EFFECT OF DIFFERENT SURFACE TREATMENT OF DENTAL IMPLANTS ON OSSEOINTEGRATION : A REVIEW

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ABSTRACT:

With the introduction of biocompatible materials like titanium and other bio ceramics and added advantages of preservation of tooth structure, implants have created a new era in dentistry as treatment option for missing teeth. Earlier short coming of lack of bonding with bone are overcome by osseointegration property of titanium and zirconia implants. This osseointegration rate of titanium dental implants is related to surface composition, surface roughness and hydrophilicity which increase the mechanical stability of implants. The present review throws some light on various methods employed for surface modifications.

AIM & OBJECTIVE- Aim of this paper is to discuss various surface treatment methods of Implants and its effect on osseointegration.

CONCLUSION : There are various surface modified implants available. Studies have proven that these implants show better osseointegration compared to machined implants.

KEYWORDS: Osseointegration, dental implants, surface roughness, nano-sized topography, biomimetic calcium phosphate, coating.

INTRODUCTION: In the past 20 years, the number of dental implant procedures have increased steadily worldwide, reaching about one million dental implantations per year. History of implants dates back to B.C and reference to the use of tooth, shell, ivory have been documented which had only mechanical retention, but accidental intervention of titanium implants by Branemark let to the wide use of Ti as dental implants due to its excellent biocompatibility and most importantly osseointegration that influences initial stability[9].

The opaque nature of this metal in patients with thin gingival biotype limited its use in anterior region which was later overcome by bio ceramic zirconia which clinically showed equal efficacy in osseointegration and biocompatibility to titanium [13]. Geometry and surface topography are crucial for short and long term success of dental implants. The rate and quality of osseointegration of Ti and zirconium implants are related to the surface properties. Osseointegration is the apparent direct attachment or connection of osseous tissue to an inert, alloplasticmaterial without intervening connective tissue. This is greatly influenced by surface treatment of the implants.Surface roughness, composition, hydrophilicity play an important role in tissue interaction, osseointegration and rapid bio fixation. This review article illustrates various surface treatmentsof Ti and zirconia implants[20].

Surface treatment of dental implants is categorised as

Surface roughness (morphological) | surface coating

Physiochemical | Biochemical

Ti plasma spraying | Acid etching | Flouride treated
Blast gritting | SLA | Plasma HA spraying
Anodization | Laser etching and MAO | Biomimetic
CaPO4 coated
Laser treated Bioactive drug coated

Nanotitania implants.

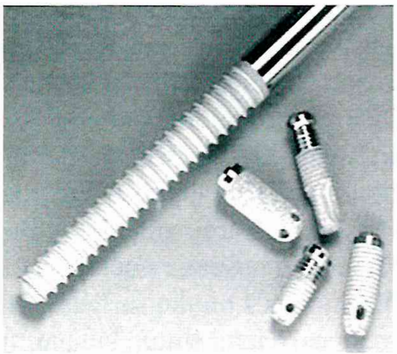


Fig 1

Fig1 Surface roughnesscan be divided into three levels: macro, micro and nano-sized topologies. The macro level is directly related to implantgeometry, with threaded screw which improves early fixation and long-term mechanical stability of the prosthesis.The micro topography maximizes the interlocking betweenmineralized bone and the surface of the implant [1, 2].Surface profiles in the nanometre range play an importantrole in the adsorption of proteins, adhesion of osteoblasticcells and thus the rate of osseointegration [3].

Roughening of implants by titanium plasma spraying:

This method consists of injecting titanium powders into a plasma torch athigh temperature. The titanium particles are projected on to the surface of where they condense and fusetogether, forming a film about 30um thick which increasesthe surface area of the implant [4].

Roughening of implants by grit-blasting: fig2: Another approach for roughening the titanium surface implants is with hard ceramic particles.

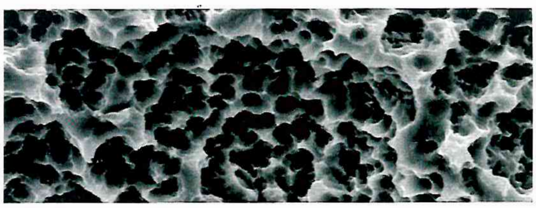


Fig 2

a) Alumina (Al2O3) is frequently used as a blasting material and produces surface roughness. However residue that remain seven after ultrasonic cleaning, acid passivation and sterilization interferes with the osseointegration of the implants.

b) Titanium oxide is also used for blasting dentalimplants [6, 7].

c) Biocompatible, osteoconductive andresorbable blasting material like Calcium phosphates such as hydroxyapatite, beta-tricalcium phosphate and mixtures have been considered useful blasting materials [8, 9].

Roughening of implants by acid-etching:

Etching with strong acids such as HCl, H2SO4, HNO3 and HFis another method for roughening titanium dental implants.Acid-etching produces micro pits on titanium surfaces with sizes ranging from 0.5 to 2um in diameter [10, 11]. Dual acidetched surfaces enhance the osteoconductive process throughthe attachment of fibrin and osteogenic cells, resulting inbone formation directly on the surface of the implant [12].Another approach involves treating titanium dentalimplants in fluoride solutions. This chemicaltreatment of the titanium created both a surface roughnessand fluoride incorporation favourable to the osseointegrationof dental implants [14,15]. Chemical treatments might reduce themechanical properties of titanium by hydrogen embrittlement of the titanium, creatingmicro cracks on its surface that could reduce the fatigue resistanceof the implants [17].

