Original Article

In Vitro Evaluation of the Effect of Different Laser Irradiations on the Enamel Surfaces of Teeth Treated with Home Bleach Procedure

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Abstract:

Introduction: The aim of this study was to evaluate the effect of dental surface treatment with Erbium-Doped Yttrium Aluminum Garnet(Er: YAG), Neodymium-Doped Yttrium Aluminium Garnet(Nd: YAG) and Carbon Dioxide Laser (CO_2) lasers and sodium ascorbate to recently home bleached enamel by scanning electron microscope (SEM).

Methods: Thirty extracted human third molars were selected for this in vitro study. The teeth were randomly divided in two groups including home bleached group and control group (non-bleached). In group 1, the samples were bleached by home bleach technique. No bleaching procedure was done in second the group which served as control group. Then, the samples of two groups were divided to five subgroups as follow: Subgroup 1: treated using Nd:YAG laser with output power of 1 W, Subgroup 2: treated using Er:YAG laser with output power of 0.5 W, Subgroup 3: treated using CO_2 laser with output power of 0.5 W, Subgroup 4: sodium ascorbate 10%, Subgroup 5: no treatment. After treatments, the surfaces were evaluated using Scanning Electron Microscope (SEM) analysis.

Results: The surfaces treated by Nd:YAG laser showed some melting and recrystallized areas and in some area droplet pattern was observed. But the surface treated by Er:YAG laser showed irregular and micro porous surface with flake pattern. CO_2 laser treatment of home-bleached surfaces resulted in melting area and cracks. Sodium ascorbate did not change the home-bleached surface.

Conclusion: Among different surface treatments used in this study, it seems that Er:YAG laser can best interact with home-bleached teeth.

Keywords: Er-YAG laser; Nd-YAG laser; carbon dioxide laser; sodium ascorbate

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Introduction

Vital tooth bleaching procedure is generally used in esthetic dentistry to treat discolored teeth[1]. Following the bleaching process, patients often require additional aesthetic interventions such as the replacement of old restorations and application of laminate veneers to restore esthetic deficiencies[2].

There are two techniques for bleaching of vital teeth: in office under the super vision of dentist, or at home, usually with the use of night guards and carbamide peroxide or hydrogen peroxide[3].

However, a number of studies have shown that the bond strengths of adhesive restorations to tooth

structures are reduced when the tooth has been bleached[1,2,4]. This reduced bond strength tends to normalize after 1 to 4 weeks. Various antioxidant agents have been tested to reverse this effect, such as 10% sodium ascorbate and the catalase enzyme, although they are not yet applicable as routine clinical procedures[5].

Recently, lasers have been used for different purposes in restorative dentistry like caries removal, surface conditioning, etc[6].

Considering the ablative effect of the Erbium-Doped Yttrium Aluminum Garnet(Er: YAG) laser on the dental structure as well as the mineralized tissue recrystallization promoted by Neodymium-Doped Yttrium Aluminium Garnet(Nd: YAG), Carbon Dioxide (CO_2) lasers, it is believed that their use could influence the post bleaching bonding, by promoting substrate heating and causing alterations in enamel and dentin morphology[7].

The aim of this study was to evaluate and compare the effect of dental surface treatment with Er: YAG, Nd: YAG and CO_2 lasers and sodium ascorbate to recently home bleached enamel by scanning electron microscope (SEM).

Methods

Thirty extracted human third molars were selected for this in vitro study. The teeth with caries, fractures and hypoplastic lesions were excluded. The remaining tissues were removed by periodontal scaler (Sonic flex 2000, kavo, Biberach, Germany). All teeth were placed in 0.5% chloramine T solution (Chloramin T Trihydrat, Merck schucharat OHG 85662 Hohenbrunn, Germany) for disinfection purpose and then stored in 4°C distilled water until use.

The teeth were randomly divided in two groups including home bleached group and control group (non-bleached).

