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Biomaterials as a Pillar of Implants

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Abstract:- The demand for dental implant has been increased and the material used for dental implant should be biocompatible. The success of implants depends upon the selection of biomaterials used in implants. The biologic environment denies accepting any materials completely. In order to overcome this implants should be selected.

Keywords:- *Biomaterials, Biocompatibility, Oral implants, Titanium, Zirconia, Ceramics, Polymers.*

I. INTRODUCTION

The study of biomaterial is called biomaterial science which encompasses elements of biology, chemistry, medicine, tissue engineering and material science. Biomaterial plays a major role in medical applications having benign function which includes procedures used in heart valve (bioactive), hydroxyl - apatite coated hip implants, dental applications, and surgery and drug delivery [1].

The aim of modern dentistry is to re-establish patient's normal function, health, speech, aesthetics regardless to atrophy, injury, diseases. Now-a day's Removable partial dentures became less acceptable by many patients and many oppose fixed partial dentures. Comparing with various dental materials, implants have higher success rate.). Ideal implants should be biocompatible, have adequate toughness, strength, wear, corrosion, fracture resistance.

The clinical outcome and prognosis of implants depends on physical and chemical properties of materials used which includes microstructure of implants, surface composition and characteristics and design factors. Osseointegration plays an important role in implant. Shape and surface area decides short and long-term success of implants [2].

II. HISTORY OF IMPLANTS AND THEIR USE IN DENTISTRY

Before the Common Era 16th &17th centuries, Archaeological records from China and Egypt shows evidence of golden ivory dental implants root replacement by allogenic tooth transplantation (17th cent England and France). Titanium blade implants were introduced in 1960s but success was short lived. 1952, Per-Ingvar Branemark uses a rabbit bone to know about the blood flow using titanium implant chamber. After sometime he tried to remove the titanium chambers from the bone and he came with the conclusion that the bone had integrated completely with the implant and the chamber could not be removed by him. He discovered "OSSEOINTEGRATION" and saw the chance for human use. Early 1980s osseointegrated implants became the accepted mode of therapy. The surgical goal is the placement of the implant in the available bone. Prosthetic positioning was not critical often edentulous patients. ALBREKTSSON 1986, at that time only 2 implant system that met criteria: a) Branemark osseointegrated screw, b) small transosteal staple. Acceptable long term results >10yrs. Success outcome dependent on: biocompatibility of implant material, macroscopic and microscopic nature of implant surface, status of the implant bed in both a health and morphologic content, technique, undisturbed healing phase, prosthetic design and long-term loading phase. Osseointegration is a histological definition, only partially a clinical and radiographic one (mobility and bone response can only be evaluated over time). Conventional gingival indices are not included in implant success. Surgical skill should be matched by the prosthodontic skills equals common denominator for any implant system.

III. CLASSIFICATION OF BIOMATERIALS USED IN IMPLANTS:

BIODYNAMIC ACTIVITY		CHEMICAL COMPOSITION	
	METALS	**CERAMICS**	**POLYMERS**
Bio tolerant	Gold		Polyethylene
	Co-Cr alloys		Polyamide
	Stainless steel		polymethylmethacrylate
	Niobium		Polytetrafluoroethylene
	Tantalum		Polyurethane
Bio inert	Commercially pure titanium	Al oxide	
	Titanium alloy(Ti-6AL-4U)	Zirconium oxide	
Bioactive		Hydroxyapatite	
		Tricalcium phosphate	
		Bio glass	
		Carbon silicon	

Table 1:- (Classification of biomaterials in implants [3, 6])

IV. PROPERTIES OF IMPLANT BIOMATERIAL [5, 10, 11, 12]:

- *Modulus of Elasticity:*

It is the measure of change in dimension (strain) with respect to stress. Ideally a biomaterial with elastic modulus comparable to bone (18GPa) should be selected which minimizes the relative movement at implant bone interface by uniforming distribution of stress.

- *Tensile, Compressive, Shear Strength:*

To improve functional stability and prevent fractures the tensile, compressive and shear strength should be more.

- *Yield Strength and Fatigue Strength:*

Yield strength of implant should be more to minimize permanent deformation. To prevent implant material fractures under cyclic loading the fatigue strength should be high.

- *Ductility:*

It refers to ability of a material to ruin artificially under a tensile stress before it fractures. A minimum ductility should be 8% for dental implant.

- *Hardness and Toughness:*

Increased hardness provides resistance to permanent surface indentation or penetration. Fracture of the implants are prevented by increasing toughness.

