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A REVIEW ON USAGE OF COMPOSITE MATERIAL IN ORTHOPAEDIC IMPLANTS

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ABSTRACT

In the field of Orthopaedics, Bone repair and regeneration along with Joint stabilization are the significant aspects which includes usage of implants in almost all the cases. For an implant to be considered as ideal it should mimic the mechanical properties along with required dimensions of the original bone, It need not mimic the composition of the bone. An implant should be chemically stable and it shouldn't cause any auto immune reactions in the body. Looking around the world we can see the usage of materials like Titanium and Ceramic most commonly in the implants which can be replaced by composite materials in which two or more materials are combined to obtain desired mechanical and chemical properties. Commonly used materials in this aspect are Stainless Steel, Cobalt-chromium alloys, Polyethylene, poly methyl methacrylate bone cement. Review on this material usage, its pros and cons will be discussed along with their properties further.

KEYWORDS

Orthopaedic Implants, Ceramic, Titanium, Stainless steel, Composite material, Materials, Chemical stability.

INTRODUCTION

Throughout the world it has been observed that millions of people are being affected by bone and joint inflammatory or degenerative diseases which are making their daily life activities difficult. In these cases many of the doctors suggest surgery or bone and joint replacement which includes orthopaedic implants. These devices are meant to be

biodegradable and are expected to serve the biological functions either by substituting or repairing the bone or cartilage or ligament. In past only a particular metal was being used as an orthopaedic implant but as the society keeps on developing, the medical field is also being improved. Metals and alloys are being used as first choice for composition of implants to avoid risk of rejection and because of the superior strength and biological inertness of the materials. Now-a-days research is being done on producing a compatible material which has ideal mechanical and biological properties as a substitution of bone or a joint. The elastic modulus, tensile strength, and the compressive strength of the implant should be studied properly and the material being used for an implant should be such that shaping or cutting of the implant should be easy even during the surgery.

THE BASIC REQUIREMENTS OF THE ORTHOPAEDIC IMPLANTS :

As the main priority it should not be rejected by the body and should be inert in body. It should not obstruct any biological function instead should provide function of which it is acting as a replacement. It should help in bone or joint healing. It need not mimic the bone or joint composition but it should full fill all the mechanical properties of the bone or joint. It shouldn't break on daily life force application like bending, twisting, and shearing stress. It shouldn't get corrosive in further life period. It shouldn't break into small pieces which may effect the body immune system. As it is known bone tissue is anisotropic hence the implant is expected to be anisotropic in nature thus exhibiting needed mechanical properties depending upon the direction of the force applied.

To obtain the bio inertness of the implants, the biomaterials are being used through 60years which can be grouped into three generations. First generation involves bio inert material, Second generation involves bioactive or biodegradable materials then further Third generation involves implanted material which is used to trigger molecular responses such that to increase the rate of healing process.

SPECIFIC MATERIALS USED IN ORTHOPAEDIC IMPLANTS:

STAINLESS STEEL:

It provides high elastic modulus which is reasonable for construct rigidity which helps in stabilizing the bone fixation.

Mostly used alloy is called 316L which is a combination of iron, Nickel, Molybdenum. It is used as plates, screws , flexible nails and sliding hip screws. But this material has its own cons due to the usage of Nickel in it which mostly produces allergic reactions in human body.

COBAL CHROME:

It is used in arthroplasty surgeries. It has high modulus of elasticity and low ductility thus providing a wide range of applications. It also posses high polishable surface and has low rate of modifications in intra operative sessions.

It is biologically inactive in bulk but it also contains Nickel which leads to hyper sensitive reactions in our body. As it is mostly used in intra-articular settings it produces micro particles which leads bone deformation and immune reactions.

POLYETHYLENE:

It is also widely used in arthroplasty mainly used as joint surface. Researchers have been trying to improve the mechanical and biological properties of the material due to the eventual failure of the bearings. It is proven to be mostly biologically inactive but it produces debris resulting in bone deformation.

It produces several infections in case of prosthetic joints which can be rectified by infusing Vitamin E in this implants which can act as a scavenger picking up the free radicals. It has also proven the longevity of the bearings.

CERAMICS:

It is inorganic and semi or non metallic depending on the compositions of the compounds used. It is good electric and thermal insulator. And is lighter then many metals.

It is used in hip replacements and arthroplasty. It is biologically inert and produces low debris . It has smooth surface thus favourable adhesive characteristics. It is most widely used orthopaedic implant.

In total hip replacement it produces squeak sound during ambulation. It is brittle and has chances of shattering in vivo.

In hard tissue replacements the materials generally used are polyester fibres or calcium sulphate along with the woven cotton fibre. These mainly help in ventilation of the human skin to avoid breaking in case of casts. In case of internal fixation these materials are used to make screws, plates, pins which will hold the bone or join together.

In knee replacements ultra high molecular weight polyethylene is used improves the stiffness and resistance due to its elastic modulus which sustains the mechanical reliability even during deformation of the bone.

In dental field these materials are used to make the surgery less traumatic and the main focus is on incorporation of ceramic microwires of aluminium oxide with poly methyl methacrylate.

Now the main focus of research is on development of the porous composite materials to use in tissue engineering applications. These porous materials are being developed in such a way to improve the compressive strength, volume fraction, size and shape of the bone.

APPLICATION IN WHICH COMPOSITE MATERIAL IS USED AS ORTHOPAEDIC IMPLANTS:

It is used in skull reconstruction, total hip or knee joint replacements, bone fracture repair, fixation of bone, dental applications and soft tissue replacements. Defective bones are repaired by allografting, autografting and bone marrow replacement. These materials are not only used in bone and joint repair but also to used for repairing muscles using electro active polymers.

Biomimetic sensors field is not yet developed by there is a scope of development in this field using composite materials which can be used as artificial ventricular muscles, artificial smooth muscles, correction of human refractive index of eye and correct the flexibility of the muscles or bones.

CONCULSION:

The usage of composite materials instead of a direct element in bone fixature really helps in increasing the rate of healing and daily biological functions of the human. In general a particular material only consists of a particular property thus when two or more materials which have desirable properties are combined to create a proper material which can provide an accurate implant. The properties like elastic modulus, resistance of bone or joint, rigidity, inert-ness, corrosive nature can be modified as needed.

It can be helped in cases in which the patient is particularly sensitive to some metals. Composites are being widely used in the field of orthopaedics to provide better lifestyle for the patient. More specifically advances can be seen in case of dentistry and lower limb prostheses which provides specific strength characteristics and biocompatibility.

In this field of medicine we can observe a vast development meeting the demands of the patients. Further there is focus of development of the upper limb prostheses which provides sensory feedback systems and natural response to the stimuli.

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