
(Effect of Er, Cr: YSGG laser on surface topography of dental implant)

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ABSTRACT

Aims: It is aim to estimate sand-blasted, large grit, acid-etched implant surface when exposed in vitro to different energy levels in constant time of Er, Cr: YSGG laser and by using SEM to evaluate implant surface topography qualitatively. Ultimately to determine the suitable parameter for the clinical use of Er, Cr: YSGG lasers to treat exposed area of peri-implantitis.

Materials and methods: Every experimental group of implant surfaces incorporated six implants and six controls. For standardization the milling machine was used for fixation of the implant and laser hand piece. All the implants surfaces exposed uniformly at a constant time to different energies. Six powers were used 1, 2, 2.5, 3, 4, 5 watts at 20 Hz, water 20%, air 40% with movable motions on each thread for 30 second and in non contact mode at 2 mm distance between MZ10 tip and target with H mode.

Results: The change at smooth area start at (2.5 watts) as melting local area and increase as power is increased while in rough surfaces there were no notable changes of sharp valleys and pits until 3 watts.

Conclusions: It is recommended to use this type of laser at above parameter for a time not more than 30 seconds without changes at surfaces.

Keywords: Er, Cr: YSGG laser, dental implant, peri-implantitis.

INTRODUCTION

Dentigerous Dental implant is a broadly documented treatment opportunity for replacing missing teeth. In spite of the long-term success of dental implants, pathogenic complications may occur. Nowadays pure titanium and titanium alloys are well established standard materials in dental implants because of their favorable combination of mechanical strength, chemical stability, and biocompatibility.

Invitro and in vivo studies strongly suggest that some types of surface modifications promote a more rapid bone formation than do machined surfaces. This could depend on an altered surface chemistry and/or an increased texture on the micrometre scale.

In 2012, the American Academy of Periodontology updated the Glossary of Periodontal Terms. They defined the biological complications around dental implants as follows:

- **Peri-implant mucositis**: A disease in which the presence of inflammation is confined to the mucosa surrounding a dental implant with no signs of loss of supporting bone.
- **Peri-implantitis**: An inflammatory process around an implant that includes both soft tissue inflammation and loss of supporting bone.
The treatment of Peri-implantitis include many methods such as; mechanical instrumentation, local antibacterial agents, surgical treatment and laser based treatment. The aim in non-surgical treatment of peri-implant mucositis and peri-implantitis to eliminate oral pathogen in the pockets around implants to a level that allows curing and reinstatement of a clinically healthy condition.

Mechanically debridement is generally performed using particular instruments made out of materials less harder than titanium like polishing with rubber cups plastic curettes in order to avoid changing of the metallic surface characteristics.

Er:YSGG Er, Cr: YSGG (Biolase, Iplus, Dental Laser, USA) was used for laser treatments of implant surfaces. Max Milling Machine from BioArt Company (Brazil) used for fixation of laser and micro motor handpiece in standard manner (Figure 1). NSK motorsystem (Japan made) used for rotation of implant in constant speed and time. An acrylic holder was fashioned for the motor hand piece, which remained in a stable position. SEM; (Vega II SBH, TESCAN,Brno, Czech) was used for observation of microscopic surface changes.

Laser device

The Er, Cr: YSGG laser (Iplus, Biolase, USA) adjusted to emit pulsing duration of 60 μsec (H mode), a repetition rate of 20 Hz, water 20%, air 40% was employed in the present study. The power in watts were variable (1, 2, 2.5, 3, 4, 5 watts). The delivery system consisted of a fiber-optic tube that terminates in Gold hand piece type with MZ10 tip (1mm diameter). The beam spot size at the tip was 1mm, and the exposure time was 30s for each thread at speed 25 RPM and the distance between implant and tip of laser was 2mm (Figure 2).

