Original Article

The Effect of Different Powers of Er:YAG Laser Treatment on Surface Morphology of an Indirect Composite Resin: SEM Evaluation

Nazanin Zeinab Garshasbzadeh[1], Mansoreh Mirzaie[1], Esmael Yassini[1], Sima Shahabi[2], Nasim Chiniforush[2]

[1]Operative Dentistry Department, School of Dentistry, Tehran University of Medical Sciences,Tehran,Iran
[2]Laser Research Center of Dentistry, School of Dentistry, Tehran University of Medial science,Tehran,Iran

Abstract:

Introduction: Indirect composites are developed to overcome the shortcomings of direct composites but, the adhesion of resin cements to indirect composites is still difficult. The purpose of this study was to evaluate the surface morphology of indirect resin composite treated by different powers of Er:YAG laser using Scanning Electron Microscopy (SEM).
Methods: indirect resin composite blocks (GC Gradia DA2, Japan) with 15× 10 × 10 mm dimensions were made according to manufacturer's instructions (n=7). The bonding surface of these blocks were polished, then the samples were divided to seven groups as follow: Erbium-Doped Yttrium Aluminum Garnet (Er:YAG)laser with output power of 2, 3, 4, 5, 6,7 W (frequency of 20 Hz, very short pulse) and no treatment. Then, the surfaces were evaluated by scanning electron microscope.
Results: The surface treated by Er:YAG laser showed a porous surface. But the amount and pattern of these irregularities differ in each group which may produce micromechanical retention compared to control group with no treatment.
Conclusion: Er:YAG laser can be used as an alternative technique for surface treatment and roughening of indirect resin composites.
Keywords: Er:YAG lasers; SEM; composite resin

Please cite this article as follows:
Garshasbzadeh NZ, Mirzaie M,Yassini E,Shahabi S,Chiniforush N. The Effect of Different Powers of Er:YAG Laser Treatment on Surface Morphology of an Indirect Composite Resin: SEM Evaluation. J Lasers Med Sci 2014;5(3):130-4

Corresponding Author: Nasim Chiniforush, DDS; PhD Candidate of Laser Dentistry, Laser Research Center of Dentistry, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran. Tel: +98-2188015017; Fax: +98-2188687471; Email: n-chiniforush@farabi.tums.ac.ir

Introduction

More conservative treatments in restorative dentistry are possible through adhesive dentistry based on the reduction in the size of cavity and the bonding procedure of materials to the dental structure[1].

Recently, resin composites have become popular clinically compared to other restorative materials due to their properties like ability to bond to tooth structure and the restoration, reduced solubility, providing esthetic and accuracy of fit[2,3].

Indirect adhesive procedures have formed a considerable portion of oral treatment[2]. Indirect restorative systems were introduced as substitution for metallic or ceramic-based restoratives[4]. One of the main factor for providing suitable physical and biological properties is adequate polymerization of resin composites[5]. Although the newest direct composite resins eliminate the shortcoming of old ones and provide better properties but it is still a challenge for their application in large posterior restorations due to polymerization shrinkage which is a main concern in cavities with high C-factor[4,6].

In indirect restorations, polymerization occurs before cementation, so shrinkage stress should be minimized. Large direct composite restorations are followed by some problems such as providing accurate anatomic form, proximal contour and contact, etc. so, indirect systems are developed to overcome these limitations[5].

Commercially available indirect composite resins have been employed for the treatment of anterior and posterior teeth by offering enhanced esthetic and handling properties. These materials are consisted of high percentage of inorganic fillers which enhance the mechanical and physical properties[7,8].

The clinical success rate of indirect composite restorations is mainly associated with bonding of the luting agent to the tooth and the restorative material. Therefore, the surface treatment of the composites is an important step in long-term clinical performance[7]. Different surface treatments like roughening the area of adhesion, sandblasting, sandblasting and silanizing can provide significant additional resistance to forces[9].

