Scanning Electron Microscope (SEM) Evaluation of Composite Surface Irradiated by Different Powers of Er:YAG Laser

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Abstract:

Introduction: The aim of this study was to evaluate the composite surface treated by different powers of Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser in comparison with bur preparation via scanning electron microscope.
Methods: Fourteen composite resin blocks with 15× 10 × 10 mm dimensions were used in this study. The samples were divided to seven groups as follow: Group 1 (power: 1 W, Energy: 50 mJ); Group 2 (power: 2 W, Energy: 100 mJ); Group 3 (power: 3W, Energy: 150 mJ); Group 4 (power: 4 W, Energy: 200 mJ); Group 5 (power: 5W, Energy: 250 mJ); Group 6 (power: 6 W, Energy: 300 mJ); Group 7: Diamond bur. Then, the samples were prepared for SEM examination.
Results: The surface treated by Er:YAG laser showed irregular and micro porous surface.
Conclusion: It seems that composite surface treatment by Er:YAG laser can be an alternative method for composite repair if suitable parameters are used.
Keywords: Er-YAG laser; composite resin; SEM.

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Introduction

Development of techniques and materials in restorative dentistry provided the effective bond between material and dental substrates [1]. Defective resin restorations are caused by discoloration of restoration, irregularities in margin of restoration, fracture and cracks, etc [2].

Repairing procedure should be minimally invasive to preserve remaining dental structure and prevent pulp irritation [3]. Several surface conditioning techniques such as acid-etching, air abrasion, burs and recently laser are used for this purpose [4-6].

Different factors affect the repairing outcome such as surface conditioning of defective composite, composite viscosity, surface porosity, adhesive type, etc [7].

One of the most applicable methods for composite surface treatment is bur. This technique has some disadvantages like pain, requiring anesthesia, being non-selective for removing materials, etc. Lasers are used in different aspects of dentistry. Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser with 2940 nm wavelength has a high absorption in water which produces heat and increases the pressure inside the tissue resulting in microexplosions. This mechanism is called water mediated ablation [8,9].

Some studies showed that Er:YAG laser is effective for treatment of direct composite resin. Eren et al. in assessing Er:YAG laser with 1.5 W output power for surface treatment of composite resin concluded that this surface treatment produced sufficient repair bond strength [10].

Also, Rossato et al. in the evaluation of laser for surface treatment of composite resin concluded that Er:YAG laser as superficial treatment showed similar bond strength compared to bur application [11].

The aim of this study was to evaluate the composite surface treated by different powers of Er:YAG laser in comparison with bur preparation by scanning electron microscope.

Methods

14 composite resin blocks (Filtek Z250XT, 3M ESPE, USA) with 15× 10 × 10 mm dimensions were made in glassy mold according to manufacturer's instruction. The bonding surface of these blocks were polished using 600 grit silicon sandpaper for 15 seconds under running water to make an even surface. Then, the samples were divided to seven groups as follow:

Group 1: Er:YAG laser with average power of 1 W, energy of 50 mJ and pulse repetition rate of 20 Hz

Group 2: Er:YAG laser with average power of 2 W, energy of 100 mJ and pulse repetition rate of 20 Hz

Group 3: Er:YAG laser with average power of 3 W, energy of 150 mJ and pulse repetition rate of 20 Hz

Group 4: Er:YAG laser with average power of 4 W, energy of 200 mJ and pulse repetition rate of 20 Hz

Group 5: Er:YAG laser with average power of 5 W, energy of 250 mJ and pulse repetition rate of 20 Hz

Group 6: Er:YAG laser with average power of 6 W, energy of 300 mJ and pulse repetition rate of 20 Hz

Group 7: diamond bur (Tizkavan, Iran)

In laser groups, the surfaces were treated by Er:YAG laser (2940D plus, Deka,

Italy), with 2940 nm wavelength, in non-contact mode and 4 mm distance above the surface. The irradiation was performed in sweeping motion. The pulse duration was 450 µsec.

After laser treatment, the surfaces were evaluated using Scanning Electron Microscope (SEM) analysis. Samples were fixed in 2.5% Glutaraldehyde 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 analyzed qualitatively with a scanning electron microscope at ×500, ×2000 and ×5000 magnification.