Laser treatment

Each implant was fixed in hand piece and rotate at 25 RPM. The laser hand piece is fixed in milling machine as shown in Figure 2 then the implant is exposed to so that each thread of implant will be exposed to laser. The implant surface exposed uniformly to laser. The fixture is dried and returned to its original package for testing. This procedure was repeated for each fixture but with different watts. The control - fixture not treated with anything. Titanium surfaces divided into smooth and rough surfaces.

RESULTS

SEM evaluation

Scanning electron microscopy was used to evaluate implant surface topography qualitatively from smooth area and rough implant surface under 100 ×, 1000 and 5000 × magnification. The SEM was operated at 20kV accelerating voltage and low vacuum-chamber pressure. Surface morphology on smooth area revealed surface with mechanical grinding texture (Figure 3). While on rough area, a honeycombed surface structure formed due to many micro rough pits derived from acid etching, sprinkled in the macro porous valleys by large grit sand-blasting. The sharp edge of each peak of the valleys was clearly observed on the implant surfaces without irradiation. The isotropic microstructure consisted of sharp, pointed long ridges and v-shaped valleys (Figure 4).

The change at smooth area started at 2.5 watt. Locally melted morphology was observed on the smooth surface, as indicated by arrows in (Figure 3). At 3 watts, in addition to local area of peeling off the outer layer there was a
spot area of black zone (Figure 5). As power increase the black zone increase and at 5 watts there is a melting area (Figure 6). The rough surface showed no major changes can till 3 watts group which revealed loosening in the shape of SLA surface at 1000x. Using software program (Imagej 1.46r) (http://rsb.info.nih.gov/ij/features.html) that analyze the scanning electron microscope of the rough surface picture by making binary images and then boundary identification edges in the picture (23). (Figure 7-13.) showed changes in area from control group and as the power of laser increase the changing of the area is increase and by using a software package (SPSS 11.0, SPSS Inc., Chicago, IL, USA) for the statistical analysis and defining the area as statistical units. Mean values and standard deviations calculated for each group. Analysis of variance (ANOVA) and post hoc testing using Duncan for comparisons within and between groups. Results were considered statistically significant at P<0.001. Table 1, 2. The significant differences from the control start at 3 watts. So the changes in the smooth surface estimated by vision on 2.5 watts and in the rough surface start at 3 watts.

DISCUSSIONS

Many surface implant treatments had been introduced to increase implant successes rate these modification may include mechanical and physicochemical properties. One of this modification is surface roughness (6-20). It has been shown that surface treatment of implant materials significantly influences the attachment of oral fibroblasts as well epithelial cells (22) also the rough surface will increase the contact area with blood cells and more platelets adherence (25, 29), and better contact osteogenesis due to migration of osteogenic cells (23, 24).

Many studies showed rough surfaces promote both bone anchoring and biomechanical stability, and facilitated better osseointegration when compared to machined (26-28). Also there is a mechanical interlocking between rough implant surface and the bone, which increase resistance to shear stress, tension and compression (24, 25). Although the presence of these benefits of rough surface its drawback is the obstruction of the effective accesses for cleaning of infected surface (26).

The regeneration and preservation of the osseointegration with well-per-implant tissues are the primary aim in the treatment of peri-implantitis. To achieve this aim, the removal of etiologic factors is essential (27). The removal of bacterial biofilm from an implant surface considered a vital element for the treatment of peri-implant diseases (19-20).

Efficient procedure for established the contaminated implant surface without changing of surface topography of the implant is essential because damage to the surface induces changes in the oxide layer and this may impairs the adhesion of fibroblasts and the biocompatibility of the implant (28, 29).

As previously mentioned many methods used for decontamination of the implant surface but some type of laser like an erbium family laser can be used as more precise method to avoid modification of implant surface and its use is recommended (22-31). This study highlighted the effect of laser on surface of implant and the result showed that the changing start at 2.5 watt. Several researches that studied the effect of erbium laser family on titanium surface and many parameters are changed in these researches. In the study has done by Huang et al. he observed Er, Cr: YSGG laser usage resulted in locally melted morphology on the specimen surface and increasing of the applied energy led to a slight increase in the melted area (21). Other study by Ercan et al. showed major changes, such as melting, flattening and deep crack formation, were observed in discs subjected to 2 W, 30 Hz, 2 mm, distance, 30s Parameters such as wavelength, output power, energy, dose and duration should be considered during irradiation (32). The level of changes was proportional to the power output.