- *Surface Tension and Surface Energy:*

Surface energy of >40 dyne/cm and surface tension of >40dyne/cm results in good tissue integration and load carrying capacity with very clean surface.

- *Biocompatibility:*

It is the ability of implant to perform biologic response. It depends on corrosion resistance and cytotoxicity of corrosion products.

- *Corrosion Resistance:*

Corrosion is disintegration of a material caused by its reaction with its environment. Cervical corrosion occurs in narrow region, pitting corrosion occurs in surface pit and galvanism occurs between two dissimilar metals.

- *Electrochemical Corrosion:*

Metal failure may occur as a result of anionic oxidation and cathodic reduction and also causes charge transfer through electrons. These can be avoided by presence of oxide layer in the surface of metal.

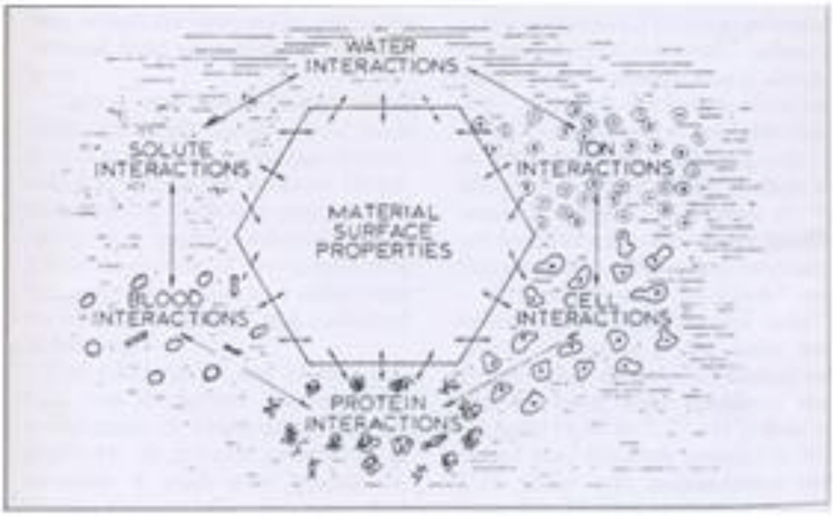

Fig 1:- Factors Affecting Biomaterials

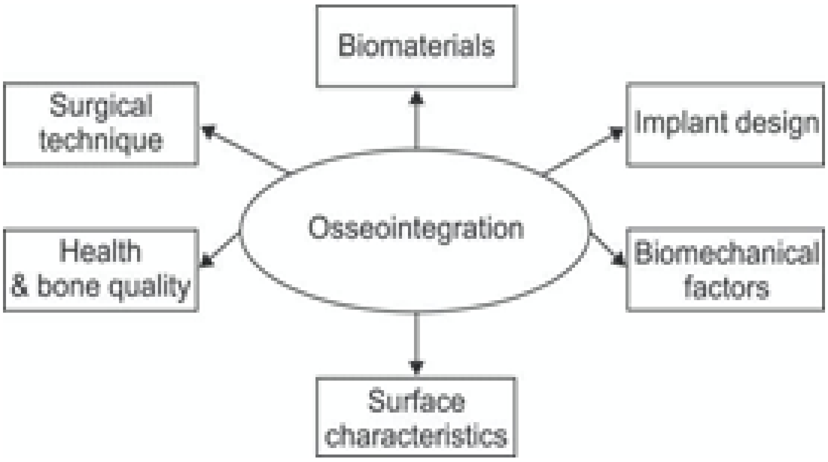

Fig 2:-Factors Affecting Osseo integration

V. MATERIALS

A. Metals and Alloys

Metals or alloys can be used for the making of dental implants. The non metallic implants such as oxidic, carbonitic, or graphitic oxide like materials are commonly used. The implants used in dentistry consists of titanium and alloys, cobalt chromium alloys, austenitic Fe-Cr-Ni-Mo steels, tantalum, niobium and zirconium alloys, precious metals, ceramics, and polymeric materials [13].