Results

The surface treated by Er:YAG laser showed irregular and micro porous surface. By increasing the power up to 5W, the surface porosity increased. But the surface treated with output power of 6 W showed excessive material deterioration. The surface treated by bur showed smear layer and grooves. (Figure 1-7)

Discussion

Repairing defective resin composite restorations instead of removing and replacing the restoration is considered more rational due to some advantages including preservation of tooth structure, trauma avoidance and restoration longevity increase [12].

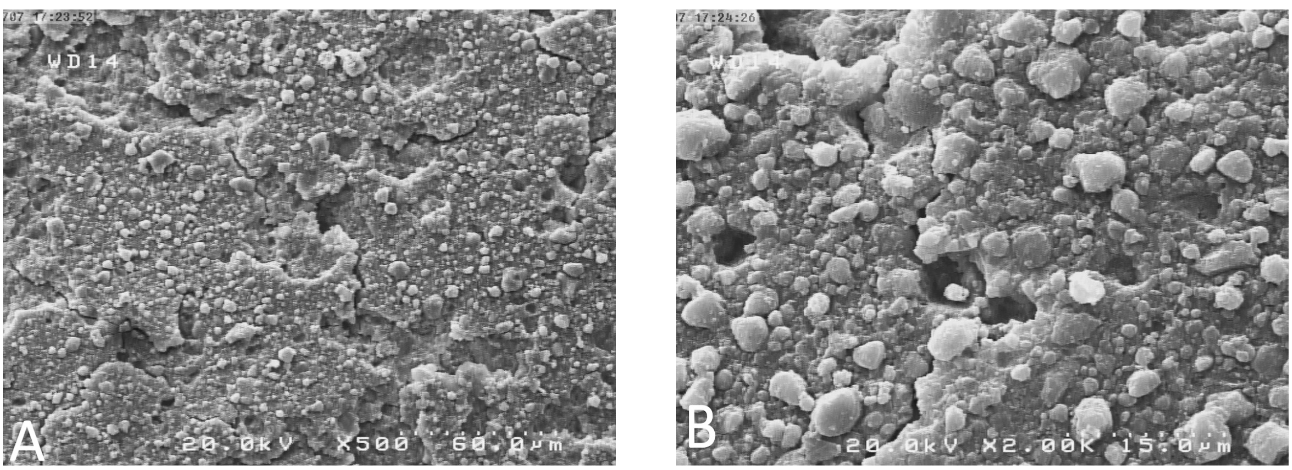

Figure 1 (A, B). Surface treated by Er:YAG laser with power of 1 W, 50 mJ (Original magnification x500, x2000)