The result of the present study can be more cleared if it merge with other study presented in the same condition and instrument which concluded that at 1.5 watt (and exact condition in this study) there is complete reduction of Enterococcus faecalis bacteria (44). So at 1.5 watt the bacteria is killed and the topography of the surface of implant is maintained without changes.

CONCLUSIONS

The power output must be restricted so as to avoid surface damage. And this laser is seems to be safe within the power settings applied in concerning the alterations in the surfaces.

REFERENCES

plants


Figure. (1) show field of work that include laser unit, milling machine and, micro motor unit.

Figure. (2) show position of fixture during laser exposure.

Figure. (3) 2.5 watts group smooth area of fixture irradiated shows local area of peeling in the smooth area.

Figure. (4) control smooth area of fixture.

Figure. (5) 3 watts group smooth area of fixture irradiated shows local area of peeling in smooth area and black spot.

Figure. (6) 5 watts group smooth area of fixture irradiated shows local area of peeling in smooth area and increase in black area.
Table (1): Analysis of variance of Surface area (ANOVA)

<table>
<thead>
<tr>
<th></th>
<th>Sum of Squares</th>
<th>df</th>
<th>Mean Square</th>
<th>F</th>
<th>Sig.</th>
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</thead>
<tbody>
<tr>
<td>Between Groups</td>
<td>178.518</td>
<td>6</td>
<td>29.753</td>
<td>8.606</td>
<td>.000</td>
</tr>
<tr>
<td>Within Groups</td>
<td>121.002</td>
<td>35</td>
<td>3.457</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>299.520</td>
<td>41</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table (2): Duncan test that compare between and within the groups of Surface area show significant difference at p < 0.001.

<table>
<thead>
<tr>
<th>Group</th>
<th>No.</th>
<th>Mean surface area± SD</th>
<th>Duncan group*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. WATT</td>
<td>6</td>
<td>25.1440 ± 2.22686</td>
<td>AB</td>
</tr>
<tr>
<td>2 WATT</td>
<td>6</td>
<td>25.6223 ± 2.26913</td>
<td>AB</td>
</tr>
<tr>
<td>2.5 WATT</td>
<td>6</td>
<td>28.0923 ± 2.55049</td>
<td>ABC</td>
</tr>
<tr>
<td>3 WATT</td>
<td>6</td>
<td>28.4888 ± 1.84521</td>
<td>BC</td>
</tr>
<tr>
<td>4 WATT</td>
<td>6</td>
<td>29.0268 ± 1.40398</td>
<td>BC</td>
</tr>
<tr>
<td>5 WATT</td>
<td>6</td>
<td>29.9702 ± 0.64713</td>
<td>C</td>
</tr>
<tr>
<td>control</td>
<td>6</td>
<td>24.1067 ± 1.33896</td>
<td>A</td>
</tr>
</tbody>
</table>

*Means with different letter were astatically significant at (p≤0.001)

Figure. (14): Histogram represents changes in rough surfaces area after exposed to laser at 3 watts. There is a significant deference and change in surface area with increased power.
Figure.(7) SEM image of control group show pits and valleys of rough area. at 5000x.

Figure.(8) binary image with edges detection of adjacent picture (control group).

Figure.(9)SEM image of 3 watt group show changing in pits and valley arrangement at 5000x.

Figure.(10) binary image with edges detection of adjacent picture (3watt group)

Figure.(12)Representative interactive 3D surface plot of control group surfaces.

Figure.(13) Representative interactive 3D surface plot of 3 watt surfaces