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Review Article

Optimizing Implant Surface for Osseointegration - A Review

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Abstract

Dental implants play an important role in replacing the missing teeth. This discussion deals with various surface treatment of dental implant using various processes like additive and subtractive process which will improve the surface characteristics and thus improve the efficiency of dental implants. The attachment between bone and implant is explained based on the concept of osseointegration. To improve the process of osseointegration, we are modifying the surface features of implant like roughness, topography and energy, so that they can lead to long success of the implant. In day to day life dental implants plays an important role so that the topic is of great relevance.

Keywords: Dental Implants; Osseointegration

Introduction

Nowadays, Dental implants are commonly used for rehabilitation of partially and completely edentilous arches. Dental implants are much better since they preserve the alveolar bone and esthetics as well as durability of prosthesis. Titanium implants provide good Anchorage with alveolar bone called as osseointegration. By changing surface characteristics by physical, chemical or mechanical means, osseointregation of the titanium implants can be enhanced. Increased surface energy from surface modification causes an increase in cell and growth factor proliferation, which in turn speeds up the osseointegration process. A study found that an increase in surface area resulting from rougher implant surfaces will eventually lead to higher cell growth and proliferation. Titanium was determined to be the preferred material for dental implants due to its exceptional biocompatibility, strong corrosion resistance, low modulus of elasticity, and great strength. Basically surface treatment is done to promote bonding between alveolar bone and implant material. A roughness over the surface, surface charge, the composition of the material etc led to better osseointegration.

Dental implants

Definition

Dental implant is defined as a prosthetic device made of alloplastic Materials is implanted into the oral tissues beneath the mucosal and /or periosteal layer and on or within the bone to provide retention and support for a fixed or removable dental prosthesis. GPT- [9].

For more than 50 years, dental implants have been used to restore lost teeth with high success rate.[1] The degree to which the implant material can meld with the surrounding tissue will determine

its success. Numerous factors, including implant type and loading circumstances, as well as bone quantity and quality, affect this integration [2].

Osseointegration

The concept of osseointegration was introduced by Per-Ingvar Branemark the year 1969 who called it as 'a direct structural and functional connection between ordered living bone and the surface of load-covering implant' [3].

Definition of osseointegration

A direct connection between living bone and a load-carrying endosseous implant at the light microscopic level" [3].

- Branemark: "Contact established without interposition of nonbone tissue between normal re- modeled bone and an implant entailing a sustained transfer and distribution of load from the implant to and within the bone tissue".
- American Academy of Implant Dentistry (1986): "The apparent direct attachment or connection of osseous tissue to an inert, allo- plastic material without intervening connective tissue".
- G.P.T. 8.

Factors influencing osseointegration

The six known factors which influence the osseointegration are

- Implant biocompatibility.
- Characteristics of design.
- Characteristics of surface.
- State of the host bed.
- Techniques of surgery
- Conditions during loading [4].

Characteristic of implant surface

The reaction of implant and hard and soft tissue depends upon the physical and chemical properties. Certain substances are "passive" toward the process of tissue healing and do not elicit an immunological response, making them biocompatible. Certain materials have harmful cellular side effects, making them unsuitable for implantation. Implant surface can improve bone apposition in an osteoconductive way due to specific materials and surface features.

Prior to osseointegration, studies on surface features to achieve bone apposition were conducted. Since titanium is a very reactive metal that does not integrate into the tissues, endo osseous implants are used in both periodontology and orthopaedics. However, instantaneous surface oxidation produces a passivation layer of titanium oxide that has properties similar to ceramics and is highly compatible with tissues [5].

Implant surface characteristics can be altered by using two methods.

- Additive Process
- Subtractive process

Additive process

By covering the surface of the implant with calcium phosphate, which resembles bone tissue, the chemical structure of the surface can be changed. According to the calcium-phosphate ratio and impurities, the cell response of hydroxy appetite by osteoblast varies [6]. To hasten bone formation titanium oxide coating are modified by Anodizing or chemical treatment to precipitate calcium phosphate which results in formation of mineralized bone.[7] In cooperating fluoride into the TiO layer produce a covalent bond between implant surfaces and bone by displacing these ions with oxygen derived from phosphate [8].

