



## Effect of Implant designing on Osseointegration: A review article

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### ABSTRACT

Since the founding of the osseointegration concept, the characteristics of the interface between bone and implant, and possible ways to improve it, have been of particular interest in dental and orthopaedic implant research. The main objective of the article is to assess the literature on the designing of dental implants framework and the variable of their designs are analysed in relation to their consequences in the process of osseointegration.<sup>1</sup>

**Keywords:** Dental implants, Implants designs, Implant surface, Osseointegration.

### I. INTRODUCTION

Tooth loss is a traumatic, even devastating, occurrence. Life's simple pleasures can cause problems and pain for the millions of adults who suffer from permanent tooth loss. The noticeable rise in patients' demands as regards quality of life and a good appearance makes it obligatory for the Prosthodontist to provide functionally, esthetically and physiologically optimal dental prosthesis.<sup>2</sup> Modern dentistry aims to restore the patients to normal contour, function, comfort, esthetics, speech and health regardless of the atrophy, disease or injury of the stomatognathic system.<sup>3,4</sup>

Preliminary implants with documented success were fabricated from noble metals or base metals shaped in either basic or pin designs that sought to create natural teeth which could then be connected to transmucosal prosthesis. Failure were believed to be caused either by poor biomechanics,

especially poor stabilization. These implants had limited success and mechanical and biological failures elicited dentists to create design that, in many instances, had no semblance to tooth morphology. The most successful designs of this type are staple, sub-periosteal, and blade form implants.<sup>5</sup>

### History

In the mid 1960's orthopedics research by Branemark demonstrated the phenomenon of osseointegration, whereby a biocompatible metal could be structurally integrated into living bone at a biochemical level.<sup>6,7</sup> The application of this theory to dental implants reduced the dependence on mechanical interlocking, and allowed the development of implant systems in a more versatile endosseous design.<sup>8</sup> Subsequently it was realized that little changes in shape, length, and width of endosseous implants could influence success rates, and implant manufacturers began providing implants in varying designs. The size and shape of implants have evolved to fit current surgical concepts and prosthetic design.<sup>6</sup> (**binon quintessence**) The external hexagonal design, admodum Branemark, originally intended as a coupling and rotational torque transfer mechanism, consequently evolved by necessity into a prosthetic indexing and anti-rotational mechanism. The expanded utilization of the hexagonal design resulted in a number of clinical complications. To mitigate these problems the external hexagonal, its transmucosal connections, and their retaking screws have undergone a number of modifications.



In 1992 English published an overview of the then available external hexagonal implants, all having the standard Branemark hex configuration.

### Mechanics of Implant Designing

Mechanics is the branch of science concerned with the behavior of physical bodies when subjected to forces or displacements, and the subsequent effects of the bodies on their environment. The interaction of the biologic system and its correlation to mechanics of the bone and the implant is termed as **Implant biomechanics**. The implant systems may vary on the design of the implant, the surface coating on the abutment. The design considerations that are of significance in dental implant mechanics include:

- A. Implant body considerations
- B. Crest module considerations
- C. Apical design considerations
- D. Abutment considerations
- E. Implant abutment considerations
- F. Surface modifications

### Bioengineering Of An Implant Design

When implants act as functionary unit for prosthesis, an elevated BRR is an ongoing response adjacent to many dental implants. A BRR higher than 500% per year in the bone immediately adjacent (within 5mm) to a V-shape threaded implant, but approximately 50% in the regions distant from the interface has been observed. These findings suggest the bone at the interface of the implants in their report is likely in the mild overload zone.

The implant had a BRR that ranged between 400% and 908% per year. The V-shaped thread of **Branemark** had a higher bone contact and reduced bone turnover rate (500%) compared with the reverse buttress thread shape with a reduced thread number (Steri-Oss implant with 680% BRR). Therefore the BRR reported is different in each of these three different designed implants.

The immensity of load may also affect the BRR at the implant interface. It is therefore hypothesized the phenomenon of the elevated BRR at the implant interface, compared with that found several millimeters away, may be used as an indication of increased biomechanical risk for the supporting implant-bone interface, as related or created by specific clinical conditions.

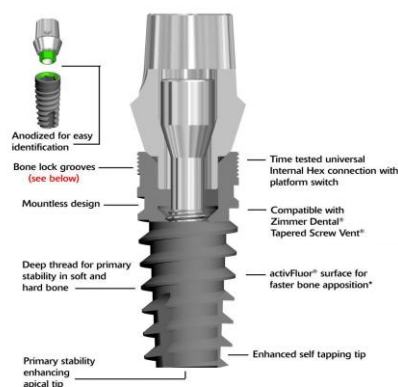


Fig 1: Implant designing for osseointegration

**Crest module consideration:** The crest module of an implant should be slightly larger than the outer thread diameter of the implant body. In this way, the crest module seals completely the osteotomy, providing a barrier and deterrent for the entry of bacteria or fibrous tissue during initial healing.

