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The effect of irradiation with Erbium, Chromium: Yttrium Scandium Gallium Garnet Laser on surface topography of sand-blasted, large grit, acid-etched dental implant: An in vitro study

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

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ABSTRACT

Aims: It is aim to estimates and-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 1,2,2.5,3,4,5at 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 (2.5watts) 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(1-4). Nowadays pure titanium and titanium alloys are well established standard materials in dental implants because of their favorable combination of mechanical strength, chemical stability, andbiocompatibility (5).

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(6, 7).

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 presenceof 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(8).

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-implantitisis to eliminate oral pathogensin the pockets around implants to a level that allows curing and reinstatement of a clinically healthy condition[9, 10].

Mechanical 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[11].Eradication of pathogens by mechanical means on implant surfaces which has threads and frequently with rough structures is difficult [12]. Even though antimicrobials are widely used for the treatment of peri-implant diseases, confirmation of their benefit is limited[9].The extra use of local antibiotics like tetracycline to mechanical therapy has been shown to reduce bleeding on probing and probing pocket depth in Peri-implantitis[13].

Surgical regenerative therapy treatment include the use of guided bone regeneration membrane for treatment of Peri-implantitis and it is generally involves implant surface detoxification of the ailing implant , placement of a bone graft then covered with a membrane[14]. different detoxification agents have been suggested by clinician such as tetracycline[15,16], citric acid[17, 18], chlorhexidine gluconate[14, 19].

Lasers are useful for the treatment of peri-implantitis the question is still exists about the possibility of direct exposure to laser may in danger titanium surfaces of implant, and if that happens ,what are those changes that take place on implant surfaces and which laser parameter have such effect. Many studies have documented the effects of different laser parameters and wavelengths on implant surfaces[20-24].

MATERIALS AND METHODS

Tools and Specimens

Forty two dental implants with SLA surface were used with this study(Diameter 3.4 Length 10 mm) , (Dentium Co. Ltd, Suwon, Korea). Er,Cr:YSGG(Biolase, Iplus type,Dental Laser, USA)wasused for laser treatments of implant surfaces .Max Milling Machine from BioArt Company (Brazil) used for fixation of laser and micro motor handpiec in standard manner(Figure.1).NSK motorsystem(Japan made)used for rotation of implant in constant speed and time .An acrylic holder wasfashioned for the motor hand piece, which remained in a stableposition.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),adjust 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 the (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 reveled 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 3watts, 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 3wattsgroup which revealed loosening in the shape of SLA surface at 1000x .Using software program (Image-j1.46r)(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[(25)], (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 star 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[(6,26)]. It has been shown that surface treatment of implant materials significantly influences the attachment of oral fibroblasts as well as epithelial cells[27] also the rough surface will increase the contact area with blood cells and more platelets adherence[(28,29)] , and better contact osteogenesis due to migration of osteogenic cells[(30, 31)].

Many studies showed rough surfaces promoted both bone anchoring and biomechanical stability, and facilitated better osseo integration when compared to machined[(26, 32, 33)]. Also there is a mechanical interlocking between rough implant surface and the bone, which increase resistance to shear stress ,tension and compression[(34, 35)]. Although the presence of these benefits of rough surface its drawback is the obstruction of the effective accesses for cleaning of infected surface[(36)].

The regeneration and preservationof 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[(37)].The removal of bacterial biofilm from an implant surface considered a vital element for the treatment of peri-implant diseases[(9, 38)], 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[(39, 40)].

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[(24, 41)]. 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[(42)]. 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[(43)]. 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 1.5watt (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.

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

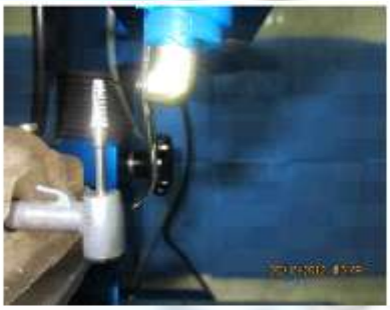

Figure.(2) show position of fixture during laser exposure.