Hydrofluoric acid etching with silane treatment did not seem to be effective for providing better bond strength[9].

Acid etching alone is not sufficient to produce effective bond strengths[10], but the effect of hydrofluoric acid treatments showed controversial results in different studies. Some authors believe that HF acid is harmful for the resin composite[10] or that its application with silane treatment does not reveal significant changes in tensile bond strength[9]. On the other hand, other authors consider that five minutes of HF etching could significantly increase the bond strength compared to airborne particle abrasion followed by application of silane coupling agent[11].

Sandblasting procedure produces retentive surface which is favorable for improvement of bond strength for indirect composite restorations[9].

The Erbium-Doped Yttrium Aluminum Garnet (Er:YAG)laser has been proposed for different aspects of clinical dentistry including caries removal, cavity preparation, surface treatment, composite removal and as a surface treatment for indirect restorations[12,13].

The aim of this study was to evaluate the surface of indirect resin composite treated by different powers of Er:YAG laser using Scanning Electron Microscopy (SEM).

Methods

indirect composite blocks (GC Gradia DA2, Japan) with 15× 10 × 10 mm dimensions were made using a stainless steel mold according to manufacturer's instructions (n=7). The bonding surface of these blocks were polished using 1200 grit SiCpaper for 15 seconds under running water to make an even surface. Then, the samples were divided into seven groups as follow:

Group 1: treated using Er:YAG laser with output power of 2 W, 100 mJ and frequency of 20 Hz very short pulses.

Group 2: treated using Er:YAG laser with output power of 3 W, 150 mJ and frequency of 20 Hz very short pulses.

Group 3: treated using Er:YAG laser with output power of 4 W, 200 mJ and frequency of 20 Hz very short pulses.

Group 4: treated using Er:YAG laser with output power of 5 W, 250 mJ and frequency of 20 Hz very short pulses.

Group 5: treated using Er:YAG laser with output power of 6 W, 300 mJ and frequency of 20 Hz very short pulses.

Group 6: treated using Er:YAG laser with output power of 7 W, 350 mJ and frequency of 20 Hz very short pulses.

Group 7: For this group no surface treatment was done as a control group.

Er:YAG laser (US2940D, Deka, Italy) with wavelength of 2940 nm was used in sweeping motion 4 mm above the surface with spot size of 1 mm. The pulse duration was set at 230 µsec.

After laser treatment, the surfaces were evaluated using Scanning Electron Microscope (SEM). The samples were dried and sputter-coated with gold. Then the prepared surfaces were analyzed with a scanning electron microscope at ×250, ×500, ×1000 and ×2000 magnifications.

Results

The surface treated by Er:YAG laser showed irregular and micro porous surface. But the amount and pattern of these irregularities differ in each group. In laser treated surfaces with output power of 2, 3 and 4W the surface porosity were enhanced with increasing power (Figure 1,2,3), but the powers after 4 W produced less porous surfaces due to higher ablation which makes the surface unsuitable owing to excessive material deterioration (Figure 4,5,6). Control group was shown in Figure 7.

Discussion

The bonding of resin cements to indirect composites is a challenging issue [2]. Various techniques have been designed to solve this problem. The aim of this study was to evaluate the effect of Er:YAG laser on indirect composite surface qualitatively.

Fewer number of monomers due to high polymerization of these composites can reduce bond strength [14]. So,