In group 1, the samples were bleached by home bleach technique. The thin layer of bleaching gel (Day white ACP, Discus Dental, CA, USA) with thickness of 2mm was placed on buccal surface of each tooth in 100% moisture for 15 min. During this process, the teeth were kept in artificial saliva at 37 °C in order to have the buccal surface not in contact with saliva. This procedure was done 1more time. Then, the samples were kept in 14 ml of artificial saliva. The solution was replaced every day. This bleaching technique was repeated for 3 weeks.

No bleaching procedure was done in the second group which served as control group.

Then, all the samples in the 2 groups were divided to five subgroups as follow:

Subgroup 1: treated using Nd:YAG laser 1064nm wavelength (Fidelis, Fotona, Jubljana, Slovenia) with output power of 1 W, frequency of 10 Hz and pulse duration of 100µs with fiber of 300µm. The irradiation was done 1 mm above the surface.

Subgroup 2: treated using Er:YAG laser 2940nm wavelength (USD20, DEKA Dental laser systems, Florence, Italy) with output power of 0.5 W, frequency of 10 Hz and pulse duration of 230 µs in non-contact mode with distance of 4 mm above the surface

Subgroup 3: treated using CO_2 laser 10600nm wavelength (US-20D, DEKA Dental laser systems, Florence, Italy) with output power of 0.5 W, frequency of 10 Hz and pulse duration of 1.5 ms, non-contact mode with distance of 7 mm above the surface.

Subgroup 4: sodium ascorbate 10% (Merck Darmstadt, Germany), 10 ml of solution with speed of 1 ml/min was poured on the surface of teeth for 10 min, and then the enamel surface was rinsed with distilled water and dried.

Subgroup 5: no treatment (control group)

After treatments, the surfaces were evaluated using Scanning Electron Microscope (SEM) (ZEISS DSM-960A, Germany) 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, prepared surfaces were evaluated qualitatively with a scanning electron microscope at ×200 and ×2000 magnification.

Results

The surfaces treated by Nd:YAG laser showed shiny and opaque macroscopically and some melting and recrystallized areas microscopically and in some area droplet pattern was observed which indicated melting area (Figure 1). But the surface treated by Er:YAG laser showed irregular and micro porous surface with flake pattern (Figure 2). CO_2 laser treatment of home-bleached surfaces resulted in melting area and cracks led to great damage (Figure 3). Also, burst blister parts can be seen due to temperature increase in superficial layer. Sodium ascorbate did not change the home-bleached surface (Figure 4). In bleached teeth with no surface treatment, superficial solubility

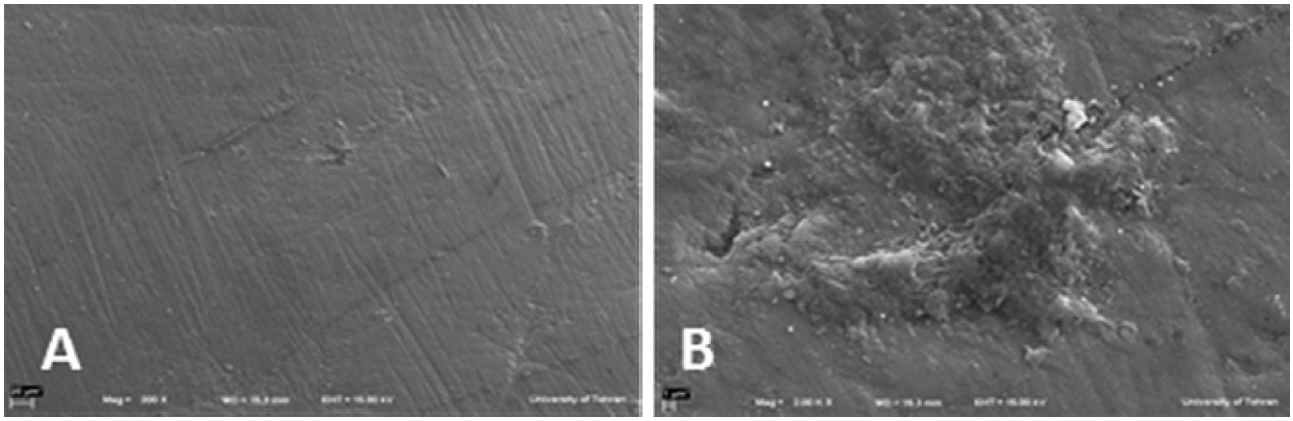

Figure 1. Home-bleached surface treated by Nd:YAG laser (Original magnification x200(A), x2000(B), bar=10µm)

