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Review Article

An overview of dental implants biomaterials - A review

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ABSTRACT

Modern day dentistry mostly utilizes Implants as the treatment of choice for partially or completely edentulous arches. The Implant biomaterial should be selected to optimize biologic performance, and maintain adequate function. This article aims to review a variety of Implant Biomaterials and different surface characterization to enhance osseointegration.

1. Introduction

Implant Prosthodontics is the phase of Prosthodontics concerned with the replacement of the missing teeth and the associated structures attached to the implant. The goal of modern implantology is to restore the form, function, contour, esthetics, speech and health regardless of the extent of the injury. Hence, it is very much important to analyse each and every parameter of the implant which can ultimately lead to success. The longevity of the implants depends on biomaterials, biomechanics, biological tissues and body serviceability. Initially implants used of stone and ivory were reported in China and Egypt. In the 16th and 17th centuries gold and ivory dental implants were used.[1]

In the early 20th century, metal Implants of Gold, Lead, Iridium, Tantalum, stainless steel and cobalt alloy were used. Between these two periods a variety of polymers, have been used as dental implant. Newer materials like Zirconia, roxolid, surface modified titanium implants are used as they not only fulfill the functional requirements but are also esthetically pleasing. The terminology "osseointegration" and bone adaptation to a dental implant has been largely contested in the dental literature since Professor Branemark introduced it. In the current era, the term "fibro-osseous integration" describes the placement of a peri-implant ligament between bone and implant resulting in a substantial reduction in bone load. A biomaterial is also known as a biological material or synthetic material, which is used to reconstruct an aspect of a living form so that it can continue to interact with living tissues. The most important aspect of biocompatibility is the material used to make dental implants.[2,3]

2. Properties of Biomaterials Mechanical Properties[4–6]

1. Modulus of elasticity (E)-Ideally a biomaterial with elastic modulus comparable to bone (18GPa) should be selected. This will ensure more uniform distribution of stress at implant bone interface as under stress both of them will deform similarly. Hence the relative movement at implant bone interface is minimized. Compressive, shear strength to prevent fractures and

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Table 1: Classification of dental implant biomaterials

Based on biocompatibility	Based on Chemical Composition		
	Metals	**Ceramics**	**Polymers**
Bio-tolerant	Gold Cobalt-chromium alloys Stainless steel Zirconium Niobium Tantalum		Polyethylene Polyamide Polymethylmethacrylate Polytetrafluroethylene Polyurethane
Bio-inert	Commercially pure titanium Titanium alloy (Ti-6Al-4V)	Aluminum oxide Zirconium oxide Poly-ether-ether-ketone	
Bioactive		Hydroxyapatite Tricalcium phosphate Tetracalcium phosphate Calcium pyrophosphate Fluorapatite Brushite Carbon-silicon Bioglass	

improve functional stability.

2. Tensile, Compressive, Shear, Strength - An implant material should have high tensile, of implant material. Increased toughness prevents fracture of the implants.
3. Yield strength and Fatigue strength - An implant material should have high yield strength and fatigue strength to prevent brittle fracture under cyclic loading
4. Ductility -ADA demands a minimum ductility of 8% for dental implant. Required for fabrication of optimal implant configurations.
5. Hardness and Toughness - Increase hardness decreases the incidence of wear.
6. Electrical and Thermal conductivity- Should be minimum to prevent thermal expansion, contraction, and oral galvanism.
7. Surface tension and surface energy - Surface energy of > 40 dyne / cm. Surface tension of 40 dyne/cm or more.
8. Biocompatibility- Ability of a material to perform with an appropriate biological response in a specific application.

2.1. Chemical properties[6–8]

Corrosion is defined as loss of metallic ions from the surface of a metal to the surrounding environment.

Crevice corrosion - Occurs in narrow region e.g. implant screw – bone interface.

Pitting corrosion -Occurs in surface pit.

Metal ions dissolve and combine with Cl ions.

Galvanic corrosion- Occurs between two dissimilar metals in contact within an electrolyte resulting in current flow between the two.

Electrochemical corrosion- In this anodic oxidation and cathodic reduction takes place resulting in metal deterioration as well as charge transfer via electrons.

2.2. Different biomaterials

1. Titanium and Titanium alloys- Titanium is one of the most biocompatible material due to its excellent corrosion resistance, due to the formation of biologically inert layer.[9,10] It spontaneously forms tenacious surface oxide on exposure to the air or physiologic saline. There are four grades of Cp Ti. The mechanical differences that exist between the different grades of cpTi is primarily because of the contaminants that are present. Iron is added for corrosion resistance and aluminum is added for increased strength and decreased density, while vanadium acts as an aluminum scavenger to prevent corrosion. Good yield strength, tensile strength, fatigue strength, modulus of elasticity (110 GPa) which helps in uniform stress distribution.[10–13]
   Titanium alloys Ti6Al4V- Consists of - Titanium, 6% Aluminum which is an alpha stabilizer and 4% Vanadium which is a beta stabilizer. It exhibits excellent corrosion resistance, Oxide layer formed is resistant to charge transfer thus contributing to biocompatibility, and Modulus of elasticity is 5.6 times that of the bone, more uniform distribution of stress. Extensively used as implant material due to excellent biocompatibility, strength, osseointegration.[14]
2. Cobalt, Chromium, Molybdenum alloy – Vitallium was introduced in 1937 by Venable Strock and Beach. It is composed of 63% Cobalt, 30% Chromium and 5%