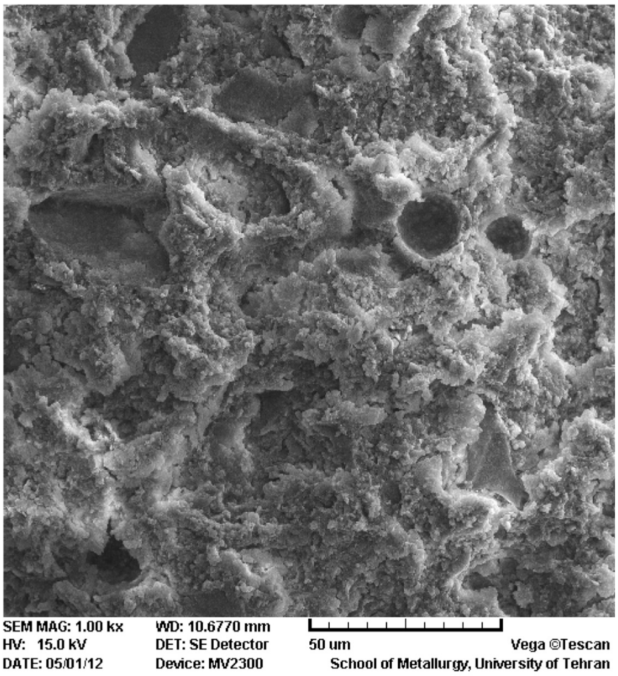

Figure 1. Surface treated by Er:YAG laser with output power of 2 W, 100 mJ (Original magnification ×1000, bar=50μm)

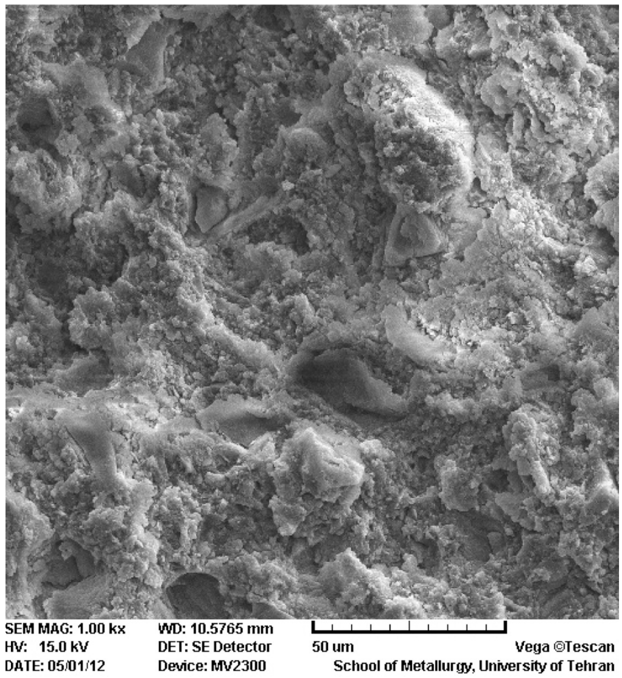

Figure 2. Surface treated by Er:YAG laser with output power of 3W, 150 mJ (Original magnification ×1000, bar=50μm)

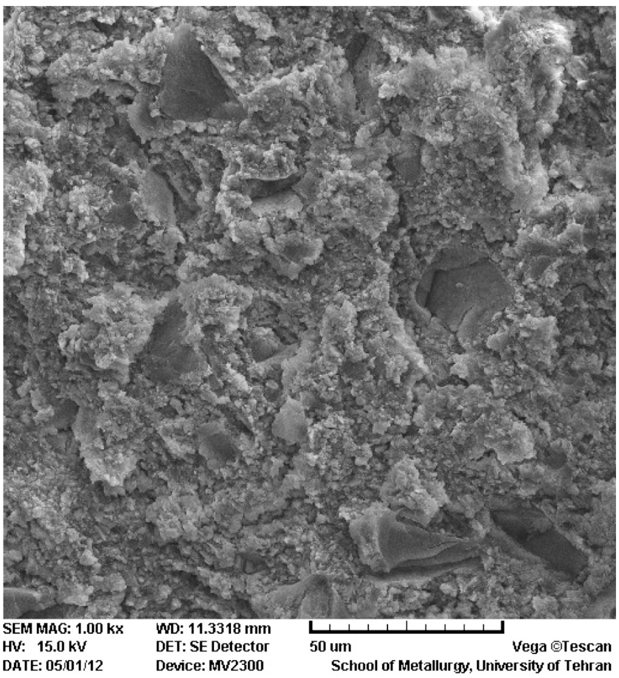

Figure 3. Surface treated by Er:YAG laser with output power of 4 W, 200 mJ (Original magnification ×1000, bar=50μm)