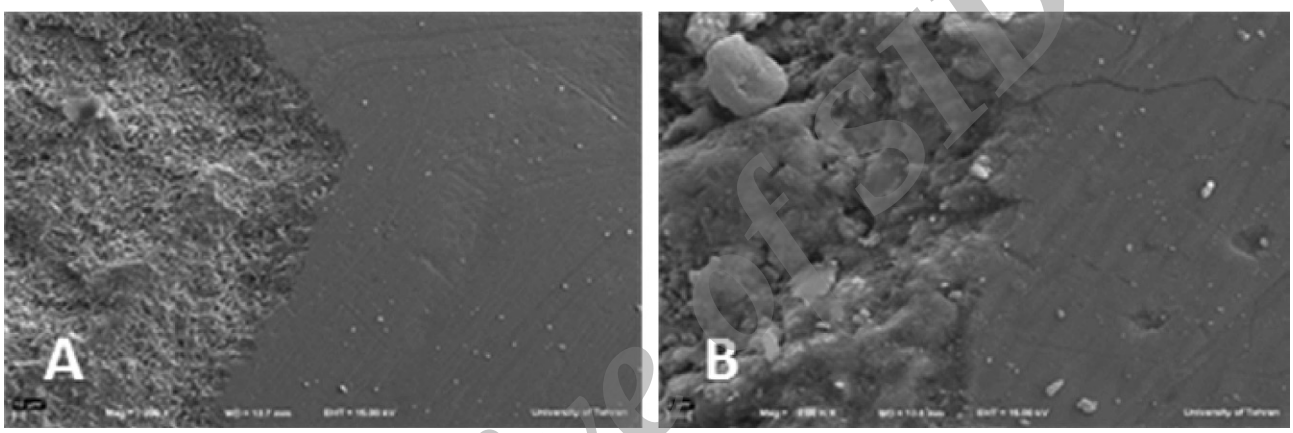

Figure 2. Home-bleached surface treated by Er:YAG laser (Original magnification x200(A), x2000(B), bar=10µm)

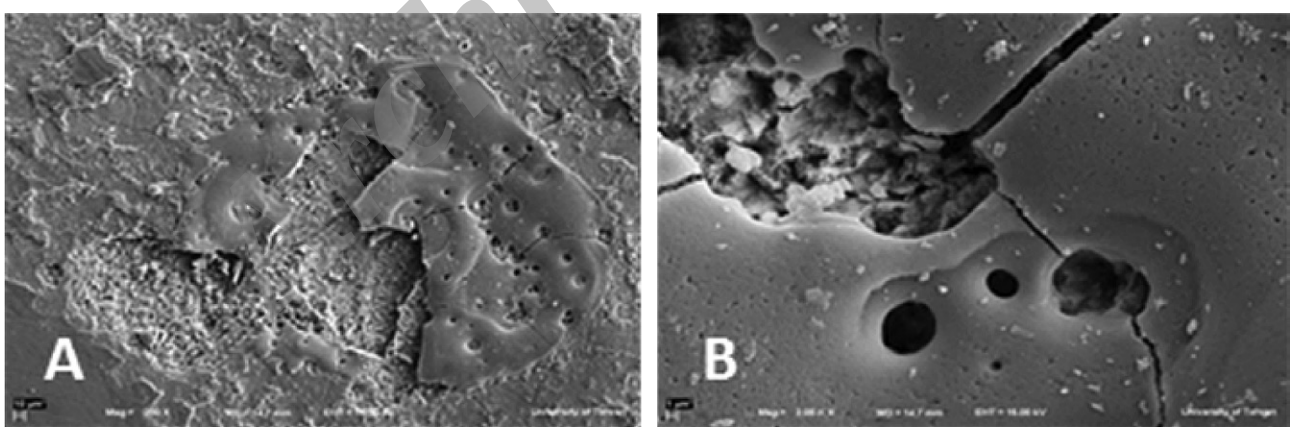

Figure 3. Home-bleached surface treated by CO_2 laser (Original magnification x200(A), x2000(B), bar=10µm)

and slight porous surface was seen (Figure 5). In non-bleached teeth, Nd:YAG laser provided melted and recrystallized areas (Figure 6), Er:YAG and CO_2 laser produced surface similar to bleached ones (Figure 7,8) and Ascorbate did not affect the surface of enamel (Figure 9).

