

# Recent Advances in Surface Characteristics of Dental Implants: A Mini Review

Pooja Mohanty<sup>1</sup>, Manoj Kumar<sup>2</sup>, Saurav Panda<sup>2</sup>, Rinkee Mohanty<sup>3</sup>, Rashmita Nayak<sup>4</sup>, Anurag Satpathy<sup>4</sup>

<sup>1</sup>Intern, Institute of Dental Sciences, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, India,

<sup>2</sup>Associate Professor, <sup>3</sup>Professor and Head, <sup>4</sup>Professor, Department of Periodontics & Oral Implantology, Institute of Dental Sciences, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, India

## Abstract

Implants have become an integral part of dentistry today and are widely being used for the replacement of missing teeth. A considerable amount of advancements has come in Implant dentistry including the quality of material, surface coatings and processes, and the surgical techniques as well. This review will deal with the implant surface design and its characteristics which have been done till now to enhance the implant-bone contact resulting in better osseointegration and subsequent long-term success of dental implants.

**Keywords:** Dental Implants, Osseointegration, Surface coatings.

## Introduction

The idea of permanently being able to replace the teeth has been a desire of civilization since the days of the Egyptians.<sup>1</sup> Periodontitis is the common cause for missing teeth but except that, other causative factors are dental caries, trauma, and genetic disorders.<sup>2</sup> For replacement of the missing teeth, there is various types of materials have been used into the jaw in ancient ages, but the demerits of these materials are, never able to achieve a stable state with surrounding tissues.<sup>2</sup> But luckily our modern dentistry introduces many dental implantation method that are much more successful & painless than previous method of implantation. In the 1950s, Dr. Per-Ingvar Branemark in Sweden discovered an implant with titanium which has sufficient strength to cope with load transferer and named this phenomenon as "Osseointegration".<sup>1</sup> Modification in

generally the surface of implants results in exceptional osseointegration.

### Surface Design of Implant:

Before the current implant systems, which are used today; there were various implant systems with geometric designs have been developed.<sup>3</sup> Some common designs of implants are listed below:

- 1. Endosseous Implants:** These implants are created to utilize a vertical column of bone, similar to the root of the natural tooth.
  - Bladelike
  - Pins
  - Cylindrical
  - Disk like
  - Tapered type
  - Screw type
  - Both tapered and screw type
- 2. Subperiosteal frame like implants:** These are used in the treatment of atrophic mandibles.<sup>3</sup>
- 3. Transmandibular implant:** These are developed to retain dentures in the edentulous lower jaw.<sup>3</sup>

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### Corresponding Author:

**Dr. Manoj Kumar**

Associate Professor, Department of Periodontics & Oral Implantology, Institute of Dental Sciences, Siksha 'O' Anusandhan Deemed to be University, Bhubaneswar, India

The implant microstructure is represented as threaded or nonthreaded. Threaded type is most commonly used now a day. 3 threaded shapes are most commonly used: V-shaped; Square shaped; Reverse buttressed. Threaded implants also classified as self-tapping or pre-tapping.

**Surface Characteristics of Implant:** It has been shown that the healing process improves positively by the surface characteristics which are also called as microtopography of implant.<sup>3</sup> Surface roughness is an important component in the osseointegration of the surface of the implant. Roughness in surface of implant shows reinforcement of osteoblastic action at 1 to 100 μm in comparison of smooth surface.<sup>2</sup>

**Modifications in Surface Characteristics of Implant:** Over the past 15 to 20 years, improvement of implant surface characteristics has been a major area of research interest and development.<sup>3</sup> Modifications of the surface of implant has been investigated and implemented to progress biologic surface properties favouring osseointegration.<sup>2</sup> Modified implant surfaces shows an increase in adsorption of cytokines, mineral ions and proteins; which results in cellular migration and attachment at the molecular level.<sup>3</sup> To improve the quality of bone formation, modification of surface characteristics (microscale or macro scale) is important and it is only possible by treating the implant by various technology, which is already done by today's technology.<sup>3</sup>

**Additive Process:** The name itself denotes that it is the process in which material should be added. By this process, chemicals are added to the existing surface which results in an improvement in microstructure and macrostructure of the implant surface. Inorganic mineral coating like calcium phosphate, bisphosphonate, hydroxyapatite, etc; plasma spraying, biocoating with growth factors (platelet-derived growth factor, bone morphogenic protein, fibroblast growth factor, transforming growth factor-beta, vascular endothelial growth factor); peptide and extracellular matrix components (hyaluronic acid, chondroitin sulphate, collagen) are different method used as additive materials and/or chemicals to the implant surface. In addition to hydroxyapatite to the surface of the implant, it has been shown that there is both improvement and acceleration in the primary bone cells proliferation or adaptation.<sup>2</sup>

**Hydroxyapatite crystals:** The key inorganic element of natural bone is the hydroxyapatite crystal.

The layering of this key element (hydroxyapatite crystal) permits an influenced and also a quick osseointegration by connecting living bone and the surface of the implant; which was manifested by many investigations.<sup>4</sup> With hydroxyapatite coating the survival rate or continuity rate at 4-8 years, the effect was upto 93.2-98.5% and at 10 years, the effect was upto 82.0%.

