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IMPLANT SURFACE TOPOGRAPHY: A REVIEW

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ABSTRACT:

Surface treatment of dental implants has been a new frontier in clinical dentistry. It is based on additive &subtractive techniques which modifies the topography. It alters the roughness/smoothness of the surface which helps achieving osseo integration. This article reviews the principles behind treating the surface of titanium, the methods employed for treating the surface.

KEYWORDS:

INTRODUCTION

Early osseo integration determines the clinical success of dental implant therapy[1]. The surface properties of titanium have been found to have an influence on the rate and quality of biological fixation. Surface morphology enhances osseo integration by directing protein adsorption kinetics. Osteo blasts tend to attach more readily and their differentiation occurs more easily on a rough surface. The Main methods that create implant roughness are acid etching, sandblasting, titanium plasma spraying and hydroxyl apatite (HA) coating.

SURFACE ROUGHNESS

Textured surface also allows in growth of the tissues [2]. The surface roughness of implants can be divided into macro, micro, and nano-sized topologies[3]. Macro-sized topographies with high rough surfaces help in initial implant stability and provide volumetric spaces for growth of bone[4].These treatments can be classified as mechanical, chemical, electrochemical, electro polishing, vacuum, thermal and laser methods.

MECHANICAL TREATMENT

The most commonly used mechanical techniques are machining, polishing, and blasting. Grinding and mechanical polishing are identical methods in that they remove some of the surface material by using a hard abrasive.

Grinding involves use of coarse particles to remove the surface. It creates rough topographies. Grinding with an abrasive grade 60 leads to Ra values around 1μm, and with the coarsest grade the surface roughness of up to 5-6 μm can be achieved[5].

Polishing involves use of fine abrasive material that is applied to a flexible wheel and then the implant is brought into direct contact with the abrasive surface. Polishing is carried out in the presence of lubricant.

Grit blasting is a process where the surface is bombarded with hard dry. Various types of ceramic particles such as alumina, silica, etc. of different sizes can be used[9-12]. In this procedure, hard ceramic particles are used. Alumina, titanium Oxide ($TiO2$) and Calcium Phosphate particles have been used for this purpose, because they are chemically stable and biocompatible. These particles are delivered through a nozzle at high velocity using compressed air. Alumina is a commonly employed blasting material.

CHEMICAL TREATMENT

A variety of chemical treatments such as solvet cleaning, wet chemical etching, and passivation treatments have been employed for modifying the implant surfaces.

Solvent cleaning is mainly aimed at cleaning the surface of the implant from oils, greases and fatty surface contaminants remaining after manufacturing process by using organic solvents (aliphatic hydrocarbons, alcohols, ketones or chlorinated hydrocarbons), surface active detergents and alkaline cleaning solutions[5].

Acid etching or pickling is used for removing oxide layer to obtain clean and uniform surface finish. Wong et al showed increased osseo integration as a result of acid etching. Micro rough surface is produced by immersing titanium implants in concentrated solution of HCL and H2SO4 heated above 100c.This is called as dual acid etching. Park and Davis demonstrated that dual acid etching increases osseo conduction and causes bone deposition directly on the implant surface. Acid treatment of the surfaces of titanium implants results in uniform roughness with micro pits ranging in size from 0.5-2 μm, increase in surface area, and an improvement in bioadhesion.

Alkaline etching is a simple technique to modify the titanium surfaces. Treatment of titanium in 4-5 M sodium hydroxide at 600°C for 24 hours has been shown to produce sodium titanate gel of 1 micron thick, with an irregular topography with high degree of open porosity. Composition and structure of this layer can be further modified by proper heat treatment. When the alkali treatment is preceded by etching in hydrochloric acid/sulfuric acid, porosity of the final surface is found to increas[6].

Passivation used for obtaining a uniformly oxidized surface to improve corrosion resistance. Surface of the implant should be neutralized, thoroughly rinsed and dried. Nitric acid passivation has no major influence on the overall surface topography of titanium surfaces[7].

ELECTROCHEMICAL TREATMENTS

Anodization depends on density of current, acid concentration and electrolyte composition. In electro-polishing technique, a controlled dissolution of the surface takes place under the influence of electrochemical reaction. Surface of the electro-polished titanium appears to be very smooth except for occasional pits that are preferentially located at grain boundaries. Although most of the surfaces have shown smooth surface, few materials have shown rough surface due to the differences in removal rate between different phases present in titanium alloy. In atomic force microscopy reveals that the surfaces are granular in appearance with granule size of few nanometers[8].

Ion implantation It is a procedure where in sodium, calcium and phosphorous ions are implanted onto the surface of implants to modify their topography at a dose of 1 into 10^{17} ions/cm^{-2} utilizing a beam energy of 25KeV and a vaccum of 10^{-6} Pa. A novel technique of double implantation was also followed where Calcium ions were implanted followed by phosphorous ions. This technique increased the corrosion resistance of titanium and also accelerated osseointegration.

Alkali and Heat Treatment When implants are alkali and heat treated it forms a foci over which bone matrix is deposited. The apatite formed due to this treatment is similar to inorganic component of bone. The apatite is formed by amorphous sodium titanate that is preformed on the metal after treatment. This is a complex process which occurs as a result of electrostatic interaction between surface of metal and fluids in the body.

VACUUM TREATMENT

Glow-discharge treatment, also known as cold plasma treatment, is based on the action of a low-pressure electrical discharge on the surface of the implant. In plasma deposition, glow discharge is used to deposit the coating material from a separate solid target (sputter deposition) and/or by reactions in the gas phase (reactive sputtering or plasma polymerization). Plasma surface modification is based on the exposure of sample surface to a glow dis-charge in order to obtain a specific modification of surface properties. Plasma treatment increases the surface energy of the implant and there by improves the wetting characteristics[9].

THERMAL TREATMENTS

Commercially pure titanium was thermally annealed to form oxide layer composed of anatase and rutile structures of TiO_2. Thermal treatment at 600°C and 650°C for 48 hours is considered appropriate for implanted materials[10].

LASER TREATMENTS

Laser enables implant surface treatment without direct contact providing better control on the micro-topography. These are clean and easy method to perform.

CONCLUSION

The wide variety and constant evolution of dental implant designs, driven by scientific findings and research studies, reflect the attempts of investigators to successfully incorporate an artificial structure within a biologic system. Implants should be carefully selected by balancing the research information of properties with the intended treatment plan.

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