Discussion

Replacement of restoration after bleaching process is often required. Therefore, reduction of bond strength in enamel after bleaching process is a concerning issue[8,9]. Different modifications can be done to enhance the bond strength. The aim of this study was to evaluate

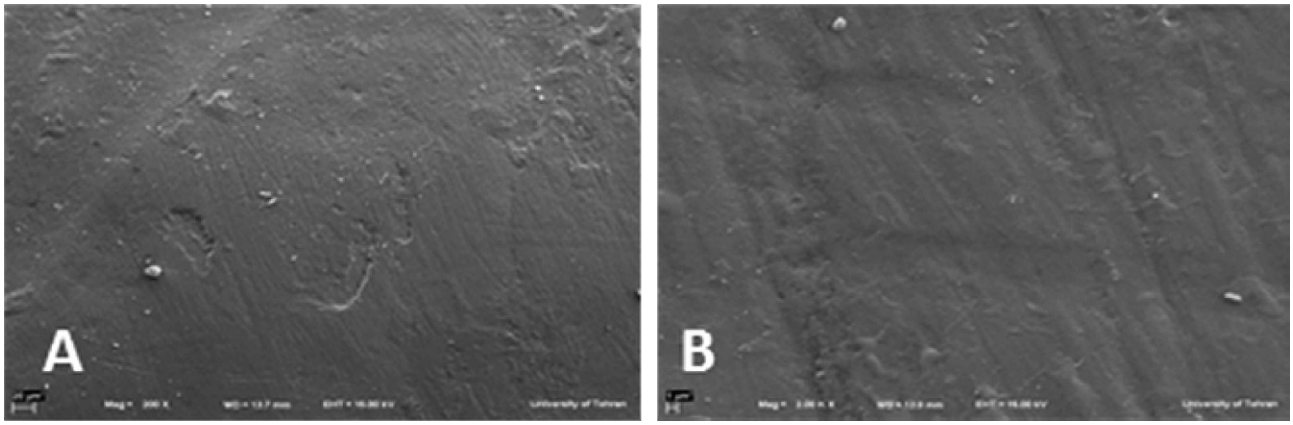

Figure 4. Home-bleached surface treated by ascorbate solution (Original magnification x200(A), x2000(B), bar=10µm)