**Titanium plasma-sprayed:** In this method, the survival rate or continuity rate at 20 years, the effect was upto 89.5%.<sup>2</sup>

**Plasma spray coating:** A combination of HA coating on titanium alloys substrate has good biocompatibility and mechanical properties, which received much attention. The process of layering of hydroxyapatite, incorporates spattering of thermally liquefied materials on the implant substrates.<sup>5</sup>

**Subtractive Process:** The name itself denotes; it is the process in which there is elimination of materials takes place. In this process, to improve or enhance or to modify the microstructure and chemical nature of the surface of the implant, elimination or alteration of the existing surface is done. It can be done by various ideas or method like machining, blasting, acid etching, or a combination of these processes. These method improve the quantity or speed of osseointegration. Among all these the first-generation design of the surface of the implant is the machined surface of implant which is with a rotating surface implant. Surface of implant treated by a process known as grit blasting, in which dispersion of particles can be done by silica or ceramic material. Roughening off the surface of titanium implant by using strong acid like nitric acid, sulphuric acid, or combination of these acids, hydrofluoric (HF) acid is done by acid etching. Sandblasted and acid-etched is the type of acid etching after sandblasting with 250-500 μm large grit particles.<sup>2</sup>

**Sandblasted and acid-etched (SLA) process:** In sandblasted and acid-etched (SLA) process, the continuity rate at 10 years effect was upto 98.8% to 99.7%.<sup>2</sup> Inductions of surface erosions by applying a strong acid onto the blasted surface is done by this SLA process. The combination of large grit sand particles and acid etching is used in this process to obtain macro roughness and micropits.<sup>5</sup>

**Grit blasting:** It is a frequently implemented physical method, which is used for surface treatments. Grit blasting is followed by an acid etching to remove

the residuals. This process is done by projections of pressurized particles or projections of silica onto the implant surface.<sup>5</sup> Many frameworks, as for examples: size, type, pressure and temperature of the particles may get an influence on the final consequences.<sup>6</sup>

**Discrete crystalline deposition:** By the process of sol-gel, Calcium phosphate particles of size 20-100nm are coated on a double acid-etched surface named discrete crystalline deposition. Exertion of an intense adhesive force of surface of the implant and making up of surface upto 50% can be done by these particles.<sup>7</sup>

**Anodic oxidation:** In this method, the implant is exposed to an electric circuit in which it is serving as anode.<sup>7</sup> It is said that when there is surface roughness is 0.44-8.68 $\mu$ m by modification of any surface then it provides a good surface for osseointegration.<sup>2</sup> Mostly good roughness of implant surface can be achieved by doing acid etching and coating.

### BIOACTIVE GLASS

The use of bioactive glass to improve the surface characteristics has shown positive results. By the addition of bioactive glass, the bio-inert nature of the titanium dental implants may benefit.<sup>8</sup> Bioactive material helps in the formation of a hydroxyapatite layer with a bond forming between the tissue and a higher dissolution rate and thus faster apatite formation.<sup>8</sup> Bioactive glass has proved to reduce biofilm mass invitro conditions.<sup>8</sup> Bioactive glass actively bonded to the bone and provide antimicrobial protection and it also helps in the reduction of treatment time.<sup>8</sup> 45S5 bioglass, 58S(sol-gel derived) bioglass, S53P4 bioglass are mostly used bioglass materials. 45S5 bioglass contains 46.1mol% SiO<sub>2</sub>, 24.4mol% Na<sub>2</sub>O, 26.9mol% CaO, 2.6mol% P<sub>2</sub>O<sub>5</sub>. 58S (sol-gel derived) bioglass contains 60mol% SiO<sub>2</sub>, 36mol% CaO, 4mol% P<sub>2</sub>O<sub>5</sub>. S53P4 bio glass contains 53mol% SiO<sub>2</sub>, 23mol% Na<sub>2</sub>O, 20mol% CaO, 4mol% P<sub>2</sub>O<sub>5</sub>.<sup>9</sup>

### CONCLUSION

Dental implants are now the state of art for dental restorative therapy. In order to achieve an abundance integration of hard and soft tissue, adhesion and proliferation of osteogenic as well as fibroblastic cells and minimization of attachment of bacterial during upgrading the recruitment should be the focus of attention of implant development. Several preclinical scrutinizations have shown the superiority of

certain surface modifications concerning to histomorph properties and biomechanical characteristics. Clinicians should consider the fact that even if several new surface treatments have been proposed, only long term results and rigorous studies can eventually prove its efficacy. To assure an everlasting success in clinically demanding circumstances, the evolution of versatile surface modifications and coatings is essential and recent findings about surface modifications have improved the success rate of implants.

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