

Effect of Laser Treatment on Surface Morphology of Indirect Composite Resin: Scanning Electron Microscope (SEM) Evaluation

Mansore Mirzaie¹, Nazanin Zeinab Garshasbzadeh¹, Esmail Yassini¹, Sima Shahabi², Nasim Chiniforush²

¹Restorative Dentistry Department, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

²Laser Research Center of Dentistry, School of Dentistry, Tehran University of Medical Science

Abstract:

Introduction: The aim of this study was to evaluate and compare the Scanning electron microscope (SEM) of indirect composite conditioned by Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser, Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) laser and Carbon Dioxide (CO₂) laser.

Methods: 18 indirect composite blocks (GC Gradia DA2, Japan) with 15 × 10 × 10 mm dimensions were made. The bonding surface of these blocks were polished, then the samples were divided into six groups as follow: Er:YAG laser with output power of 0.5 W and frequency of 10 Hz, Nd:YAG laser with output power of 0.25, 0.5 W and frequency of 10 Hz, CO₂ laser with output power of 0.5 W and frequency of 10 Hz and 5 Hz, and no treatment. Then, the surfaces were evaluated by SEM.

Results: Irregularities were observed in Er:YAG laser samples compared to control group that produced suitable retention for adhesion of cements. Nd:YAG and CO₂ lasers showed melting areas.

Conclusion: Among different lasers, Er:YAG laser can be used as an alternative technique for surface treatment of indirect composites.

Keywords: Er:YAG laser; Nd:YAG lasers; CO₂ laser

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***Corresponding Author:** Nasim Chiniforush, DDS; 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

According to development in bonding systems, curing procedure and mechanical characteristics of resin systems, newer generation of composite resins shows more wear resistance and color stability than older ones but polymerization shrinkage is still an important problem in adhesive techniques¹⁻³.

Indirect composites are designed to overcome limitations of direct composites such as polymerization shrinkage and conversion degree to improve mechanical features of this extra-oral procedure, thus

providing better proximal contacts, better morphology and occlusal adjustment can be achieved by these materials⁴⁻⁷.

Post curing in higher temperature leads to more release of stress in direct composites rather than indirect ones. This reduced stress results in better bonding and improved sealing⁸.

Clinical application of indirect composites depends on bonding of cement to teeth and material, achieving this adhesion is very difficult⁹.

Primary purpose in cementation process is providing stable bonding and marginal adaptation to teeth and

restorations. Resin cement by distribution of stress in interface of resin and restoration leads to optimum bond to indirect composites^{10,11}.

Surface treatment of indirect composites can be done by several techniques like sand blasting, HF, silane, etc. The application of silane leads to chemical adhesion between organic fillers and organic matrix^{4,12}.

Laser is one the methods of surface treatment used for improving micromechanical retention and bond strength of resin cement to composites¹³.

The aim of this study was to evaluate and compare the Scanning electron microscope (SEM) of indirect composite conditioned by Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser, Neodymium-Doped Yttrium Aluminium Garnet (Nd:YAG) laser and Carbon Dioxide (CO₂) laser.

Methods

18 indirect composite blocks (GC Gradia DA2, Japan) 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 six groups as follow:

Group 1: treated using Er:YAG laser (2940D plus, Deka, Italy) with output power of 0.5 W and frequency of 10 Hz

Group 2: treated using Nd:YAG laser (Fotona, Slovenia) with output power of 0.25 W and frequency of 10 Hz

Group 3: treated using Nd:YAG laser with output power of 0.5 W and frequency of 10 Hz

Group 4: treated using CO₂ laser (Smart US20D, Deka, Italy) with output power of 0.5 W and frequency of 10 Hz

Group 5: treated using CO₂ laser with output power of 0.5 W and frequency of 5 Hz

Group 6: For this group no surface treatment was done as a control group.

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 with a scanning electron microscope at ×500, ×1000 and ×5000 magnification.

Results

The surfaces treated by Er:YAG laser showed irregular and micro porous surfaces. The surfaces treated by Nd:YAG laser also showed some irregularities but melting areas could be observed. CO₂ laser treatment of surfaces resulted in melting of superficial layer of materials (Figures 1-6).