Molybdenum. It has high mechanical strength, good corrosion resistance, Low ductility, direct apposition of bone to implant though seen; it is interspersed with fibrous tissue Uses.[15,16]

Iron, Chromium, Nickel based alloy - These are surgical steel alloys or Austenitic steel. Have a long history of use as orthopedic and dental implant devices. It has high mechanical strength, high ductility and Pitting and crevice corrosion.[5]

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4. Precious metals- include Gold, Platinum, and Palladium. They are noble metals unaffected by air, moisture, heat and most solvents. Does not depend on surface oxides for their inertness and have Low mechanical strength and does not demonstrate osseointegration, hence not used.
5. Ceramics - Ceramics are inorganic, non metallic materials manufactured by compacting and sintering at elevated temperature. It Consists of- Bioinert ceramics which includes Aluminum oxide, Titanium oxide, Zirconium oxide; Bioactive ceramics which includes Calcium phosphate ceramics, hydroxyapatite, tricalcium phosphate. Bioinert ceramics are full oxides i.e. bulk and surface thus excellent bio compatibility. It has good mechanical strength, low ductility which results in brittleness and Color is similar to hard tissue. It is used as surface coatings over metals and to enhance their biocompatibility. Bioactive ceramics- CPC have biochemical composition similar to natural bone and forms direct chemical bonding with surrounding bone due to presence of free calcium and phosphate compounds as implant surface. Lower mechanical tensile and shear and fatigue strength. CPC show varied degree of resorption or solubility in physiologic fluids .The resorption depends on crystalline. Glass ceramics are bioactive ceramics. Silica based glass with additions of calcium and phosphate produced by controlled crystallization. It has high mechanical strength and less resistant to tensile and bending stresses. They chemically bond to the bone due to formation of calcium phosphate surface layer.[17]
6. Carbon and carbon silicon compounds - Vitreous Carbon and Carbon compounds were introduced in 1960 for use in implantology. They are Inert, biocompatible, have Modulus of elasticity close to that of bone and are susceptible to fracture under tensile stress.
7. Polymers- Polymeric implants were first introduced in 1930s. However they have not found extensive use in implant due to their Low mechanical strength and lack of osseointegration.[18,19][18]
8. Composites - Combination of polymer and other synthetic biomaterial. They have advantages that properties can be altered to suit clinical application.
9. Zirconia- It was used for dental prosthetic surgery with endosseous implants in early nineties. Monoclinic, cubic and tetragonal are the three crystal forms in which polymorphic Zirconia structure is present. Zirconia, on room temperature, acquires a monoclinic structure and changes into tetragonal phase at 1170 °C, followed by a cubic phase at 2370 °C.[19,20]

3. Implant Surface Characterization

Implant surface characterization helps to increase the interaction between the host tissue and the implant. The following techniques can be used to increase the characterization.[21,22]

Sandblasting- Small grits in chosen shape and size are forced across implant surfaces by compressed air that creates a crater. The blasting media can be Alumina oxide or titanium oxide. Sandblasting has been shown to allow the adhesion, proliferation and differentiation of osteoblasts.

Acid etching- Immersing Implants in strong acids (e.g., nitric acid, hydrochloric acid, hydrofluoric acid, sulfuric acid and their mixtures) for a given period of time, creates a micro- roughness of 0.5–3 μm.

Sand blasted and acid etched surface (SLA) - SLA combines sandblasting and acid-etching.

Anodized surfaces- The oxidation process has been used in dental implants to change the characteristics of the oxide layer and consequently to improve the biocompatibility of the surface.

Surface coatings- Implant surface may be covered with porous coatings which increases the surface area and roughness, attachment strength at bone implant interface and Biocompatibility. Several coating techniques exist. Two types – Plasma sprayed titanium and Plasma sprayed hydroxyapatite. Thickness of coating should be 0.04 to 0.05 mm. Increases the surface area by 600%. The particles melt and are sprayed on to the substrate. HA coated implants can be used in D3 and D4 bone which show poor bone density and structure as they increase bone contact levels, forms stronger bone implant interface, produces faster healing and greater initial stability.

4. Conclusion

Different varieties of implant biomaterials are available. The success and longevity of the implants depends on the appropriate selection of biomaterials. Thus it is very important to have an adequate knowledge of various materials and their properties which will render patient with a successful treatment.

5. Conflict of Interest

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