbium laser can provide other benefits including reduced hypersensitivity, as well as microbial elimination within the cavity. These advantages make erbium laser popular for cavity preparation (17).

Conclusion

It can be concluded that Er:YAG laser can be an alternative technique for surface treatment and can be considered as safe as the conventional methods. Also, it's important to select the appropriate parameters for conditioning the surface.

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