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REVIEW OF BIOMATERIAL

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ABSTRACT
Biomaterials are in the form of implants like sutures, bone plates, joint replacementsas well asmedical devices like pacemakers, artificial hearts, blood tubes are widely used to replace and/or restore the function of traumatized or degenerated tissues or organs, and thus improve the quality of life of the patients. The first and foremost requirement for the choice of biomaterial is its acceptability by the human body. A biomaterial used for implant should possess some important properties in order to long-term usage in the body without reaction. The most common classes of biomaterials used as biomedical material like metals, Polymers, ceramics and composites. These four classes are used singly and in combination to form most of the implantation devices available today. This review will be of value to researchers who are interested in the state of the art of biomaterial evaluation and selection of biomaterials.

INTRODUCTION
Biomaterial is any matter, surface, construct that interact with living systems. The study of bio-material is defined as bio-material engineering. It has experienced steady and strong growth over its history with many companies investing large amounts of money into the development of new products. Biomaterials can be derived either from nature as well as synthesized in the laboratory using a variety of chemical approaches, utilizing metallic components ceramics or composite materials. They are often used and/or adapted for a medical application, and thus comprise whole or part of a living structure or biomedical device which performs, augments, or replaces a natural function. This function may be used for a heart valve or bioactive with a more interactive functionality such as hydroxy-apatite coated hip implants. Biomaterials are also used every day in dental applications, surgery, and drug delivery.

1.1: USE OF BIOMATERIALS:
The primary reason that biomaterials are used is to physically replace hard or soft tissues that become damaged or destroyed by some pathological process. Though the tissues and structures of the body perform for an extended period of time in most people suffer from a variety of destructive processes including fracture, infection and cancer that cause pain, disfigurement as well as loss of functioning. Under these circumstances, it is possible to remove the diseased tissue and replace it with some suitable synthetic material.

CLASSIFICATION OF BIOMATERIALS:
2.1: BY SOURCE:
2.1.1: NATURAL
AUTOGRAFT: autologous (or autogenous): bone obtained from the same individual receiving the graft.
ALLOGRAFT: harvested from an individual other than the one receiving the graft.
XENOGRAFTS: origin from a species other than human (e.g. bovine, wood)
2.2.2: SYNTHETIC.
2.2: BY BIOLOGICAL ROLE:
BIOINERT: does not interact with the body.**bioactive:** actively participate in tissue re- pair.
BIORESORBABLE: resorb and provide element for the tissue repair.
2.3: BY COMPOSITION:
Metals & alloys.
Polymers.
Ceramic, glass, glass-ceramic.
Natural materials (from plant and animal).
2.4: BY STRUCTURE:
Bulk.
Stems, plates, screws, pins.
Coatings.
Protective.
bioactive (HA, BAG).

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Porous.
Porous metallic surface layer.
Scaffolds for tissue engineering.

PROPERTIES OF BIOMATERIAL

1. **TOXICOLOGY:** Biomaterial should not be toxic unless it is specifically engineered for such requirements (for example a "smart bomb" drug delivery system that targets cancer cells and destroy them).

2. **BIOCOMPATIBILITY:** It is the ability of a material to perform with an appropriate host responsein a specific application.

3. **FUNCTIONAL TISSUE STRUCTURE AND PATHOBIOLOGY:** Biomaterials incorporated into medical devices is implanted into tissues and organs, therefore key principles governing the structure of normal and biomaterial should not give off anything from itsmass unless it is specifically designed to do so.

4. **HEALING:** Special processes are invoked when a material or device heals in the body. Injury to tissue will be stimulating well-defined the inflammatory reaction sequences that leads to healing. When a foreign body is present in the wound site, the reaction sequence is referred to as the "foreign body reaction".

5. **MECHANICAL AND PERFORMANCE REQUIREMENTS:** Biomaterials and devices are having mechanical and performance requirement that originate from the physical properties of the materials. The following are three categories of such requirements: 1.Performance 2. Durability and 3.Physical Properties.

DIFFERENT APPLICATIONS OF BIOMATERIAL

4.1: METALS: As a class of materials, metals arethe most widely used for load-bearing implants. For instance, some of the most common orthopedic surgeries involve the implantation of metallic implants. These range from simple wires and screws to fracture fixation plates and total joint prostheses (artificial joints) for hips, knees, shoulders, ankles, and so on. In addition to orthopedics, metallic implants are used in maxillofacial surgery cardiovascular surgery and as dental materials. Many metals and alloys are used for medical device applications. The most commonly employed stainless steels, commercially pure titanium and titanium alloys and cobalt-base alloys.

Table 1.1: Metallic Biomaterial

Metals	Applications
Stainless Steel	Surgical instruments, fracture fixation, stents etc.
Co-Cr-Mo	Bone and joint replacement, heart valves, dental implants.
Ti and its alloy	Bone plates, orthodontic wire
Gold alloy	Dental restoration.
Silver products	Antibacterial agents.