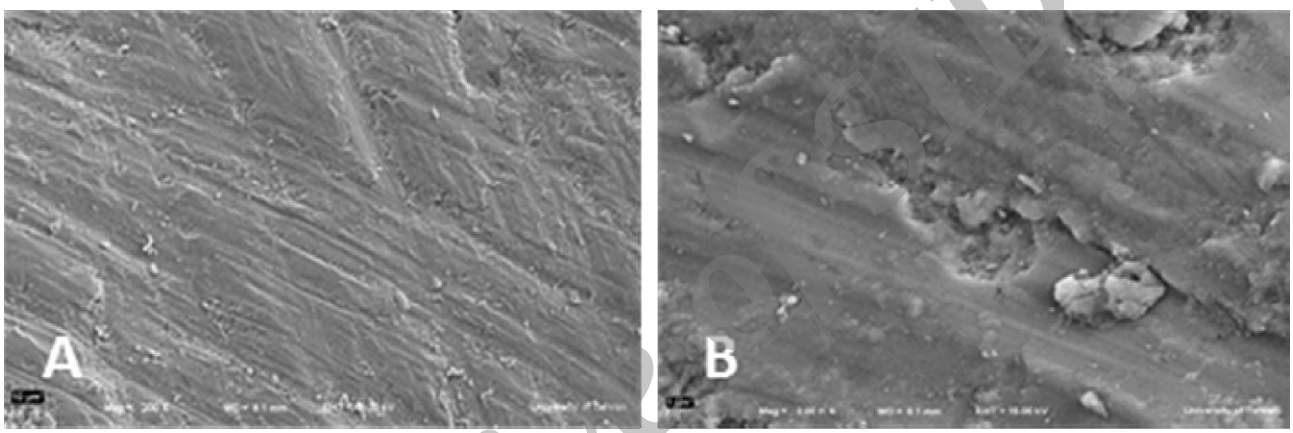

Figure 5. Home-bleached surface with no treatment Original magnification x200(A), x2000(B), bar=10µm)

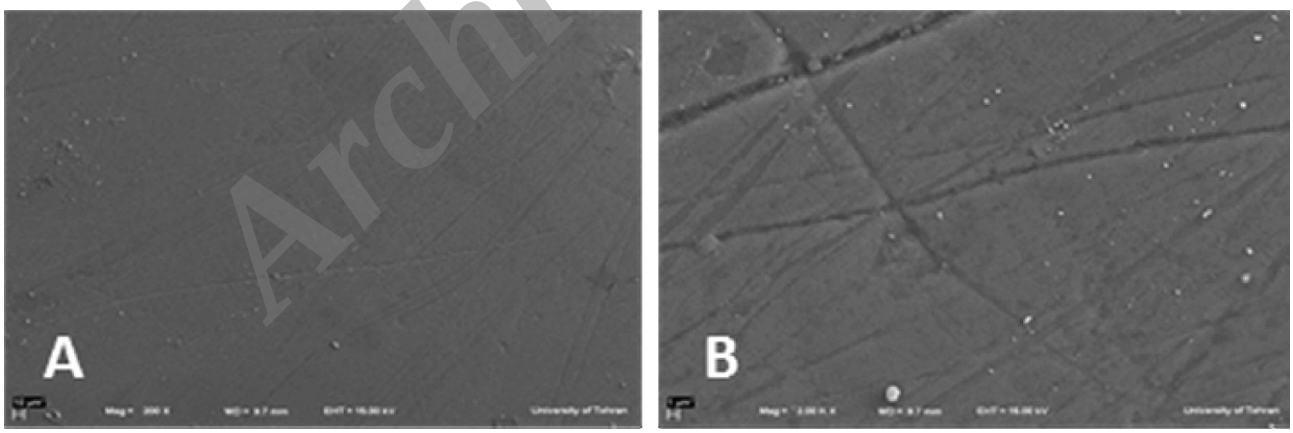

Figure 6. Non-bleached surface treated by Nd:YAG laser (Original magnification x200(A), x2000(B), bar=10µm)

the home-bleached enamel surface treated by Er:YAG, Nd:YAG, CO_2 and Ascorbate by SEM to determine which surface is more suitable to achieve enough bond strength in qualitative manner.

Different studies showed that after home bleaching procedure, the structure of enamel is changed producing porous surface with loss of prismatic components. Also, other factors such as calcium loss, changes in organic substances and decrease in microhardness are responsible for decrease in bond strength[10-12].

The mechanism of Er:YAG laser on dental substrate is through absorption of laser energy by water which