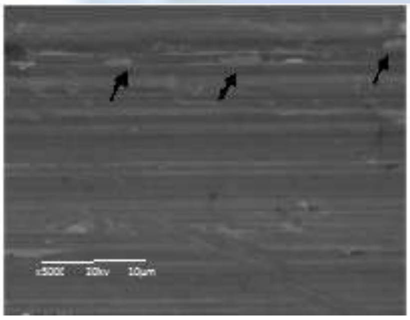

Figure.(3) 2.5 watts group smooth area of fixture irradiated showslocal area of peeling in the smooth area.

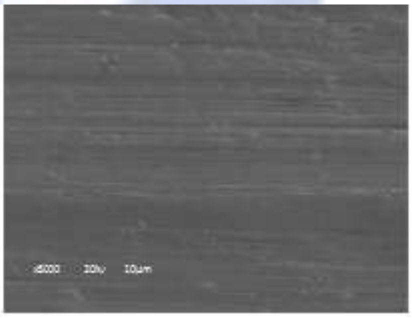

Figure.(4)control smooth area of fixture.

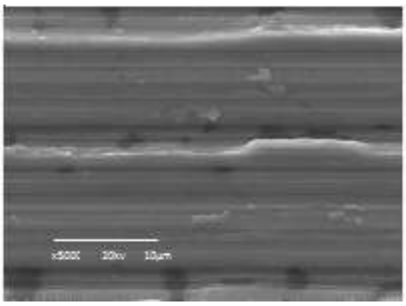

Figure.(5) 3 watts group smooth area of fixture irradiated shows local area of peeling in smooth area and black spot.

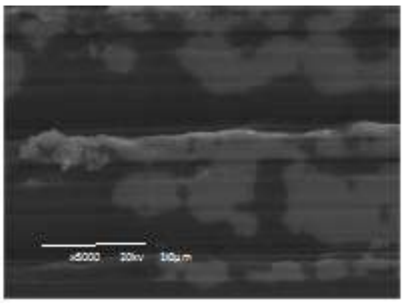

Figure.(6) 5 watts group smooth area of fixture irradiated shows local area of peeling in smooth area and increase in black area.

Table (1): Analysis of variance of Surface area (ANOVA)

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	178.518	6	29.753	8.606	.000
Within Groups	121.002	35	3.457		
Total	299.520	41			

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

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

***Means with different letter were astatically significant at($p \leq 0.001$)**

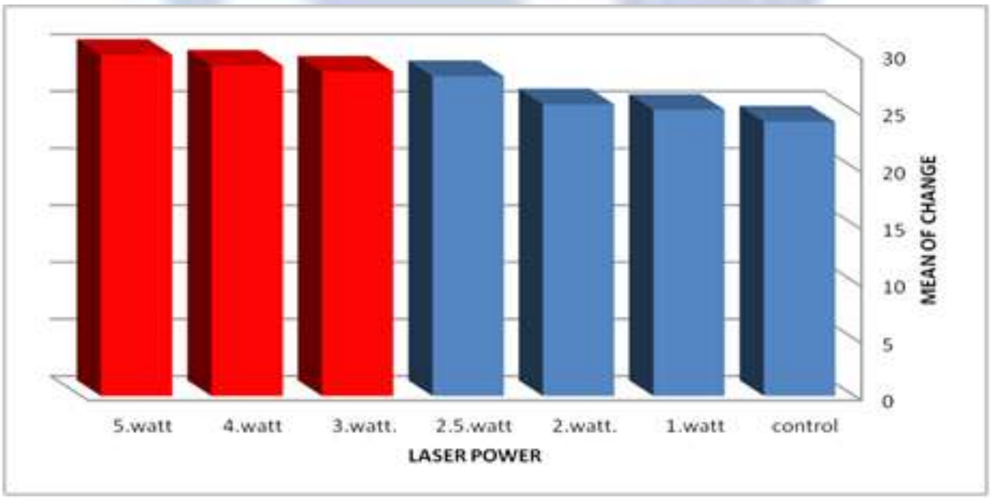

Figure. (14): Histogram represents changes in rough surfaces area after exposed to laser at 3 watts. There is a significant deference and change in surface area with increased power.

