



# Implant Materials: Topography and Their Influence in Osseointegration

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## Abstract

With advancements in science and technology, edentulousness has been provided with a permanent solution in the form of dental implants. Implant materials have been evolving in various aspects to enhance their property of Osseointegration since their discovery. With research revealing the intense process of bone formation and biology around osseointegration, scientists have been experimenting with various compositions of alloys, allotropic forms, and commercially pure (cp) forms of titanium. Topographical modifications and their effect on new bone formations will be dealt with in this article.

**Keywords:** Osseointegration; Dental Implants

**Abbreviations:** CP: Commercially Pure.

## Introduction

The skeletal system is a complex system in the body with a sensitive hard tissue bone formed and resorbed by a subtle equilibrium through an intricate process. The balance maintained by osteoblasts and osteoclasts is dictated by several metabolic and local factors which eventually lead to the structure and organization. While an average bone formation and remodeling process range from 3 to 6 months, acute bone loss is not so uncommon in dentistry. With research advancing in the biology associated with bone formation and resorption, Implantology has progressed in many challenging cases.

## Methods and Materials

In this article, we have conducted a literature review to analyze the importance of modifications of certain regions of dental implants to improve the success rate and long-term stability of the implants placed.

## Search Criteria

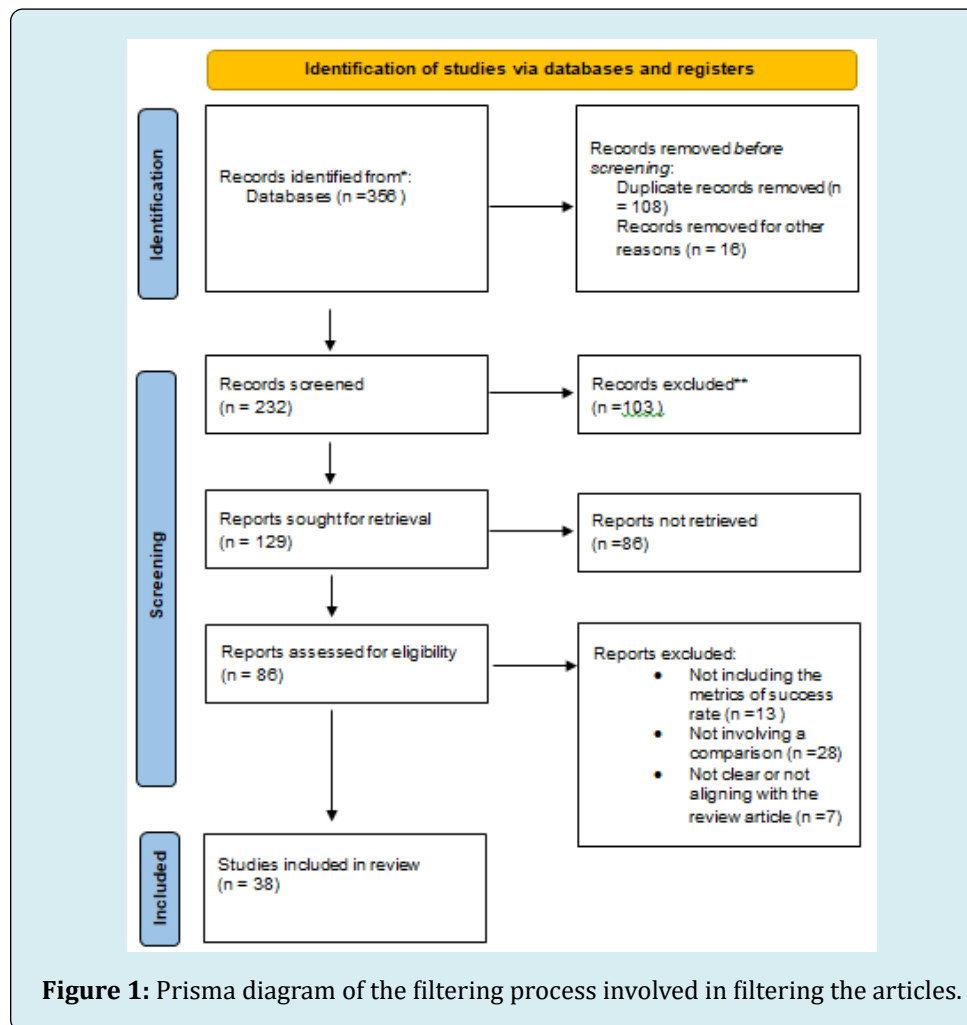
This includes articles between 2011 to 2021 for a period of 11 years, published in English, and includes substantial information relevant to the process of surface modifications of dental implants in electronic databases like Medline PubMed, Scopus, and The Cochrane. The search terms include 'dental' + ' Implant' + 'surface modifications' or 'implant topography' or 'topography modifications'.

## Selection of Studies

The initial search including the terms and the period of 11 years between 2011 to 2021 brings about 356 articles. Duplicates were eliminated after the initial filter. They were refined for English and it came down to 232. When filtering

for the content and the relevance of the article to the theme of the review we had to cut down the search to 129 articles. When the articles were filtered for the availability of the full text of the article we were restricted to a total of 32 articles Figure 1.