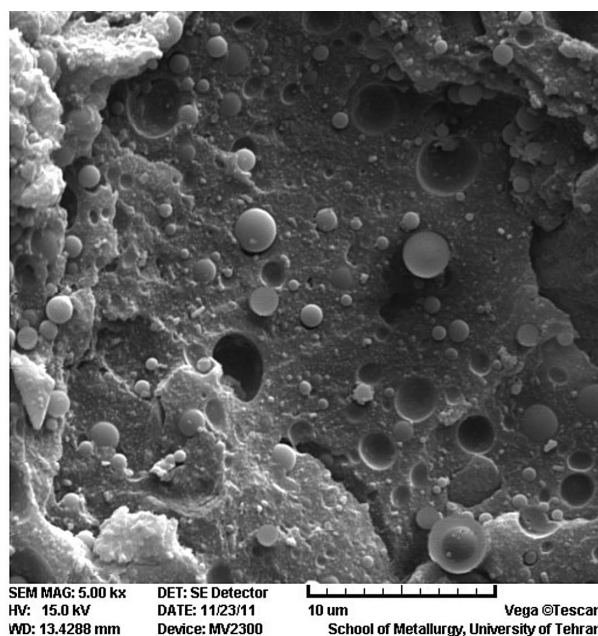


Figure 1. Surface treated by Er:YAG laser with output power of 0.5 W (Original magnification ×5000, bar=10µm)

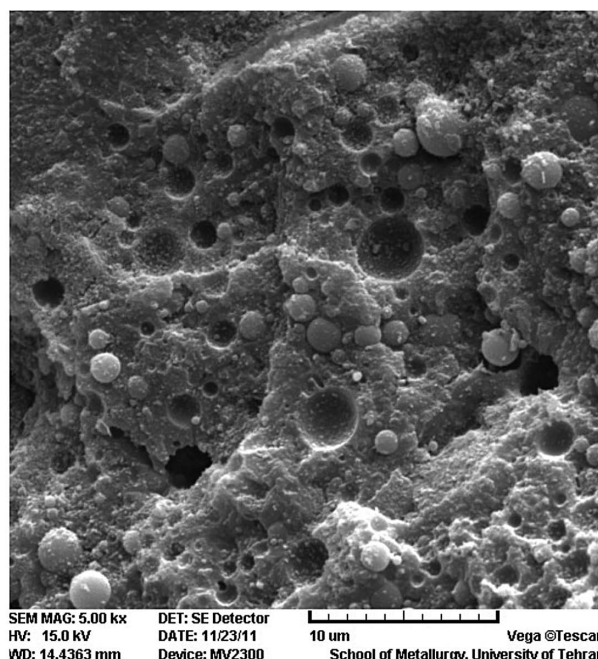
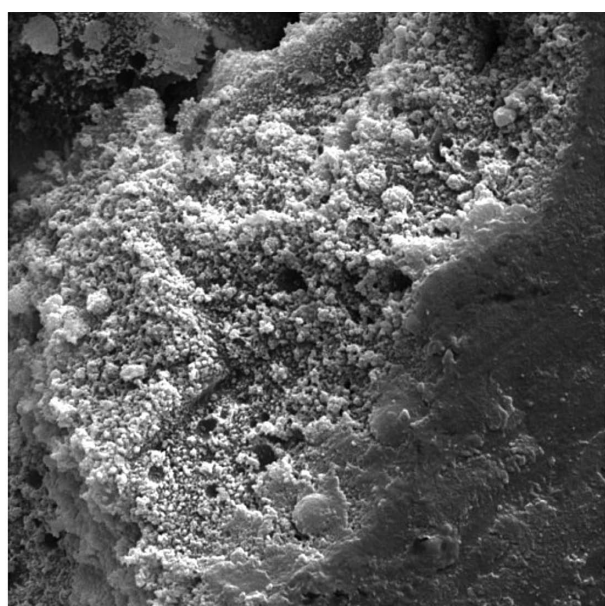
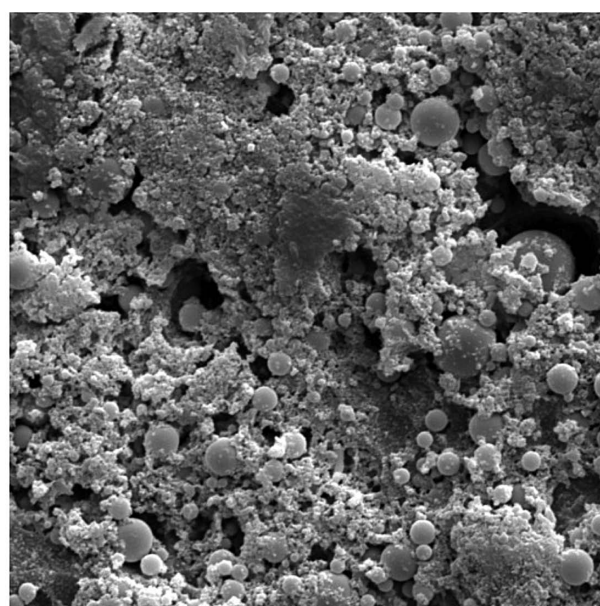