➢ *Titanium And Titanium-6 Aiuminium-4 Vanadium (Ti-6al-4v)*

Titanium gets oxidizes in room temperature. Both et al. made a study to know the action of rabbit bone to 54 various metals and alloys used in implants. His study showed that titanium allows the bone to grow adjacent to the oxide surfaces and showed that titanium allowed bone growth near the oxide surfaces. Beder et al, Gross et al, Clarke et al, and brettle give evidence for these materials. The strength values of compact bone are approximately 1.5 times lesser than the strength values for the wrought soft and ductile metals. The modulus of elasticity of titanium is greater than compact bone, and this property is important for proper distribution of mechanical stress. Titanium, aluminium vanadium are most commonly used titanium. The wrought alloys are stronger than compact bone. It gives more chances for designs with thinner sections. The modulus of elasticity of the alloy is 5.6 times greater than that of titanium and compact bone. They form 100% Titania. Mechanically, titanium has higher ductility than titanium alloys. The reuse of implant is strictly prohibited because when an abutment of implant is twisted or misshaped during implantation, local strain may occur at neck of implant which is both cumulative and deformative. Sometimes mechanical processes may contaminate the surface of implant [13].

➢ *Cobalt –Chromium-Molybdenum Based Alloys:*

The cobalt based alloys are most often used in a cast or cast-and annealed metallurgic condition. Cobalt based alloys helps in custom fabrication of framework. The alloy includes cobalt, chromium, and molybdenum as the major elements. Strength and surface abrasion resistance is based on cobalt, chromium, molybdenum, nickel, and carbon. Corrosion resistance is provided by both chromium and molybdenum. The cobalt based alloys are least ductile and exhibits excellent biocompatibility profile in surgical implants. Nickel is used in biocorrosion products, and carbon is used to maintain mechanical properties such as ductility [13].

➢ *Iron-Chromium-Nickel-Based Alloys:*

The surgical stainless steel alloys are used in making of orthopedic and dental implant devices. Similar to titanium, this is used in a wrought and heat-treated metallurgic condition, having high strength and high ductility alloy. Iron based alloys are used for the fabrication of ramus blade and frames and in pins used for stabilization. This alloy is contraindicated to patients allergic to nickel as nickel is major element in this alloy. Due to its galvanic and corrosion property it shows concern about galvanic coupling and bio corrosion [13].

➢ *Other Metals And Alloys:*

The other metals are tantalum, iridium, gold, palladium, zirconium, hafnium, tungsten. Platinum and palladium are poorly used in implant because of its low strength. Due to its nobility and availability gold based alloys are used in surgical implant materials. [13]. Ex. bosker endosteal staple.

B. Ceramics and Carbon:

Ceramics are inorganic, non-metallic, nonpolymetric materials. Because of their inertness to biodegradation, high strength, physical characteristics oxide ceramics were introduced for surgical implant. Ceramics have been used as coatings on implants [13].

➢ *Aluminium, Titanium, And Zirconium Oxide:*

Aluminium, titanium, and zirconium oxides having high strength are used as root form, endosteal plate form, and pin type in dental implants. The compressive, tensile, and bending strength are more than the strength of compact bone. The aluminium, titanium, and zirconium oxide ceramics are clear, white, cream, or light grey colour, which make them to be used as anterior root form devices. Minimum of thermal, electrical conductivity, biodegradation, and minimum reactions with bone, soft tissue, and the oral environment are identified as beneficial when compared with other biomaterials. Ceramics are chemically inert. Sterilization can decrease strength for some ceramics [13].

➢ *Carbon And Carbon Silicon Compound:*

Chemical inertness and lack of ductility makes carbon compounds to be grouped under ceramics. Ceramics and carbonitic substances are used as coating. Biodegradation initiates tissue stability, resistance minimum to scratching related to oral hygiene procedure [13].

C. Polymers and Composites:

The synthetic polymers and composites are used as biomaterial application [13].

➢ *Polymers:*

Inactive polymers include polytetrafluoroethylene (PTFE), polyethylene terephthalate (PET), polymethylmethacrylate (PMMA), ultrahigh-molecular weight polyethylene (UHMW-PE), polydimethylsiloxane (PDS, or silicone rubber [SR]), polypropylene (PP), and polysulfone (PSF). The polymers have reduced strength, modulus of elasticity and greater elongations to fracture compared with other classes of biomaterials. Elasticity of polymers is similar to that of soft tissues. For tissue attachment, replacements and coatings, polymers have been fabricated in porous and solid forms. Major uses are internal force distribution for osteointegrated implants [13].

➢ *Composites:*

Polymers and composites of polymers are not suitable for sterilization and handling techniques. When exposed to semi clean surrounding most polymeric biomaterials gather dust or other particle and cleaning of it may requires a laboratory. Composite have extended period of experience and higher quality of biocompatibility profiles [13].

VI. CONCLUSION

Now a days implant has been most commonly used and it gives life for patients with tooth loss. It replaces many treatments which is done earlier. Titanium was most commonly used before the introduction of Zirconia implants. Implant is now considered as a first treatment option.

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