International Journal Dental and Medical Sciences Research
Volume 4, Issue 1, Jan-Feb 2022 pp296-299www.ijdmsrjournal.com ISSN: 2582-6018

Dental Implant Surface Treatment- Everything worth knowing.

Dr.Alok Sharma (Prof.&HOD Dept. of prosthodontics crown & Bridges and implantology NIMS Dental College and Hospital Jaipur.)
Dr.PaarasKotwal (3rdYr P.G prosthodontics crown & Bridges and implantology)
Dr. Vipul Vashist (3rdYr P.G prosthodontics crown & Bridges and implantology)
Dr. Rashmi Raman (3rdYr P.G prosthodontics crown& Bridges and implantology)
Corresponding author- Dr.PaarasKotwal (3rdYr P.G prosthodontics crown & Bridges and implantology)
E-mail address- paaraskotwal98@gmail.com

Submitted: 25-01-2022 Revised: 01-02-2022 Accepted: 04-02-2022

ABSTRACT-The successful replacement of lost natural teeth by tissue integrated tooth root analogues is a major advancement over last 25 years.Implant surface plays a vital role for the cellular level molecular interaction to achieve the better osteointegration. Hence, various surface treatment options have been adopted as the latest course of action for the titanium (Ti) implants. This review article tells about the various methods of surface treatments and there responses observed by various surface designs.

Introduction-

Implants have become an integral facet of prosthodontic therapy serving as transmucosal structures to support single teeth, fixed partial dentures, complete arch reconstructions and complete removable dentures or to reconstruct maxillofacial defects. However to elicit proper biological response to dental implants with adequate mechanical properties has remained a challenge. [1]

The history of dental implants as a treatment for replacement of missing teeth goes back many centuries where dental implants of bamboo, ivory and wood were used. Since then a tremendous improvement in the material and design of dental implants has taken place.The rate of clinical success of the use of oral implants is widely related to the bone formation at the implant surface called osseointegration, a term coined by Dr.Branemark in 1952 in contrast with fibrous encapsulation that often leads to loss of the implant and consequent failure of the treatment.[2]

Albrektsson et al suggested the following as the six most important factors for establishing reliable osseointegration: implant material, implant design, surface quality, bone status, surgical technique and loading conditions. Of these, surface structure is the one of the most critical factors influencing the clinical outcome of implants. The surface quality of an implant depends on the chemical, physical, mechanical and topographical properties of its surface. Implant technology is continuously evolving as new research findings provide a better understanding of the biologic principles that govern the development of a dynamic interface between the living tissue and an artificial structure. Surface composition and roughness are parameters that may play a role in implant tissue interaction and osseointegration.[3]

In various studies related to implant surfaces, Cooper(2000) concluded that an increase in the surface roughness of commercially pure titanium implants improved bone integration with respect to the amount of bone formed at the interface, increased osteoconduction and osteogenesis. This article is indented to provide an overview of the various implant surface modifications and topographies that have been developed to improve the quantity and quality of the bone-to-implant interface.[3]

Classification of implant surfaces

Implant surfaces have been classified on different criteria, such as roughness, texture and orientation of irregularities.

I. Wennerberg and coworkers have classified implant surfaces based on the surface roughness as:
1. Minimally rough (0.5–1 μm)
2. Intermediately rough (1–2 μm)
3. Rough (2–3 μm)

II. Based on the technique used to alter the surface topography, two types of implant surfaces can be obtained:
1. Convex profile : obtained by techniques that add material on the bulk metal called additive process

Eg.hydroxylapatite (HA) an other Calcium phosphate coatings,Titaniumplasma sprayed(TPS) surfaces,Ion deposition

2. Concave profile: obtained by techniques where particles will be removed from the surface creating pits or pores on the surface called subtractive process Eg.Electropolishing, Mechanical polishing, Blasting , Etching, Oxidation

III. Based on the orientation of surface irregularities implant surfaces are divided as:

1. Isotropic surfaces: have the same topography independent of measuring direction.
2. Anisotropic surfaces: have clear directionality and differ considerably in roughness.