**Apical design considerations :** Root form implants are circular in the cross section. This permits a round drill to prepare a round hole, precisely fitting the body implant. An anti rotational feature is incorporated, usually in the apical region of implant body. The anti rotational features like a whole or vent being most common design. Theoretically, the bone can grow through the apical hole, and resist torsional loads applied to the implant.

**Abutment considerations:** Retention rapidly decreases with the increase in taper. Manufactured implant abutment for cement often exhibits a total taper of 25 degrees. The surface area of a crown or implant abutment influences the amount of retention. There is linear increase in retention as the diameter increases, for preparations with identical height.

A tall preparation offer greater retention than a short abutment. The additional height not only increases the surface area but also place more axial walls under tensile stress rather shear stress. Also height of preparation influences the amount of resistance. Manufactured implant abutments are often 5, 7 or 9mm in height. Some manufacturer supply 5 mm high abutment to save preparation time to the dentist. Anterior prosthesis often may require longer implant abutments to resist the arc of removal, or resist lateral force in the anterior regions of mouth.



**Surface modifications:** The methods employed for surface modifications of implants can be broadly classified into 3 types-mechanical; chemical; and physical. These different methods can be employed to change the implant surface chemistry, morphology, and structure. The main objective of these techniques 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. Examples of such implants are machined dental implants, Grit-blasted surface Etched surface dental implant, Sandblasted and acid-etched (SLA) implant, Plasma-spray coating implant.

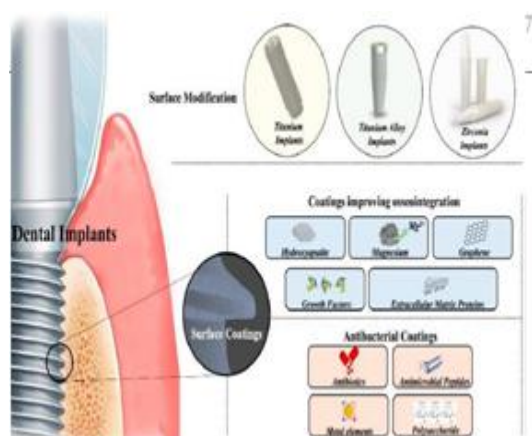


Fig 2: Effect of surface designing at implant bone interface.

### Biologically active drugs incorporated dental implants

Several attempts have been made to improve and accelerate osseointegration by modification of surface properties, such as introducing bioactive factors to titanium surfaces. Of these, some osteogenic drugs have been applied to implant surfaces. Incorporation of bone antiresorptive drugs, bone support.

**Bisphosphonates:** Bisphosphate-loaded implant surfaces have been reported to improve implant osseointegration

### **Implant design and implant failure**

#### **Surgical failure**

There are many reasons for the failure of an implant to integrate initially with the bone. The primary causes of failure relate to excessive heat production during the preparation of osteotomy or excessive pressure at the implant bone interface at

the time of implant insertion. An implant can fail immediately after the implant has integrated with the tissues. Before failure the implant appears to have rigid fixation, and all clinical indicators are within normal limits. However once the implant becomes loaded, the implant becomes mobile within 6 to 18 months. This is also called early loading failure by Misch and Jividen. The cause of this failure is usually excessive stress for the bone implant interface.

#### **Impact of occlusal overload on mechanical components**

Abutment screw loosening has been detected in an overall average of 6% of implant prosthesis. The greater the stress applied to the prosthesis (single tooth overdenture) the greater the risk of screw loosening. Cantilevers also increase the risk of screw loosening as they increase the forces in direct relationship to the length of the cantilever the greater the crown height attached to the abutment, the greater the risk of screw loosening. The height or depth of an anti rotational component of the implant body also can affect the amounts of force applied to the abutment screw.

## **II. DISCUSSION**

Dental implant treatment plans including biomechanics have been advocated by Misch to lessen the most common complications- those related to stress. The planning of the prosthesis is first made, including whether the restoration is fixed or removable, how many teeth are replaced, and the esthetic demands. The patient force factors are then considered to assess the magnitude and type of force applied to the restoration. The bone density is evaluated in the regions of the potential implant placement.

In accordance to the patient force factors and the bone density in the implant sites, implant positions and the implant number are selected e.g. when the patient has parafunction and the bone is less dense or when a cantilever is present, the greater force exerted on the implant abutments will transmit greater stresses to the implant bone interface. The next consideration is the Biomechanical load management is dependent on two factors: the nature of the applied force and the functional surface area over which the load is dissipated. The implant size directly affects the functional surface area that distributes a load transferred through the prosthesis.

## **III. CONCLUSION**

It is imperative that a greater understanding of the parameters that govern the long term success of implants to be developed.



The design of an 'optimal' implant requires the integration of material, physical, biologic, chemical, mechanical and economic factors. Implant success is primarily a function of biomaterials and biochemical factors.

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