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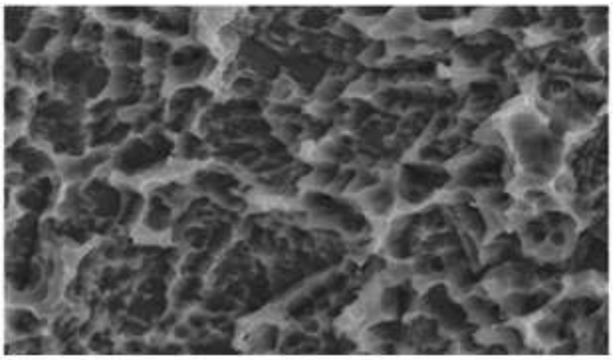

Figure.(7) SEM image of control group show pits and valleys of rough area. at 5000x.

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

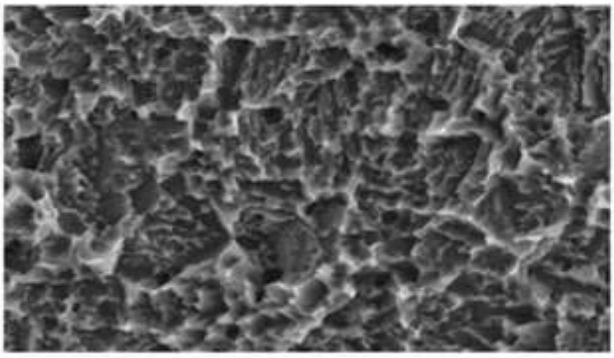

Figure.(9)SEM image of 3 watt group show changing in pits and valley arrangement at 5000x.

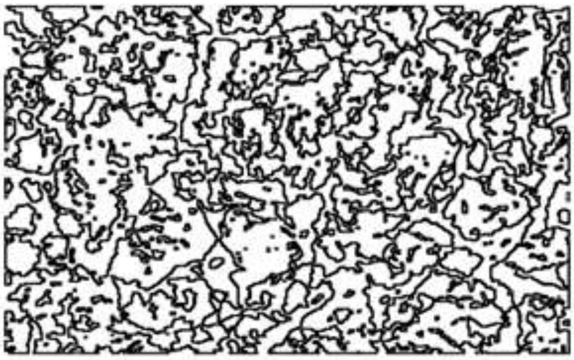

Figure.(10) binary image with edges detection of adjacent picture (3watt group)

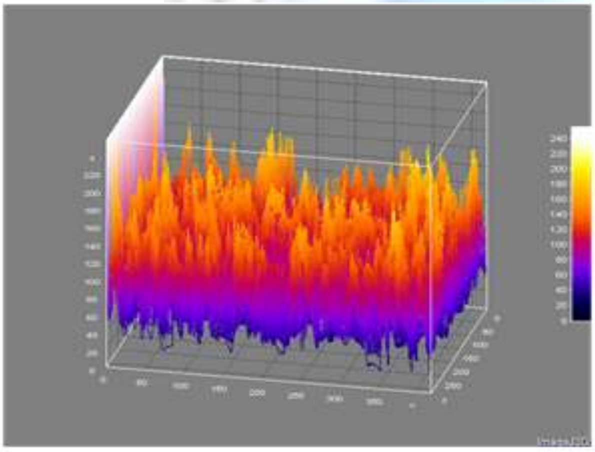

Figure.(12)Representative interactive 3D surface plot of control group surfaces.

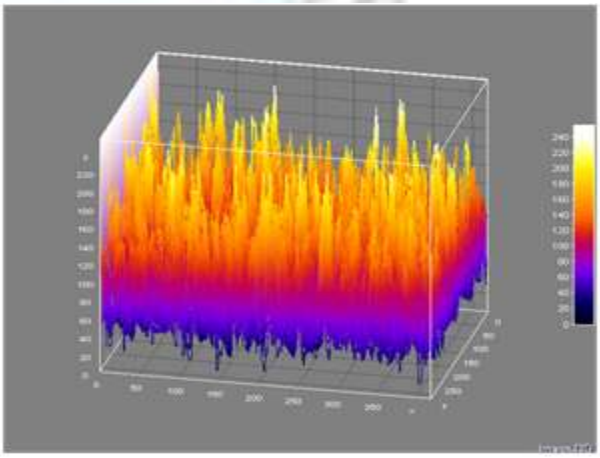

Figure.(13) Representative interactive 3D surface plot of 3 watt surfaces