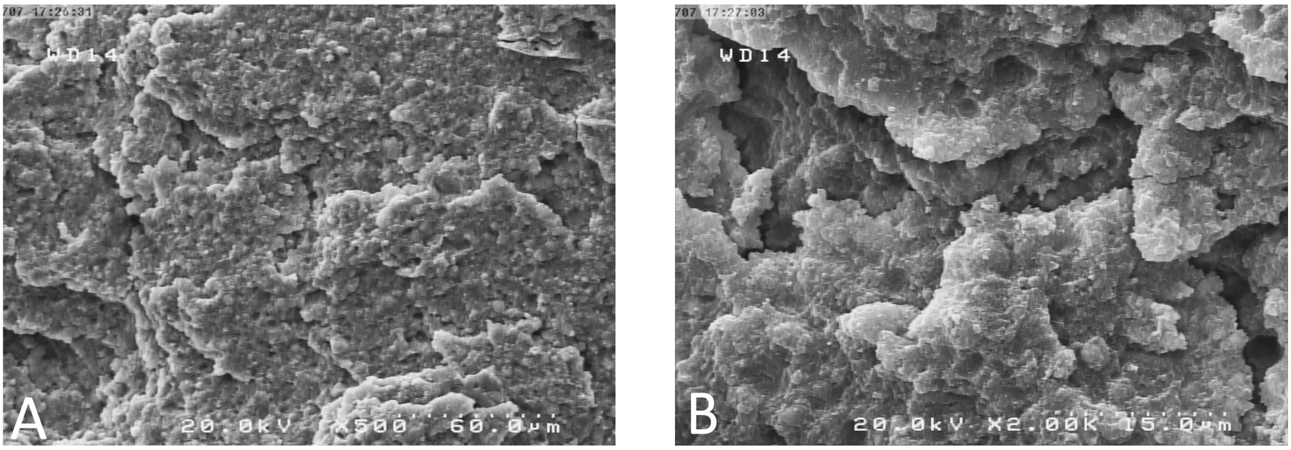

Figure 2 (A, B). Surface treated by Er:YAG laser with power of 2 W, 100 mJ (Original magnification x500, x2000)

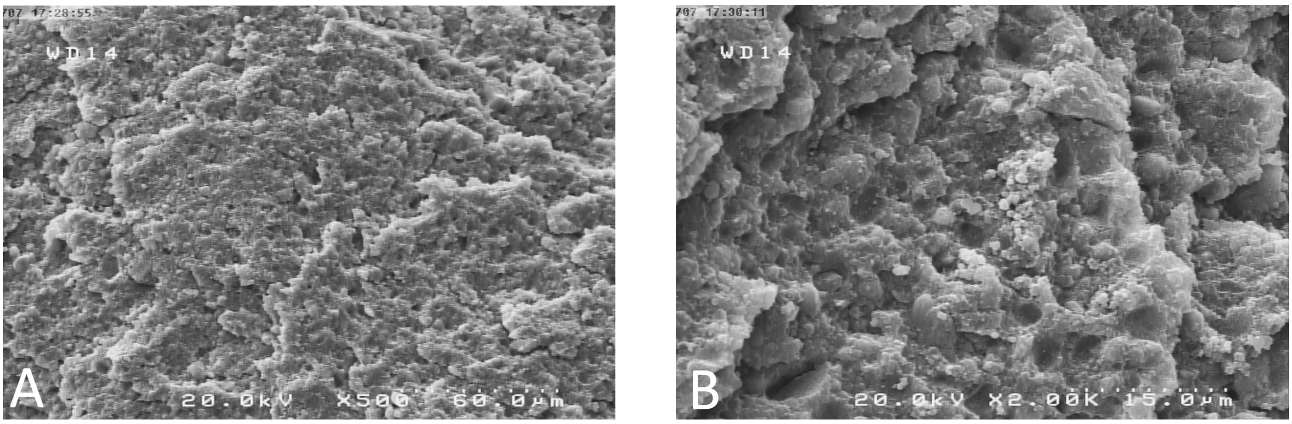

Figure 3 (A, B). Surface treated by Er:YAG laser with power of 3 W, 150 mJ (Original magnification x500, x2000)

