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Laser textured novel patterns on Ti6Al4V alloy for dental implants surface improvement

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ABSTRACT

Creating laser texture on dental implants is a novel method for accelerating osseointegration and prolongation of lifespan. The purpose of this research was twofold: (1) Creating intersecting lines pattern with different angles (0°, 15°, 30°, 45°, 60°, 75°, and 90°) on the surface of Ti6Al4V, using pulse Nd:YAG laser with a wavelength of 1064 nm and a pulse length of 170 ns and (2) comparing optical and SEM images, EDS analyses, contact angles (CAs), and surface free energies (FEs) for different intersecting lines angles. CA and FE depended on the intersecting lines angle according to $Y = Y_0 + A\sin\left(\frac{x}{B} + C\right)$, where Y is the CA or FE; x is the intersecting lines angle; and Y_0, A, B, and C are constants. Oxygen was present on all samples. The lowest CA and the highest FE occurred at 60° intersecting lines. FE was independent of minor changes in the microgrooves' depth, intersections' number, and the number of texture lines.

Key words: laser surface texturing, Ti6Al4V implants, contact angle, surface free energy, intersecting lines

I. INTRODUCTION

One application of titanium and its alloys is in the production of implantable biomaterials.[1] Ti6Al4V with a combination of physical-structural and mechanical attractiveness along with excellent biocompatibility and insignificant toxicity has been increasingly considered for medical engineering applications, especially, in the manufacture of dental implants.[2] Dental implants are evaluated clinically and by patients' satisfaction.[3–7] It seems that the use of this method will be necessary until humans acquire the knowledge and technology of the possibility of the intraoral growth of new teeth.[8–10] One of the most important problems of dental implants is their loosening over time, which eventually forces the patient to replace them. This procedure renews the patient's pain, worries, and treatment costs.[11]

Therefore, most researchers in this field are trying to find a way to delay this complication in order to increase the implant's lifespan. Creating a strong connection between the implant and the surrounding bone can significantly reduce implant loosening.[12] The urgent need to strengthen the adhesion of the implant to the surrounding bone has stimulated the use of various techniques for surface modification of the implant.[13–15] These techniques include photolithography, sandblasting, electron beam, ion beam, plasma spray, acid etching, anodizing, laser irradiation, etc.[12,16]

The surface texture pattern and surface roughness of an implant will have a significant effect on the biological response of the surrounding bone, resulting in micromechanical interlocking between the implant and the surrounding bone.[14–19] The quality and quantity of this biological response are very important in realizing the phenomenon of Osseointegration (direct contact between the living bone and implant).

One of the common environmentally friendly methods that has recently been used to create roughness and produce various regular patterns on the surface of dental implants is laser ablation. By controlling the ablation, desired texture patterns can be created on the surface of the implant.[20,21] Laser surface texture production has several important advantages, such as removing all surface