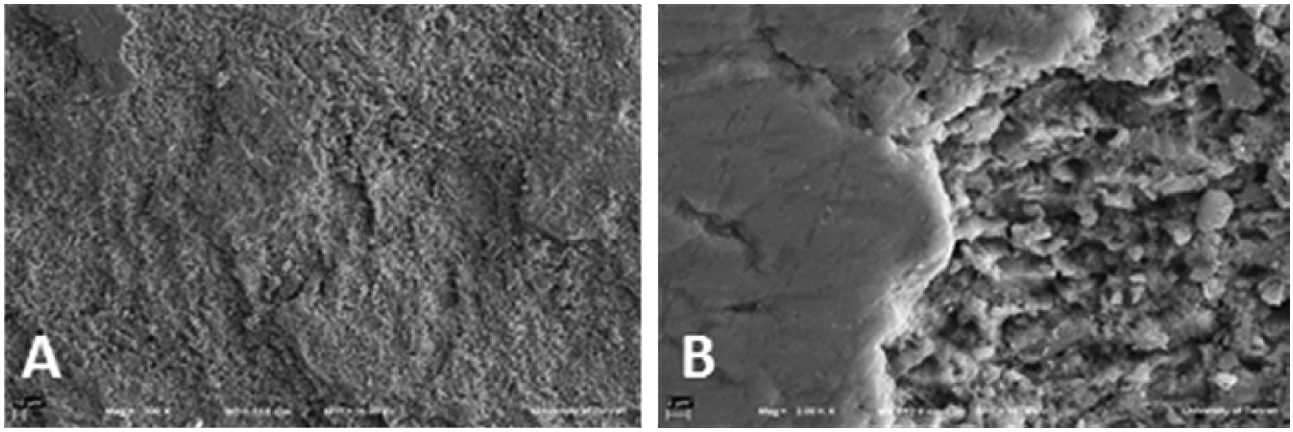

Figure 7. Non-bleached surface treated by Er:YAG laser (Original magnification x200(A), x2000(B), bar=10µm)

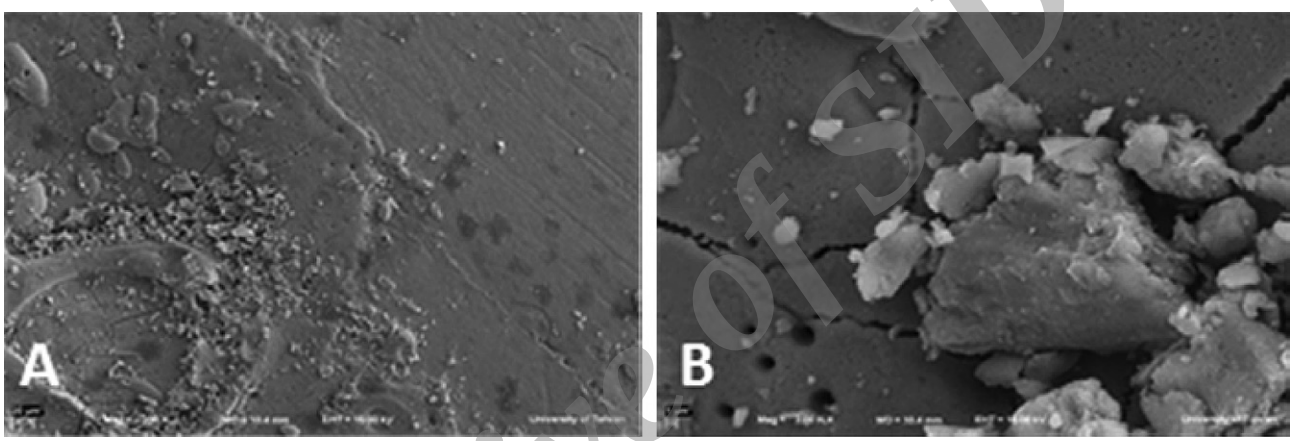

Figure 8. Non-bleached surface treated by CO_2 laser (Original magnification x200(A), x2000(B), bar=10µm)