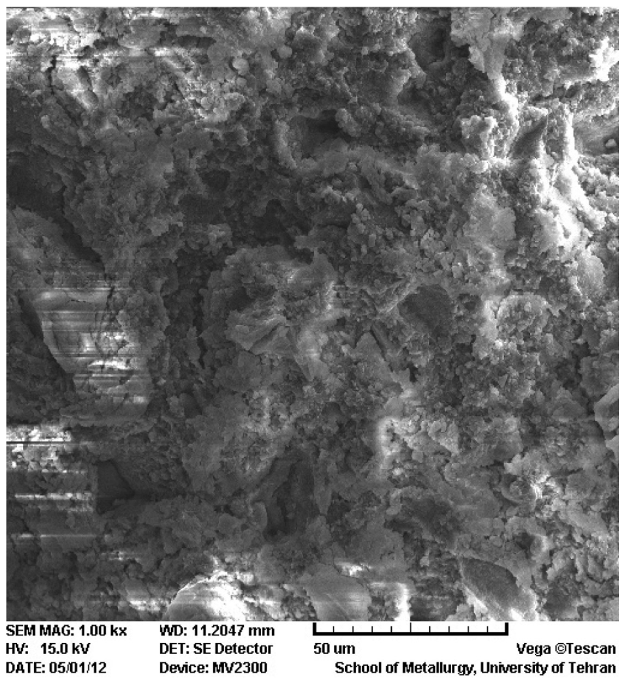

Figure 4. Surface treated by Er:YAG laser with output power of 5 W, 250 mJ (Original magnification ×1000, bar=50μm)

it is necessary to produce some roughness to obtain mechanical retention [15]. Burnett et al. reported that Er:YAG laser increased the tensile bond strength between composite and resin cement compared to fluoridric acid or air abrasion which is mainly related to loss of resin matrix and exposure of filler particles [16]. Moretto et al. stated that the Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er;Cr:YSGG) laser in powers less than 5 watt has a negative effect on microtensile bond strength of resin cement to indirect composites [17].

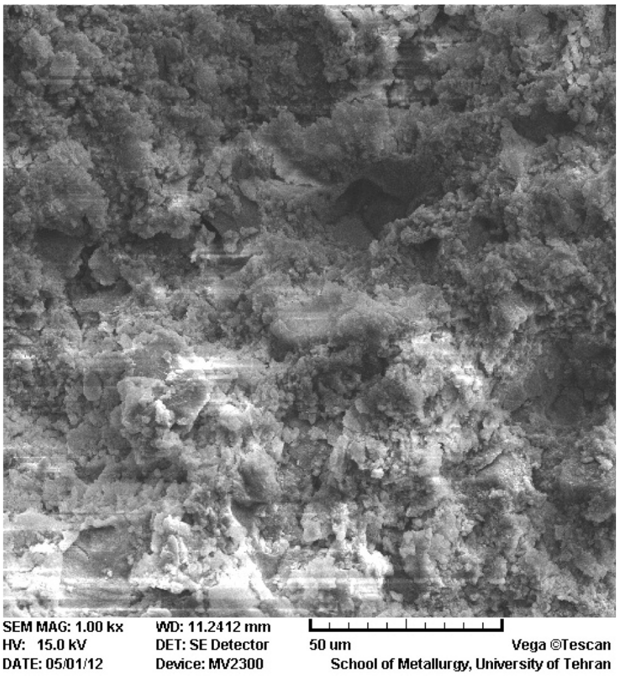

Figure 5. Surface treated by Er:YAG laser with output power of 6 W, 300 mJ (Original magnification ×1000, bar=50µm)