4.2: TITANIUM AND ITS ALLOY: Titanium and its alloys are getting great attention in both medical anddental fields because of:
(a) Excellent biocompatibility;
(b) Light weight;
(c) Excellent balance of mechanical properties;
(d) Excellent corrosion resistance.
They are commonly used for implant devices replacing failed hard tissue like (1) artificial hip joints (2) artificial knee joint (3) bone plate (4) dental implants (5) dental products such as crowns bridges and dentures and (6) used to fix soft tissue, such as blood vessels. In the elemental form, titanium has a high melting point (1668^{0}C) and possesses a hexagonal closely packed structure (HCP) up to a temperature 882.5^{0}C. Titanium transforms into a body centered cubic structure (bcc) above this temperature.

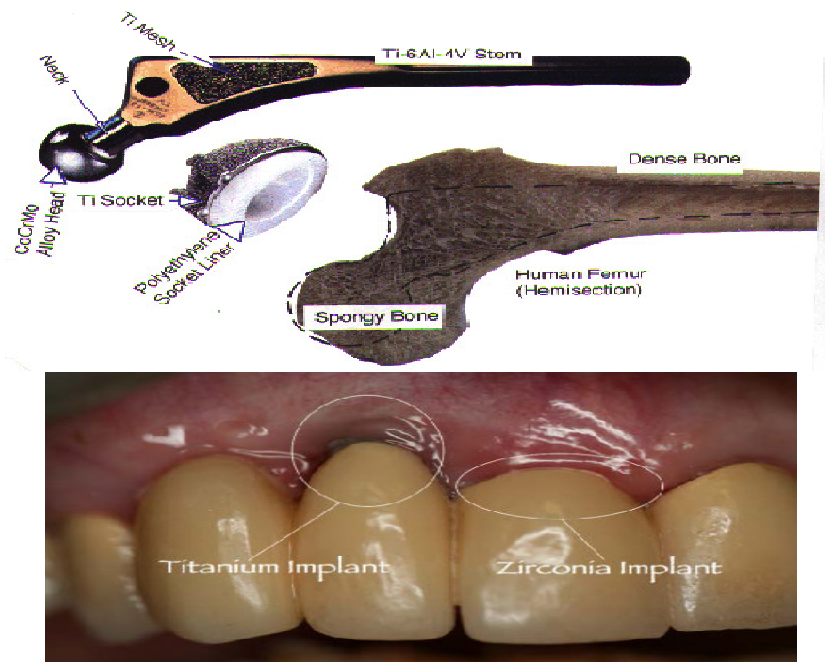

Figure 4.1: Titanium alloy used for dental surgery.

4.3: STAINLESS STEEL: Stainless steel was first used successfully as an important material in thesurgical field.
I- Type 302: stainless steel was introduced, which is stronger and more resistant to corrosion than the vanadium steel.
II-Type316: stainless steel was introduced, which contains a small percentage of molybdenum (18-8sMo) to improve the corrosion resistance in chloride solution (salt water).
III- Type 316L: stainless steel.
The carbon content was reduced from 0.08 to a maximum amount of 0.03% for better corrosion resistance to chloride solution. The inclusion of molybdenum enhances resistance to pitting corrosion in salt water. Even the 316L stainless steels may corrode in the body under certain circumstances in highly stressed and oxygen depleted region, such as the contacts under the screws of the bone fracture plate. Thus, these stainless steels are suitable to use only in temporary implant devices, such as fracture plates, screws, and hip nails.

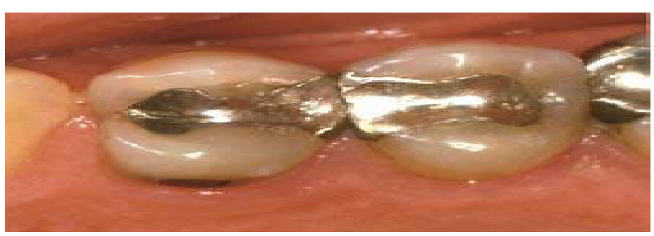

Figure 4.2: Stainless steel as a biomaterial

4.4: CO-CR ALLOYS:
There are basically two types of cobalt-chromium alloys:
1- The CoCrMo alloy [Cr (27-30%), Mo (5-7%), Ni (2.5%)] has been used for many decades in dentistry, and in making artificial joints.
2- The CoNiCrMo alloy [Cr (19-21%), Ni (33-37%), and Mo (9-11%)] has been used for making the stems of prostheses for heavily loaded joints, such as knee and hip.
The ASTM lists four types of CoCr alloys, which are recommend for surgical implant applications: There are two basicelements of the Co-Cr alloys form a solid solution of 65% Co. The molybdenum is added to produce finer

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grains, which result in higher strength after casting. The chromium enhances corrosion resistance, as well as solid solution strengthening of the alloy. CoNiCrMo alloy contains approximately 35% Co and Ni each. These alloys are highly corrosion resistant to seawater (containing chloride ions) under stress.