Figure 2. Surface treated by Nd:YAG laser with output power of 0.25 W (Original magnification ×5000, bar=10µm)



SEM MAG: 5.00 kx DET: SE Detector
 HV: 15.0 kV DATE: 11/23/11
 WD: 13.3778 mm Device: MV2300
 10 um Vega ©Tescan
 School of Metallurgy, University of Tehran

Figure 3. Surface treated by Nd:YAG laser with output power of 0.5 W (Original magnification $\times 5000$, bar= $10\mu\text{m}$)



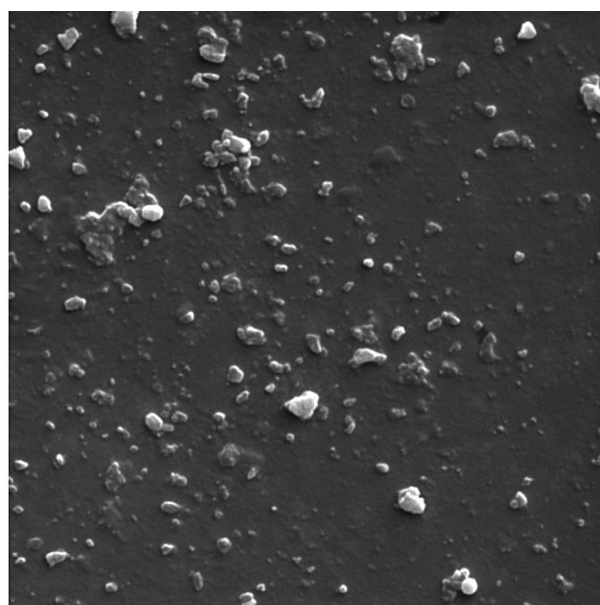
SEM MAG: 5.00 kx DET: SE Detector
 HV: 15.0 kV DATE: 11/23/11
 WD: 13.0633 mm Device: MV2300
 10 um Vega ©Tescan
 School of Metallurgy, University of Tehran

Figure 4. Surface treated by CO₂ laser with output power of 0.5 W and frequency of 10 Hz (Original magnification $\times 5000$, bar= $10\mu\text{m}$)



SEM MAG: 5.00 kx DET: SE Detector
 HV: 15.0 kV DATE: 11/23/11
 WD: 15.3848 mm Device: MV2300
 10 um Vega ©Tescan
 School of Metallurgy, University of Tehran

Figure 5. Surface treated by CO₂ laser with output power of 0.5 W and frequency of 5 Hz (Original magnification $\times 5000$, bar= $10\mu\text{m}$)



SEM MAG: 5.00 kx DET: SE Detector
 HV: 15.0 kV DATE: 11/23/11
 WD: 16.0158 mm Device: MV2300
 10 um Vega ©Tescan
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Figure 6. No surface treatment (Control group)

Discussion

An ideal adhesive material should present no shrinkage during polymerization and have physicochemical properties similar to dental hard tissues¹⁴. Some studies have shown that laboratory

Processed composites showed 25-80% decrease in bond strength¹⁵.

To enhance the bond strength, the surface of restorations should become rough enough. Therefore, mechanical retention can be provided and more number of free carbon bonds on surface can be made

available¹⁶.

The utilization of Er:YAG laser in dental hard tissues is considered efficient when associated with adhesive procedures¹⁷. In a few studies like Burnett (2004) in assessing the effect of surface treatment with Er:YAG laser on tensile bond strength, increased bond strength was shown which is mainly due to loss of resin matrix and exposure of filler particles¹⁸.

Moezizadeh in 2012 reported that the surface treatments using sandblast and laser beam of 1W power along with silane are two effective methods to increase the bond strength of composites¹⁹.

In the present study, results of SEM evaluation showed that exposure of composites to laser beams caused irregularities and surface roughness which do not follow particular pattern and by increasing the laser power, these changes also increase.

Conclusion

Among different lasers, Er:YAG laser can be used as an alternative technique for surface treatment of indirect composites. There is still need to do more researches to find the best protocol for achieving to the best bonding.

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