Alteration in implant surfaces-

The approaches to alter implant surfaces can be classified as physicochemical, morphologic or biochemical.

I. Physicochemical method:
II. Morphological method:
III. Biochemical method

I. Physicochemical method:

It mainly involves the alteration of surface energy, surface charge and surface composition with the aim of improving the bone–implant interface. The method employed is the glow discharge method, which increases the cell adhesion properties.

II. Morphological method:

It mainly deals with alteration of surface morphology and roughness to influence cell and tissue response to implants. In addition; surfaces with specially contoured grooves can induce contact guidance, whereby direction of cell movement is affected by morphology of substrate.

Morphological methods of surface modification may be further classified as into three types-

a)Mechanical.
b)Chemical.
c)Physical.

The main objective of thesetechniques is to improve the bio-mechanical properties of the implant such as stimulation of bone formation to enhance osseointegration, removal of surface contaminants and improvement of wear and corrosion resistance

A. Mechanical treatment:

Mechanical treatments involve either removal of surface material by cutting or abrasive action, or the surface of the implant is deformed (and/or partially removed) by particle blasting. The most commonly employed mechanical techniques are machining, polishing and blasting.

B. Chemical methods:

Chemical methods of implant surface modifications include chemical treatment with acids or alkali, hydrogen peroxide treatment, sol-gel, chemical vapor deposition and anodization. Chemical surface modification of Ti has been widely applied to alter surface roughness and composition and enhance wettability/surface energy. The process of acid treatment serves to remove the surface oxide and contamination which leads to a clean and homogenous surface. The acids commonly used include hydrochloric acid, sulfuric acid, hydrofluoric acid and nitric acid.

C. Physical methods:

The physical methods of implant surface modification include plasma spraying, sputtering and ion deposition The various morphological methods of surface modifications of titanium implants are as follows:

1. Turning:

A turned machined implant has a smooth surface macroscopically but scanning electron microscopy analysis shows that the surfaces of machined implants have grooves, ridges and marks of the tools used for their manufacturing .

These surface defects provide mechanical resistance through bone interlocking.

In machined implants bone contacted only the tip of the thread and not the root of the thread and also there is no connection between peri implant bony surface and implant surface.

2. Blasting:

Blasting implant surface with particles of various diameters is one of the frequently used methods of surface alteration. Ceramic particles are projected through a nozzle at high velocity by means of compressed air. It is mainly performed by Al_2O_3 and TiO_2, with particle size ranging from small, medium to large (150–350 µm) grit.

3. Etching:

Titanium is a corrosion-resistant metal even though some acids like strong acids such as HCl, H_2SO_4, HNO_3 and HF can be used for etching i.e. removing a small amount of material to create pits on the surface and roughening dental implants. Acid-etching produces micro pits on implant surfaces with sizes ranging from 0.5 to 2 µm in diameter.

Various modifications on the technique have been employed, such as :

1. Dual acid-etched technique: It is proposed to produce a microtexture rather than a macrotexture. Immersion of titanium implants for several minutes in a mixture of concentrated HCl and H_2SO_4 heated above 100°C (dual acid etching) is employed to produce a microrough surface. This

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type of surface promotes rapidosseointegration while maintaining long-term success over 3 years.

2. Sandblasted and acid-etched (SLA) method: A combination of blasting
and etching has been a commonly used surface modification technique during the last one and a half decade. The surface is produced by a large grit 250–500µm blasting process followed by etching with hydrochloric/sulfuric acid.

3.Thermal etching**:** Friadent Plus from Dentsply released the next generation implant surface which features a thermal etching process called BioPoreStructuring. The specific etching acid they use creates an ideal physical,
chemical and biological surface needed to attract osteoblasts to the surface.

4. Plasma-sprayed surfaces:
Plasma-spraying is a technique in which hydroxyapatite (HA) ceramic particles are injected into a plasma torch at high temperature approximately 15,000,20,000 K and projected on to the surface of the titanium where they condense
and fuse together, forming a film in an inert environment like argon to a thickness of 0-100 µm.