POLYMERS

There are a large number of polymeric materials that have been used as implants orpart of implant systems. The polymeric system includes acrylics, polyamides, polyesters, polyethylene, polysiloxanes, polyurethane, and a number of reprocessed biological materials. Some of the applications include the use of membrane of ethylene-vinyl-acetate (EVA) copolymer for controlled release and the use of poly-glycolic acid for use as a resorbable suture material. Some other typical biomedical polymeric materials applications include: artificial heart, kidney, liver, pancreas, bladder, bone cement, catheters, contact lenses, cornea and eye-lens replacements, external and internal ear repairs, heart valves, cardiac assist devices, implantable pumps, joint replacements, pacemaker, encapsulations, soft-tissue replacement, artificial blood vessels, artificial skin, and sutures.

Table:5.1:Polymer and its Biomaterial applications.

Polymer	**Application**
Polyethylene	Knee, hip,shoulder joints
Silicone	Finger joints
Acrylic, nylon	sutures
Acetal, polyethylene, polyurethane	Heart pacemaker
Polyester,PTFE,PVC	Blood vessels
Polydimethyl siloxane	Facial prosthesis
Polymethyl methacrylate	Bone cement

5.1:TOTAL HIP REPLACEMENT: Total joint replacement is widely regarded as the major achievement in orthopedic surgery in the 20th century. Arthroplasty, or the creation of a new joint, is the name given to the surgical treatment of degenerate joints aimed at the relief of pain and the restoration of movement. This has been achieved by excision, interposition, and replacementArthroplasty and bytechniques that have been developed over approximately 180 years.

5.2:KNEE IMPLANTS: In total knee arthroplasty (TKA), the diseased cartilage surfaces of the lower femur (thighbone), the tibia (shinbone), and the patella (kneecap) are replaced by a prosthesis made of metal alloys and polymeric materials. Most of the other structures of the knee, such as the connecting ligaments, remain intact.

5.3:SILICONES: The most significant orthopedic applications of silicones are the hand and foot joint implants. The properties of silicone elastomer have also found application in numerous catherters,shunts, and drains. Many other groups like Phenyl, vinyl, trifluro-propyl can be substituted for the methyl groups along the chain.

COMPOSITE MATERIAL

Composite materials have been extensively used in dentistry and prosthesis designersare nowincorporating these materials into other applications. Typically, a matrix ofultrahigh-molecular-weight polyethylene (UHMWPE) is reinforced with carbon fibers.These carbon fibers are made by pyrolizing acrylic fibers to obtain oriented graphiticstructure of high tensile strength and high modulus of elasticity. The carbon fibers are 6-15mm in diameter, and they are randomly oriented in the matrix. In order for the highmodulus property of the reinforcing fibers to strengthen the matrix, a sufficient interfacialbond between the fiber and matrix must be achieved during the manufacturing process.This fiber reinforced composite can then be used to make a variety of implants such asintra-medullary rods and artificial joints. Since the mechanical properties of thesecomposites with the proportion of carbon fibers in the composites, it is possible to modifythe material design flexibility to suit the ultimate design of prostheses.Composites have unique properties and are usually stronger than any of the singlematerials from which

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they are made. Workers in this field have taken advantages of thisfact and applied it to some difficult problems where tissue in-growth is necessary.

Examples:

Deposited Al2O3 onto carbon;

Carbon / PTFE;

Al2O3 / PTFE;

PLA-coated Carbon fibers.

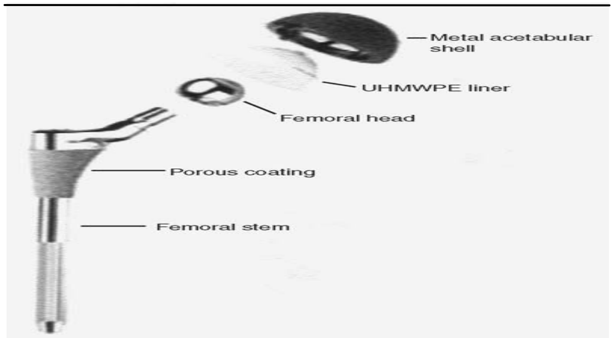

Figure 1.3: Typical components found in an unassembled totalhip replacement (THR) implant. It should be notedthat this is one of many artificial joint designs used in THR Arthroplasty.

CERAMICS

The most frequently used ceramic implant materials include aluminum oxides, calciumphosphates, and appetites and graphite. Glasses have also been developed for medicalapplications. The use of ceramics was motivated by:

(i) Their inertness in the body,

(ii) Their formability into a variety of shapes and porosities,

(iii) Their high compressive strength, and

(iv)Some cases their excellent wear characteristics.

Selected applications of ceramics include:

(a) Hip prostheses,(b) Artificial knees,(c) Bone grafts,(d) Variety of tissues in growth related applications in (d.1) Orthopedics(d.2) Dentistry, and(d.3) Heart valves.

CONCLUSIONS

A biomaterial is essentially a material that is used and adapted for amedical application. Biomaterials can have a benign function, suchas being used for a heart valve, or may be bioactive. Used for a moreinteractive purpose such as hydroxy-apatite coated hip implants andsuch implants are lasting upwards of twenty years.

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