## Prisma

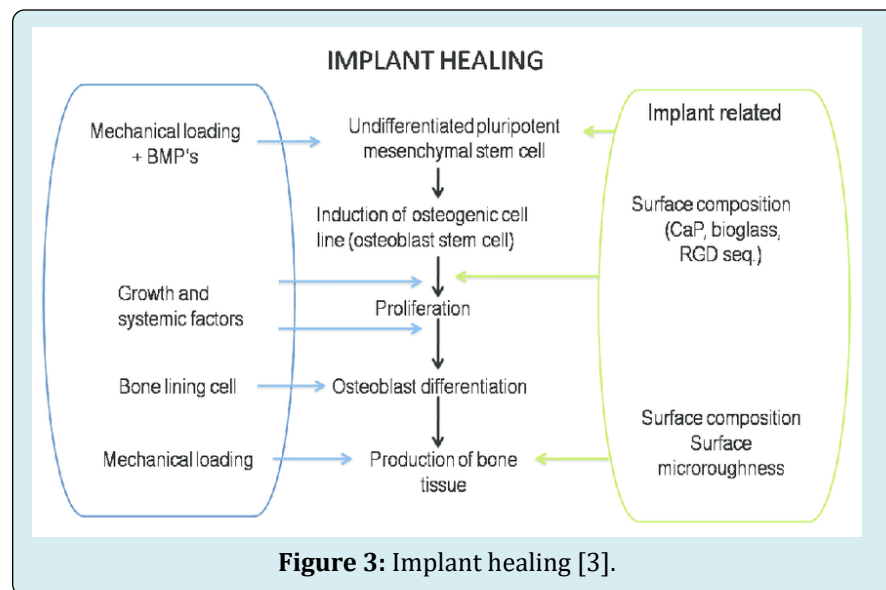
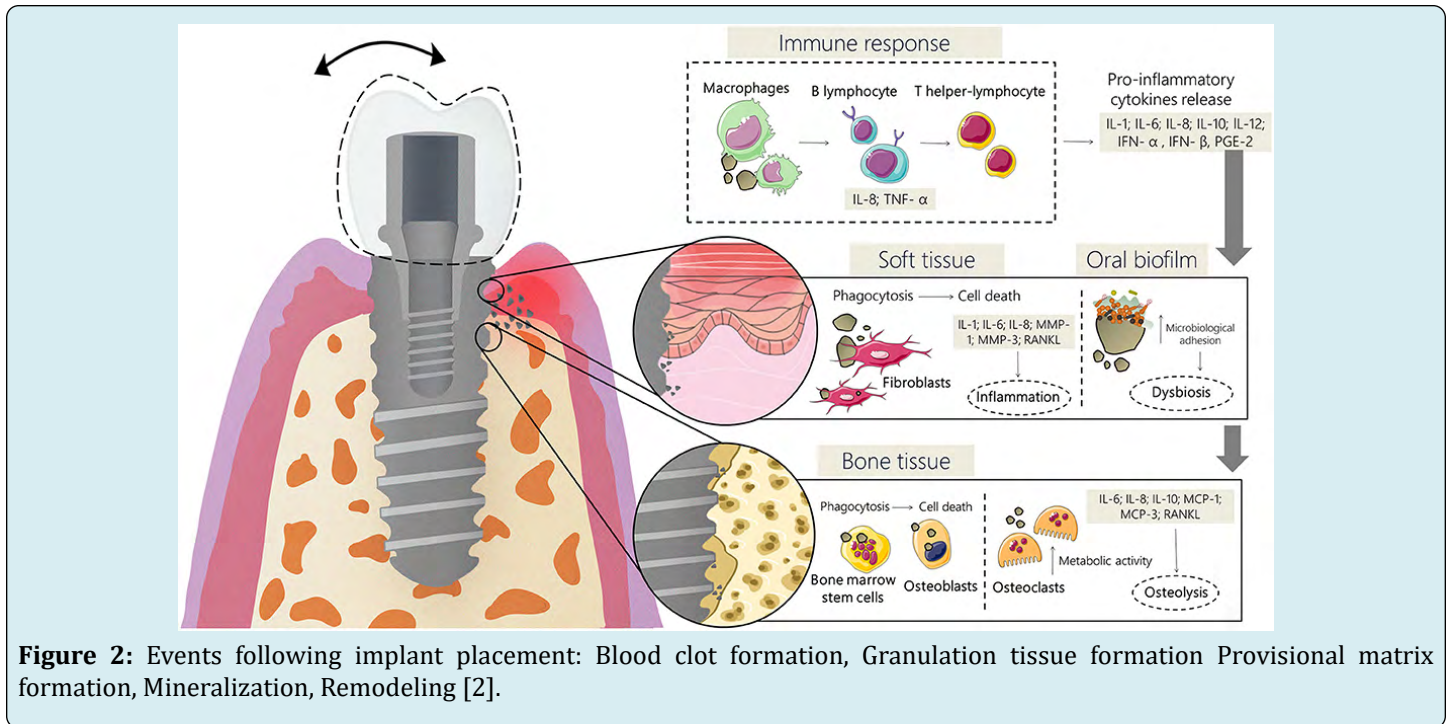


This article mainly focuses on the efficiency of osseointegration of surface-modified implants in the patients with at least edentulous spaces and receiving implants. This article evaluates if surface modification of implant surfaces helps in osseointegration better when compared to smooth or unmodified implant surfaces.