5. Ion-sputtering coating:

It is the process by which a thin layer of HA can be coated onto an implant substrate. This is performed by directing a beam of ion onto an HA block that is vaporized to create plasma and then recondensing this plasma onto the implant.

6. Anodized surface:

All titanium implants have a native oxide layer but oxidized implants have been prepared with a thicker oxide layer. Micro- or nano-porous surfaces may also be produced by potentiostatic or galvanostaticanodization of titanium in strong acids (H_2SO_4 , H_3PO_4 , HNO_3 , HF) at high current density (200A/m2) or potential (100 V). The result of the anodization is to thicken the oxide layer to more than 1000nm on titanium.

7. Porous surfaces:

These are produced when spherical powder of the metallic/ceramic material becomes a coherent mass within the metallic core of the implant body. These are characterized by pore size, shape, volume and depth, which are affected by the size of the spherical particles and the temperature and pressure of the sintering chamber.

8. Coating:

i. Hydroxyapatite coatings:

Indications:

•For type 4 bone (based on Misch and Judy classification)
•Fresh extraction sites.
•Newly grafted sites.

9.Laser ablation technique: Implant surface roughening using the previously discussed methods would cause surface contamination. Laser techniques have recently been developed as an alternative to these techniques. Laser enables implant surface treatment without direct contact and provides better control on the micro-topography of implant.

10. Pulsed laser deposition (PLD): PLD is a unique physical vapor deposition process that uses a pulsed laser such as KrF to ablate the target material, forming a highly energetic plume that deposits the film onto the substrate. 139. The PLD technique involves three main steps: ablation of the target material, formation of a highly energetic plume and the growth of the film on the substrate.

11. Nano-roughness and nanostructures
All surfaces possess nano roughness, however not all of them have defined nanostructures. Nanostructured materials are defined in the literature as materials containing structural elements with dimensions in the range of 1-100 nm.

III Biochemical methods:

These methods offer an alternative/ adjunct to physiochemical and morphological methods. This of biology and biochemistry of cellular function and differentiation

i)Nanotubes and Stem Cells Accelerate Bone Growth UC San Diego bioengineers and material science experts used a nanobio technology method of placingmesenchymal stem cells on top of very thin titanium oxide nanotubes in order to control the conversion paths, called differentiation, into osteoblasts or bone building cells. Mesenchymal stem cells, which are different from embryonic stem cells, can be extracted and directly supplied from a patient's own bone marrow.

ii) Biologically active drugs incorporated dental implants

a. Bisphosphonates

Bisphosphonate incorporated on to Ti implants increased bone density locally in theperi-implant region with the effect of the antiresorptive drug limited to the vicinity of the implant. Other experimental studies using PSHA-coated dental implants immersed in pamidronate or zoledronate demonstrated a significant increase in bone contact area.

b. Simvastatin

Simvastatin, could induce the expression of bone morphogenetic protein (BMP)
2 messenger ribonucleic acid that might promote bone formation.

c. Antibiotic coating

i. Gentamycin along with the layer of HA can be coated onto the implant surface, which may act as a local prophylactic agent along with the systemic antibiotics in dental implant surgery.
ii. Tetracycline-HCl functions as an antimicrobial agent capable of killing microorganisms that may be present on the contaminated implant surface. It also effectively removes the smear layer as well as endotoxins from the implant surface.

Need For Implant Surface Treatment

•To increase the surface area
•To bring better bonding
•To increase surface roughness
•To make the make them more passive
•To remove the surface contamination

CONCLUSION

The surface treatment in the field of implantology has shown tremendous increase in the success rate of implant. The major challenge is mostly this technique are performed in condition different from natural condition. So the tissue reaction towards this surface treatment should be fully understood. The success of an implant is depending up on the use of various modifications in accordance with the situation to obtain maximum benefit for the patient.

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