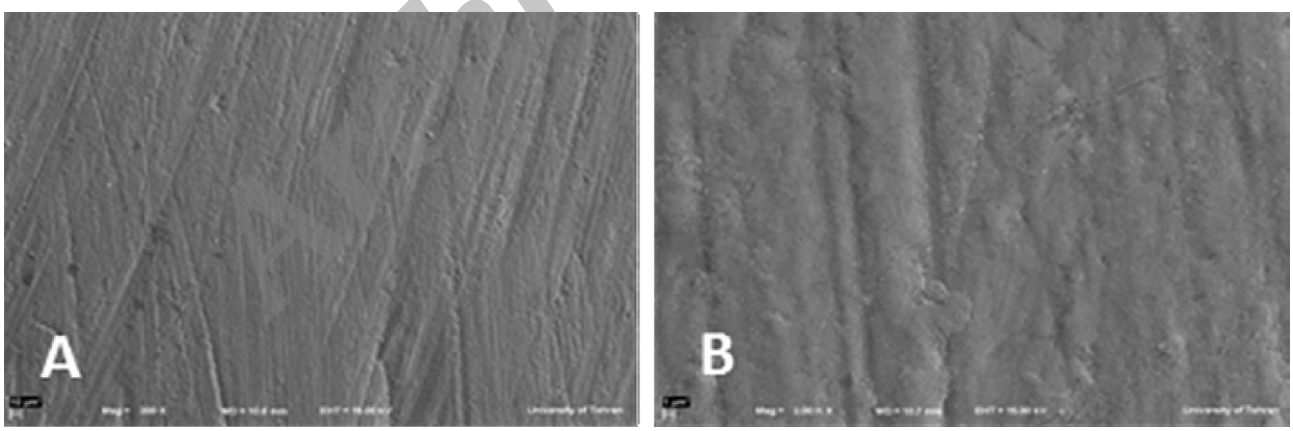

Figure 9. Non-bleached surface treated by ascorbate solution (Original magnification x200(A), x2000(B), bar=10µm)

causes microexplosion and ablation of dental hard tissue[13]. SEM images in Er:YAG laser treated group showed a rough and irregular surface without smear layer production. During these microexplosions, heat produced which can remove the oxygen from surface to enhance the bond strength. Also, Er:YAG laser irradiation produced etched enamel which is favorable for bonding procedure.

On the other hand, Nd:YAG laser treated group showed melting area due to thermal effects that can eliminate residual oxygen produced by bleaching technique[14].

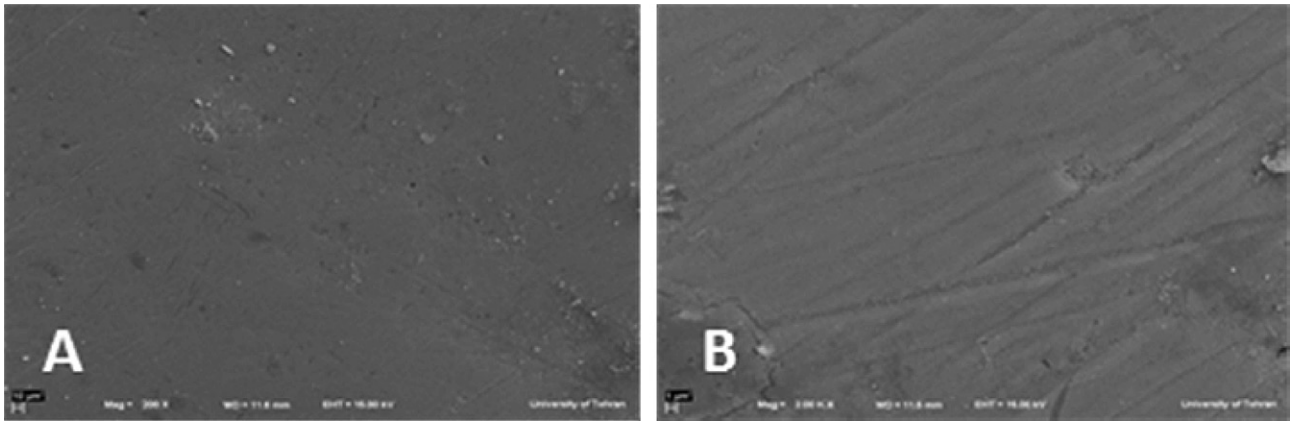

Figure 10. Non-bleached surface with no treatment Original magnification x200(A), x2000(B), bar=10µm)

Fissure and cracks can be observed in CO_2 laser treated group that can also contribute to heat production on surface of enamel which is beneficial for reduction of residual oxygen but the disadvantages of these cracks on bond strength should be considered[15].

Sodium ascorbate as a famous antioxidant agent has the ability to remove free radicals of oxygen[16]. The SEM images of this group showed no changes compared to control group.

Further studies are needed to clarify which laser treatment is more appropriate for increasing the bond strength after bleaching procedure.

Conclusion

Among different surface treatments used in this study, it seems that Er:YAG laser can best interact with home-bleached teeth and provide the suitable substrate for adhesion.

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