Introduction

Recently, orthodontic treatment has increased among adults. Most of these patients have amalgam restorations on posterior teeth which are considered a big challenge for orthodontist regarding the bonding procedure.\(^1,2\) In order to achieve desirable bonding to amalgam, different studies were performed including various surface treatments and the application of different types of resins and adhesives.\(^3,4\)

Surface treatment can be done by diamond bur, sandblasting, and chemical corrosion to improve bonding to amalgam surface.\(^5\)

The application of lasers for treatment of dental substrate has gained special attention. Among different lasers, Erbium family lasers are used for treatment of dental hard tissues.\(^6\)

It was shown that erbium-doped yttrium aluminum garnet (Er:YAG) laser with a wavelength of 2940 nm can ablate amalgam surface and produce micro craters.\(^7\) On the other hand, Oskoee et al\(^8\) in assessing the bonding of orthodontic brackets to silver amalgam treated by erbium, chromium doped yttrium scandium gallium garnet (Er-Cr:YSGG) laser compared to the sandblasting technique concluded that laser treatment increased the shear bond strength of stainless steel orthodontic brackets to amalgam restorations.\(^8\)

The aim of this study was to evaluate amalgam surfaces treated by different output powers of Er:YAG laser by scanning electron microscope (SEM).

Methods

Twenty-one amalgam blocks (8 mm × 8 mm, 3 mm thickness) were prepared by condensing silver amalgam (Speedex, Coltene, Switzerland) and burnishing with instruments. After keeping them for 24 hours in distilled water, they were divided into 7 groups as follow: G1: Er:YAG laser (1 W, 50 mJ), G2: Er:YAG laser (2 W, 100 mJ), G3: Er:YAG laser (3 W, 150 mJ), G4: Sandblast, G5: Sandblast + Er:YAG laser (1 W, 50 mJ), G6: Sandblast + Er:YAG laser (2 W, 100 mJ) and G7: Sandblast + Er:YAG laser (3 W, 150 mJ). Then after preparation of all samples, they were examined by SEM.

Results:
The SEM results of amalgam surfaces treated by different output powers of Er:YAG laser showed some pitting areas with non-homogenous irregularities

Conclusion:
It seems that the application of sandblasting accompanied by Er:YAG laser irradiation can provide proper surface for bonding of orthodontic brackets.

Keywords:
Amalgam; Orthodontic bracket; Er:YAG lasers.
CAN VEGA, USA) evaluation at x1000, x2000 and x5000.

**Results**
The SEM results of amalgam surfaces treated by different output powers of Er:YAG laser showed some pitting areas with non-homogenous irregularities (Figures 1-3). Figure 4 showed sandblasted amalgam surface with scratch-like irregularities. More irregularities were achieved in sandblast + laser irradiation (Figures 4-6).

**Table 1. Study Groups**

<table>
<thead>
<tr>
<th>Groups</th>
<th>Treatment</th>
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<tbody>
<tr>
<td>G1</td>
<td>Er:YAG laser (1 W, 50 mJ)</td>
</tr>
<tr>
<td>G2</td>
<td>Er:YAG laser (2 W, 100 mJ)</td>
</tr>
<tr>
<td>G3</td>
<td>Er:YAG laser (3 W, 150 mJ)</td>
</tr>
<tr>
<td>G4</td>
<td>Sandblast</td>
</tr>
<tr>
<td>G5</td>
<td>Sandblast + Er:YAG laser (1 W, 50 mJ)</td>
</tr>
<tr>
<td>G6</td>
<td>Sandblast + Er:YAG laser (2 W, 100 mJ)</td>
</tr>
<tr>
<td>G7</td>
<td>Sandblast + Er:YAG laser (3 W, 150 mJ)</td>
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</table>

**Discussion**
Providing suitable bond strength between brackets and amalgam is one of the challenging problems in orthodontics. The purpose of this study was to evaluate amalgam surfaces treated by different powers of Er:YAG laser compared to laser irradiation following sandblasting in a qualitative manner. Sandblasting is a conventional method for surface treatment. Amalgam surface after sandblasting showed scratched irregularities that may have positive effect on achieving higher bond strength. Several studies showed that this method can be beneficial for providing enough bond strength.

Skilton et al in assessing the shear bond strength of brackets bonded to amalgam surfaces roughened by diamond bur or sandblasted by aluminum oxide concluded that sandblasting is more effective for providing higher shear bond strength compared to bur. Er:YAG laser can ablate amalgam, which was reported by
Hibst and Keller. Water irrigation does not have an effect on ablation efficacy. It can just control the temperature rise. SEM images showed micro-irregularities after laser irradiation on amalgam surfaces.

Oskoee et al in the evaluation of Er:Cr:YSGG laser on conditioning amalgam surfaces for bracket bonding compared to sandblasting technique came to the conclusion that erbium laser had positive effect on shear bond strength of brackets to amalgam. Despite surface evaluation, mercury vapor release during laser ablation should be considered as a hazardous factor for dental staffs. Further studies are needed to assess the bond strength of orthodontic brackets to amalgam restorations besides mercury vapor release and thermal changes evaluation.

Conclusion
Based on SEM results, the application of sandblasting technique accompanied by Er:YAG laser irradiation can provide suitable surface for bonding of brackets.

Conflict of Interest
The authors have no conflict of interest to declare.

References