Macromolecules such as glycoprotein and proteoglycan which prevents mineralization is inhibited by the release of fluoride [9]. Additive process alters the microstructure of implant surface while the subtractive process provides a micro roughness [5].

Methods

Sintering (direct metal laser sintering)-DMLS

Used to create implants with bone compatible properties.

Plasma spraying

The surface of the Titanium is sprayed with molten metal and imperfections like valleys and pores are created on the surface resulting in mechanical interlock between bone and implant. Also increased surface area helps in initial fixation of implant.

Anodization

It is the method by which oxide layers are electrochemically formed on the surface of titanium implants. It is surface helps in the strong fixation of the implant to the bone.

Nano structure surface

It' is a type of anodization by means of galvanostatic reaction of titanium in strong acids like sulphuric acid, phosphoric acid, nitric acid, etc at high density($2A/m^2$) or potential (100V).

Sol gel coating implant

A thin homogeneous layer is formed on the implant surface which will provide more toughness, early bone formation and will promote Osseointegration.

Electrophoresis deposition

In this colloidal particle in a liquid medium move towards a counter charged electron under the influence of electric field.

Bio mimetic precipitate

Here, the implant is coated with the biomimetic agent. such as

Bio -ceramics

- Hydroxyapatite(HA)
- Calcium phosphate phases.

Bioactive proteins

- Bone morphogenic proteins (BMP)
- Type1collagen
- RGD peptide sequence.
- Ions
- Fluoride.

Polymers

- Chitosan

Drug in cooperated

Implant surface are treated with antibacterial agents to keep the site devoid of infection, decontamination and detoxification. Eg: Gentamicin -HA coating, Tetracycline-HCl treatment [10].

Subtractive process

Subtractive process contains machining, acid etching and blasting which improves surface roughness of the implant [5]. The degree of micro roughness required for implant-bone adhesion depends upon the chemical nature of the implant [11]. The acid etching and blasting will improve the micro roughness and also modify the surface chemistry of the implant surface [5].

Methods

Machined surface

In this, implant surface is submitted to decontamination process followed by turning process and the surface is also known as machined or smooth implant. Distance osteogenesis is one of the main characteristics of turned surface. This method is used in the past and now modification are proposed to make the surface roughen, to increase the surface area and to improve the stability of implant [11].

Grit blasting or sand blasting

It is the process to create a surface irregularity by blasting an abrasive media through a nozzle with the help of compressed air. The materials used for this purpose are titanium oxide, alumina and calcium phosphate. This process can also leave remaining particle on implant surface which can modify the bone healing process [10]. Speed of rotation, pressure, number and size of the particle are the factors that will affect the process of sandblasting [11].

Acid etching

This the process which is used to create small pits of 0.5 to2 mm by etching with strong acids like HCl, H_2SO_4, HNO_3, etc... at a high temperature (100°C). Dual acid etching technique is also used which is more efficient [10].

Dual acid etching

By immersing the Titanium implant in a combination of HCL and H_2SO_4 and heating above 100°C can increase submicron topography which results in an increased biological property of the implant. This process increased the osteo conductive activity of the implant [10].

Laser peening

A high intensity nano second pulse of laser beam of 3- 5 width is used to collide with protective layer of metallic surface leading to its melting [10].

Sand blasting and acid etching (SLA)

In this process, sandblasting along with acid etching is done. The blasting is done with aluminium oxide and titanium oxide followed by etching with HCl and H_2SO_4. It will modify the micro and macro structure of the implant and also improve Osseo conducting property and ability to induce cell proliferation [10].

Electro polishing (electrochemical polishing/anodic polishing/electrolytic polishing)

This process will remove surface roughness by suspending peaks and valleys present on the surface by using concentrated acid solution having high viscosity such as sulphuric acid and phosphoric acid [10].

Purpose of implant surface treatment

Surface treatment will increase the surface are, surface roughness, provide better bonding, making them more passive and also removes the surface contamination [10].

Conclusion

Surface treatment of the implant helped to improve the success rate in the field of implantology. It is used to improve surface roughness as well as surface chemistry of the implant. A wide range of the coating methods are available which can be selected according to the specific requirements and maximum benefit for the patient. Till now which property of surface irregularity and which combination would provide a more predictable osseointegration is not identified.

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