Roughening of implants by anodization:

Micro- or nano-porous surface produced bypotentiostatic or galvanostatic anodization of titanium instrong acids havebeen proposed to explain osseointegration by mechanical interlocking through bone growth in pores, and biochemical bonding [19].

Osteoconductive calcium phosphate coatings on dental implants fig3:

Metal implants have been coated with layers of calciumphosphates mainly composed of hydroxyapatite. Following implantation, the release of calcium phosphate into the periimplant region increases the saturation of body fluids and precipitates a biological apatite onto the surface of the implant[15, 16]. The bone healing process around the implant is enhanced by this biological apatite layer. Theplasma-spraying coating method has been used for titanium dental implants in clinical practice.Plasma-spraying technique is used for hydroxyapatite(HA) ceramic particle coating [18, 19]. The major concerns with plasma-sprayed coatings are the possible delamination of the coating from the surface of the titanium implant and failure at the implant-coating interface.

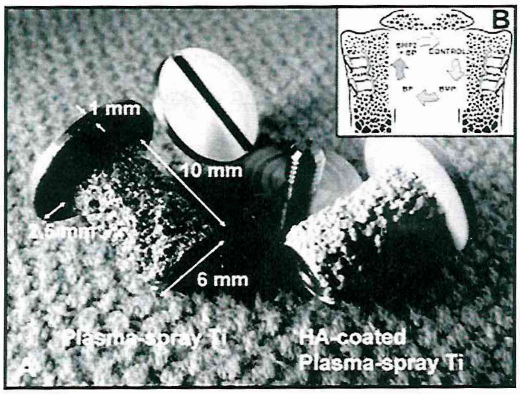


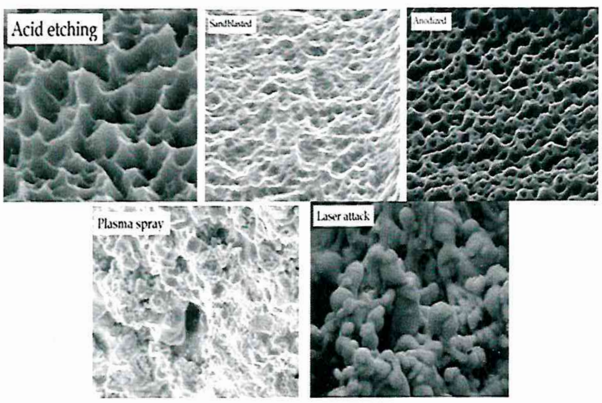
Fig 3

Future trends in dental implant surfaces:

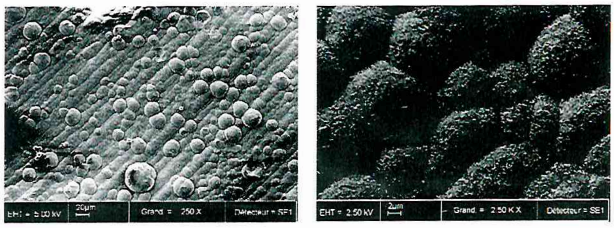
These concern the modifications of surface roughness at the nanoscale level for promoting protein adsorption, celladhesion. Bio mimetic calcium phosphate coatings enhance osteoconduction. Incorporation of biological drugs acceleratesthe bone healing processin the peri-implant area.

Surface roughness at the nanoscale level:

In vitro experimental studies [20] have demonstrated that the attachment ofosteoblastic cells.



Biomimetic calcium phosphate coatings on titanium dental implants:



In order to avoid the drawbacks of plasma-sprayed HA coatings, scientists have developed a new coating method inspired by the natural process of bio mineralization.

The first method involves the electro deposition of calciumphosphate which leadst o the formation of brushite coatings which are subsequentlyconverted into apatite by hydrothermal processing[20].

The second method is based on the bio mimetic precipitationof calcium phosphate on titanium surfaces by immersion in SBF. This method involves the heterogeneous nucleation and growth of bone-like crystals on the surface of the implant at physiological temperatures and under pH conditions.

Incorporation of biologically active drugs intotitanium dental implants:

The surface of titanium dental implants may be coated with bone-stimulating agents such as growth factors in order to enhance the bone healing process locally. The limiting factor is that the active product has to be released progressively and not in a single burst. Another possibility may be the adjunction of a plasmid containing the gene coding for a BMP [19]. This possibility is limited due to the poor efficacy of inserting plasmids into the cells and the expression of the protein. In addition, over production of BMPs by cells might not be desirable after the bone healing process.

Surface coating of Zirconia:

Mechanical properties of Zirconia surface are suitable to be used as implants.Healthy periimplant tissue is seen in experimented animals; but there are no long term studies and follow up studies for Zirconia.It is alternative to titanium when patient is allergic to titanium implants and in anterior tooth replacement in patients having thin gingival biotype. Zirconia surface is modified by sand blasting, sand blasting plus acid etching, ion modifications, HA coating. Zirconia implants give better esthetical benefit but mechanical properties and osseointegration of titanium is superior.

CONCLUSION

Dental implants with various surface treatments are available. Most of these surfaces have proven clinical efficiency(>95% over 5 years) .Each of these surface modification stried has its own significance. There is no gold standard for any of the modifications [20]. Zirconia is a budding implant material which is of a great experimental interest. However, the development of these surfaces has been empirical and requires further studies. The exact role of surface chemistry and topography on the early events of the osseointegration of dental implants remain poorly understood. The future of dental implantology should aim at developing surfaces with controlled and standardized topography or chemistry. This approach is the only way to understand protein, cell and tissue interactions with implant surfaces [19]. These strategies should ultimately enhance the osseointegration process of dental implants for their immediate loading and long-termsuccess.

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