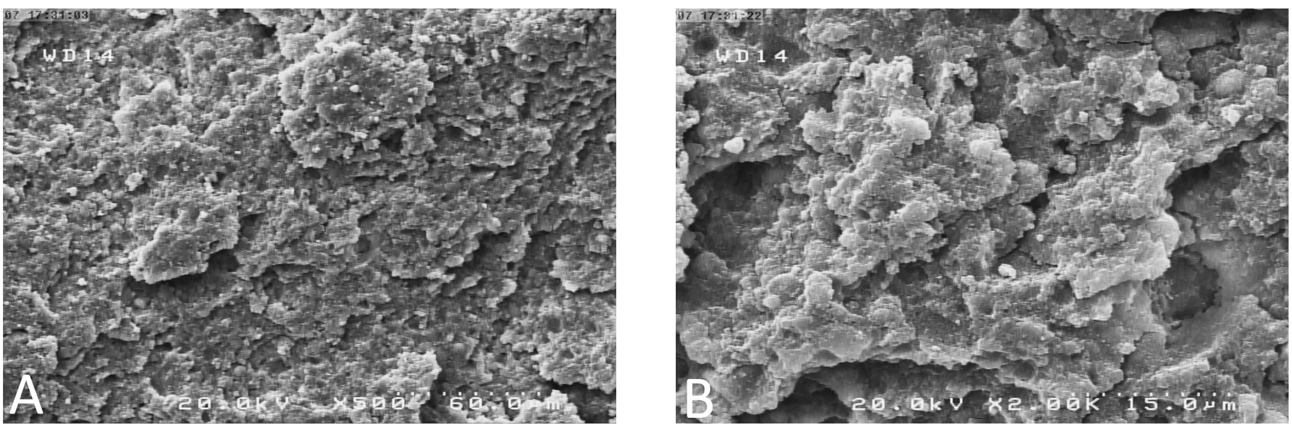

Figure 4 (A, B). Surface treated by Er:YAG laser with power of 4 W, 200 mJ (Original magnification x500, x2000)

The aim of this study was to evaluate the effect of different powers of Er:YAG laser on composite surface compared to bur preparation.

It has been reported that the main factor for providing a favorable bond between old composite and repair composite is micro retentive inter locking. By increasing the surface roughness, better mechanical interlock can be achieved which is followed by production of free carbon bonds on surface [13].

The application of bur on composite surface produced grooves and smear layer. The smear layer formation has negative effect on bonding that can be reduced by

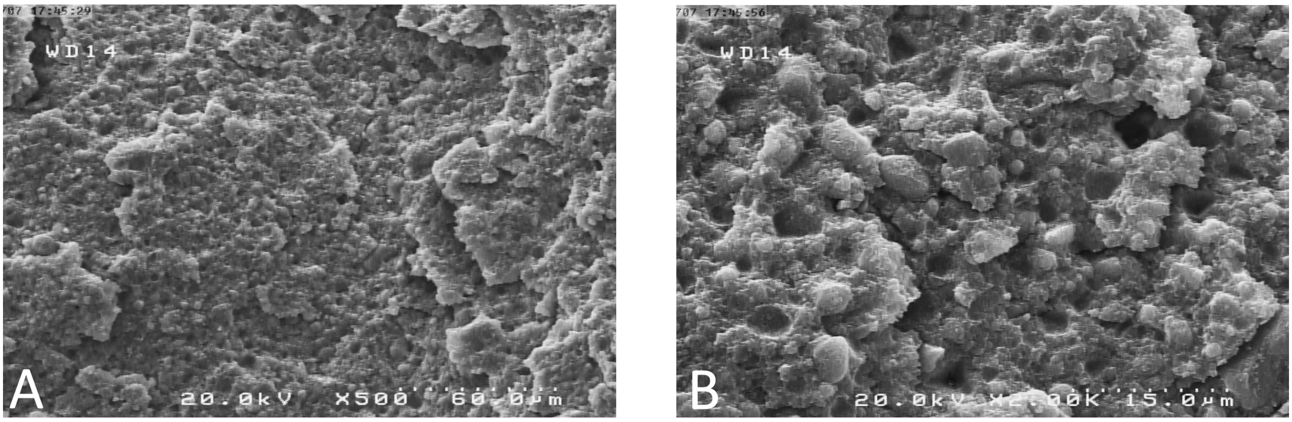

Figure 5 (A, B). Surface treated by Er:YAG laser with power of 5 W, 250 mJ (Original magnification x500, x2000)

