Osseointegration: Its Mechanism and Recent Updates

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Commentary

A direct structural and functional link between organised, living bone and the surface of a load-bearing implant is referred to as osseointegration. It is necessary for implant stability and is a requirement for implant loading and long-term clinical success of end osseous dental implants [1].

Osseointegration mechanism

Once direct bone repair is triggered, osseointegration follows a common, biologically defined schedule.

Phase 1: Inflammatory
Phase 2: Proliferation
Phase 3: Maturation

Inflammatory phase: When platelets come into contact with synthetic surfaces during this phase, they produce platelet aggregation and thrombosis. When blood comes into contact with proteins or foreign material, the clotting cascade is triggered, causing blood to coagulate. Increased numbers of thymus-dependent lymphocytes (T cells), B cells, Killer (K) cells, Natural Killer (NK) cells, and macrophages produce a non-specific inflammatory response that becomes more particular in nature [2].

Proliferative phase: Neovascularization, or vascular ingrowth from the surrounding essential tissues, occurs during the proliferative phase. The local inflammatory cells' metabolism drives the differentiation of local mesenchymal cells into fibroblasts, osteoblasts, and chondroblasts. Immature connective tissue is produced, which matures into bone callus.

Maturation phase: Complete bone remodelling occurs after remodelling of the juvenile bone matrix with linked resorption and deposition of bone, leaving a zone of live lamellar bone that is continuous with the surrounding basal bone.

Factors influencing Osseointegration

The basis of a successful endosseous implant is osseointegration. The interface, the qualities of a surface that allow for biocompatibility, design characteristics, the status of the host bed, the surgical method, and the loading circumstances are all essential elements that impact the development and maintenance of bone at the implant surface [3].

Bone-Implant interface: Osseointegration is a remarkable process in which bone directly confronts the implant surface without any collagen or fibroblastic matrix in between. The quantity of bone around the implant surfaces may be related to the strength of the contact between bone and implant immediately after implant placement (0-12 weeks). Biophysical stimulation and the amount of time provided for healing are two more factors that may influence the interface's strength. According to studies, meaningful increases in bone implant interactions occur for at least three years [4].

Implant biocompatibility: Commercially pure titanium is widely used as an implant material because it is highly biocompatible, corrosion resistant, and non-toxic to macrophages or fibroblasts, has no inflammatory response in peri-implant tissues, and is composed of an oxide layer that can self-repair when damaged by reoxidation. Titanium -6 Aluminum-4 Vanadium (TI-6AL-4 V) alloy, another implant material, demonstrates soft tissue responses that are substantially comparable to those seen with cp Ti [5].

Surfaces used: Ti (Titanium) or Ti alloys when exposed to air or normal physiologic environments cause the formation of oxide layer. TiO2 is the most common oxide, and it protects against corrosion. The presence of calcium and phosphate ions in the oxide layers suggests that there is an active ion exchange at the bone implant interface.

Porous surfaces have also been demonstrated to improve ionic connections, establish a dual physical and chemical anchor system, and increase load bearing capacity. Porous surfaces can also improve tensile strength and healing rates by allowing bone to develop three-dimensionally. Plasma spraying is used to coat the majority of commercially available implants.

HA coatings having the benefit of increasing surface area, lowering corrosion rates, and speeding up bone production by allowing osteoblast differentiation to occur more quickly. Furthermore, HA coated implants are better able to bear stresses due to improved biomechanics. The better structured bone pattern and higher degree of mineralization at the contact, as well as enhanced bone penetration, are all benefits of HA (which improves fixation). The ability of HA to attach to bone makes it a very desired and arguably the most dependable surface available today.

Recent innovations

- Advanced computer assisted design/computer aided manufacturing software is used for computer aided radiography treatment planning and surgical guide production.
- Implant surfaces with hydrophilic characteristics that encourage new bone development (osteoconduction).
- The application of recombinant human growth factors to the implant surface or as part of the implant placement.
- Changes in surface chemistry to speed up bone development (fluoride modified titanium oxide surface).

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