## Process of Osseointegration

The process of osseointegration is an extensive process initiated with the surgical insertion of an implant and extends

till it is unified in the underlying bone. The immediate steps after insertion include blood clot formation around the implant followed by absorption of the cells onto the implant surface. The cells on the implant surface will then form granulation tissue which later translates into a provisional matrix which forms a base for the cells to be embedded. These cells later initiate the mineralization phase which extends up to 6 months based on the systemic conditions of the recipient. During this phase, new bone formation and remodeling of the formed bone occur [1] (Figures 2 & 3).



Research revealed the importance of implant surface in the initial stages facilitating osseointegration. Several factors like charge, roughness, hydrophilicity, and surface characterizations have been identified to play a major role in enhancing cell adhesion to the implant surface [4].

Implants have been classified into 3 major categories based on the roughness of the surface.

- 1. Smooth:** These were the initial implants designed during the Brane mark period in implantology.
- 2. Moderately rough:** These were the second-generation implants and included moderately rough surfaces which

could enable optimal osseointegration.

- 3. Extremely rough:** These implants are designed using advanced technology like nano and have a bioactive surface. These are aimed to increase the osseointegration and hydrophilicity of the cells but high susceptibility to microbial growth has been documented through the cause is not completely claimed to be associated with the topography, the surgical procedure also needs to be accounted for [5].

The surface texture has been playing a major role in recent age implants. There are several techniques and procedures

to design and manipulate the topography of the Implant surface. The various types of the implant modifications are classified mainly into the following categories [6-13].

#### Additive Method

1. **Coatings**
  - a) Plasma spray,
  - b) Antibiotic coatings,
  - c) osteogenic agents like BMP, Growth factors
  - d) nano coatings.

#### Photo functionalization

##### Subtractive method

- a) Sandblasting
- b) Acid etching
- c) Laser Ablation

##### Both

1. Electrolytic addition/reduction

#### Additive Method

This includes enhancing the surface with substances that could help in osteointegration from a biological perspective or physical interlocking for initial stability.

- The addition of plasma spray and osteogenic agents involves adding a layer of plasma proteins obtained from centrifugation of blood leading to a prepared surface layer for better surface interaction for blood cells [13-16].
- The antibiotic coating is a preventive layer that aids in inhibiting bacterial growth in the early stages of implant placement hence promoting a healthy healing phase which is vital for implant success [17,18].
- Nano coating of implant surface results in providing a more hydrophilic surface which promotes cell adherence to implant surface after placement. Nano treatment of a surface can be tricky as it leaves a charged surface which can also work in an opposite way to the desired outcome [19-23].

#### Subtractive Method

This includes removing surface material from the implant surface to increase surface area to provide a greater area for the cells to interact with the implant body.

- a) Sandblasting includes subjecting the implant surface to gritting agents sprayed on to them at high speeds leading to the removal of fine particles. Commonly used abrasives can be alumina and titanium dioxide [24,25].
- b) Acid etching involves the chemical removal of substances with acids like hydrochloric acid, sulphuric acid, hydrofluoric acid, and nitric acid. This is mostly done to remove the surface impurities after sandblasting

process.

- c) Laser Ablation is a process of treating the surface with a high-intensity laser beam to augment the texture of the implant surface [26,27].

The electrolytic method includes addition or subtraction of the implant surface and selectively opting to place the implant at the cathodic or the anodic ends. This is technique sensitive procedure, and the material can be added or subtracted.

The success of the implants also depends on the shape of the design of the implant surface, Bone Implant contact, and hygiene habits of the recipient [28]. The surface with a high contact angle attracts fewer bacteria but it does not favor cell migration and adhesion to the surface of the implant. While there are also the darker sides associated with surface modifications like corrosion and modification of mechanical properties like friction due to biofilms. Also, there are higher chances of implant failure in extremely rough implant surfaces as they form lodging sites for bacterial growth [5,18,19,29-35].

#### Recent advances in Surface Modified Implants

- a) 3d printed implants using nanotechnology are a theoretical concept that aims at accommodating stem cells obtained from the recipient of implants and embedding osteoblasts and osteocytes on the implant surface in the slots allotted to them by the nano printer [36,37].
- b) Addition of functional groups on the surface of the implants can increase the surface wettability and increase the adhesion of stem cells to increase bone formation [38-40].

#### Conclusion

Modern implantology aims to provide good initial stability with great tissue integration and rapid bone healing. In the process of improving the implant success researchers have adapted several surface improvisations to improve the final outcomes. The clinicians need to select the implant surface modification based on the patient's requirements and health status.

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