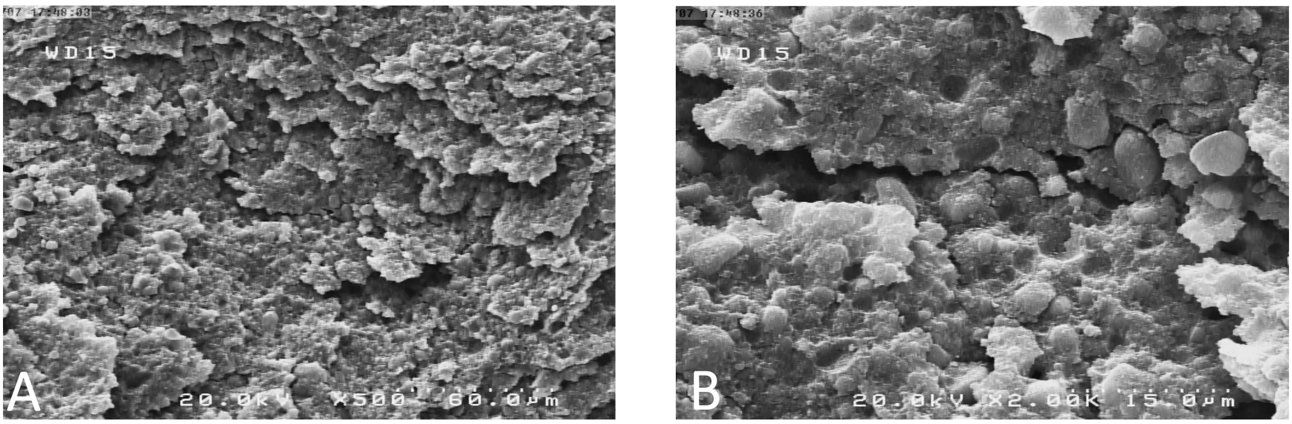

Figure 6 (A, B). Surface treated by Er:YAG laser with power of 6 W, 300 mJ (Original magnification x500, x2000)

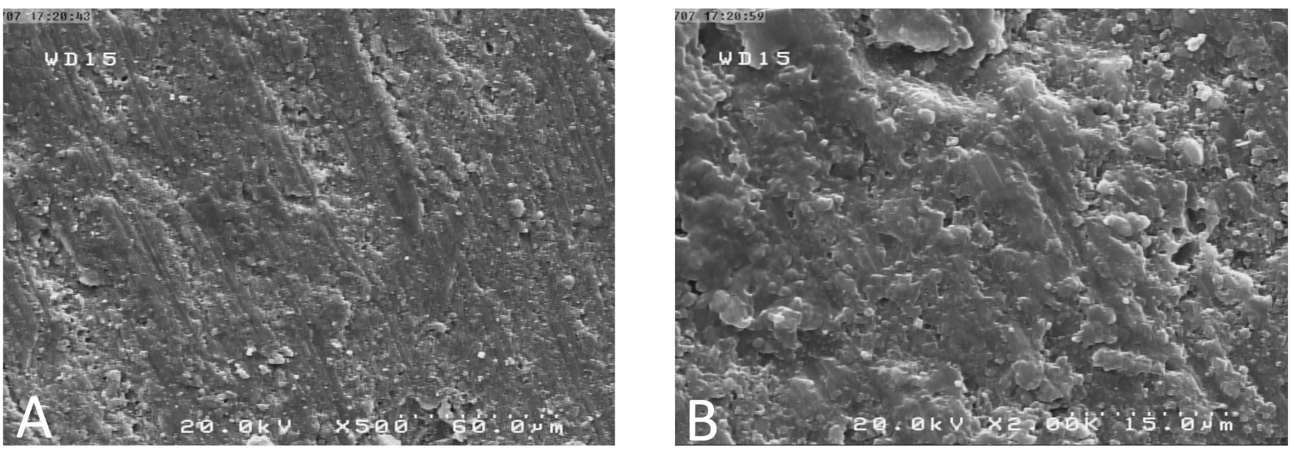

Figure 7 (A, B). Surface treatment by bur (Original magnification x500, x2000)

application of acid etching [14].

In contrast laser application produced retentive surface without smear layer production which may provide higher bond strength.

Er:YAG laser is well absorbed by water and hydroxyapatite present in dental structure. So, it is considered as a safe laser for cavity preparation, surface modification, composite removal, etc [15]. Lasers can ablate composite resin selectively and minimize the enamel removal but it should be applied with water and air spray to reduce the thermal side effects [16].

The results of this study showed that by increasing the output power of Er:YAG laser, the composite surface became unsuitable due to excessive material deterioration but powers below 5 W produced retentive surface that can interact with composite resin.

On the other hand, Lizarelli et al. stated that the type of composite resin (chemical composition, structure) and laser parameters can influence the penetration depth and ablation rate [17].

There are limited studies which evaluated the effect of laser on repair of composite resin. More invitro and clinical studies are needed to create appropriate guidelines for repairing of composite resin restoration.

Conclusion

It seems that composite surface treatment by Er:YAG laser can be an alternative method for composite repair if suitable parameters are used.

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