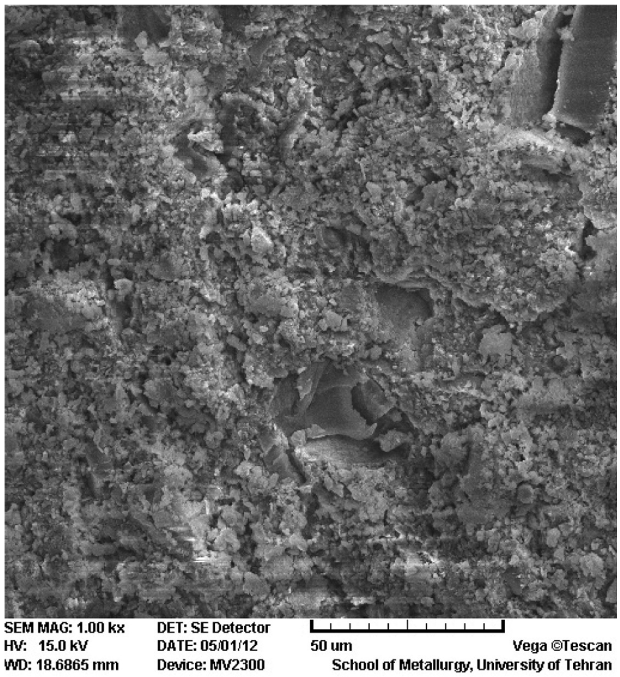

Figure 6. Surface treated by Er:YAG laser with output power of 7 W, 350 mJ (Original magnification ×1000, bar=50µm)

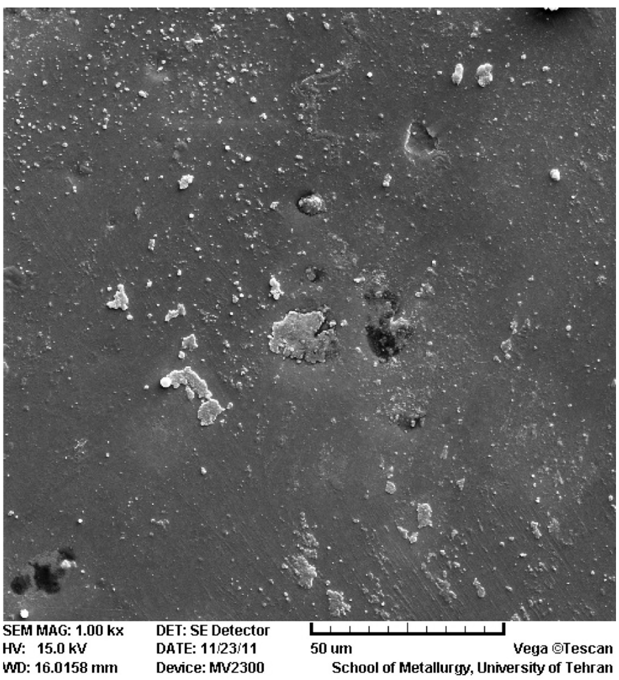

Figure 7. Non treated (Original magnification ×1000, bar=50µm)

On contrary, Moezizadeh et al. showed that surface treatment of indirect composites by Er;Cr:YSGG laser with output power of 1 W produced the highest bond strength and the use of 2 W laser power decreased the bond strength [18].

In Teresa's research, the samples irradiated with minimum energy density and water coolant produced better results than higher ones so, they proposed that lower powers of laser will condition the surface and the higher ones will ablate it [19].

The results of the present study showed that exposure of composites to laser irradiation caused irregularities and surface roughness which had no particular pattern. This can be accompanied by higher bond strength compared to surface treated by conventional methods. The mechanism of Er:YAG interaction with composite resin is related to hydroxyl radicals through conversion of light to energy. The heat produced inside the composite lead to explosion or ablation[16].

More researches are still needed to find the best parameters to produce the proper roughness that resin cement can penetrate best to achieve the highest bond strength.

Conclusion

Er:YAG laser with proper parameters can be used as a technique for surface treatment and roughening of indirect resin composites.

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