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**REVIEW ON IMPLANT MATERIALS**

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**ABSTRACT**

The selection of materials for medical applications is usually based on considerations of biocompatibility. When metals and alloys are considered, the susceptibility of the material to corrosion and the effect the corrosion has on the tissue are the central aspects of biocompatibility. Corrosion resistance of the currently used 316L stainless steel, cobalt-chromium, and titanium-based implant alloys. When a metal implant is placed in the human body, it becomes surrounded by a layer of fibrous tissue of a thickness that is proportional to the amount and toxicity of the dissolution products and to the amount of motion between the implant and the adjacent tissues. Superior fracture and fatigue resistance have made metals the materials of choice for traditional load-bearing applications. In this review, the functionality of currently used metals and alloys is discussed with respect to applications.

**KEYWORDS:** Magnetic field Laser Engineered Net Shaping (LENS), Finite Element Method, Femur Bone.MRI/CT

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**INTRODUCTION**

Over the last several decades, an increase in longevity and life expectancy has raised the average age of the world's population. Implants are object or material inserted or grafted into the body for therapeutic, diagnostic, or experimental purposes sterile drug product made by compression, inching, or sintering. This worldwide increase in the average age of the population has, in turned to a rapidly increasing number of surgical procedures involving prosthesis implantation, because as the human body ages, the load bearing joints become more prone to ailments. This has resulted in an urgent need for improved biomaterials and processing technologies for implants, more so for orthopaedic and dental applications.

**BIOMATERIALS IN ORTHOPEDIC**

It is important for orthopedic surgeons to understand the nature of biomaterials, their structural configurations, and their properties, as well as the effects of their interaction with soft and hard tissues, blood, and intra and extracellular fluids of the human body.

The orthopedics field has benefited from the great efforts of many orthopedic surgeons, experimental surgery laboratories, and research centers and from research work at universities, academies, societies,

scientific organizations, and many interdisciplinary groups. However, many challenges remain to be conquered in the development of new biomaterials that will improve the long-term performance of clinical results in orthopedic surgery. The main biomaterials used in orthopedic surgery are divided into two types metals and nonmetals.

**Metals:**

The use of metals in therapeutic procedures dates back several centuries. Metallic implants were used in the 7th century. In the 18th century a metal screw implant was used for the first time. The majority of elements in the periodic table are metals. Metallic biomaterials have their main applications in load-bearing systems such as hip and knee prostheses and for the fixation of internal and external bone fractures. It is very important to know the physical and chemical properties of the different metallic materials used in orthopedic surgery as well as their interaction with the host tissue of the human body.

The metallic implants most widely used in orthopedic surgery are:

- Low carbon grade austenitic stainless steels: 316L
- Titanium and titanium-base alloys, and other titanium-base alloys

- Cobalt alloys: Co-Cr-Mo, and other cobalt-base alloys.

#### Non metals:

Three main subgroups make up this category: polymers, ceramics, and Composites.

##### (1) Polymers:

Polymers are organic materials that form large chains made up of many repeating units. Polymers are extensively used in joint replacement components. Currently the polymers most widely used in joint replacements are:

- Ultrahigh molecular weight polyethylene (UHMWPE)
- Acrylic bone cements
- Thermoplastic polyether ether ketone (PEEK)
- Bioabsorbables

##### (2) Ceramics:

Ceramics are polycrystalline materials. The great majority are compounds made up of metallic as well as nonmetallic elements; they generally have ionic bonds or ionic with some covalent bonds. The main characteristics of ceramic materials are hardness and brittleness. They work mainly on compression forces; on tension forces, their behavior is poor. The main ceramics in orthopedic surgery and their applications are:

- Alumina,  $Al_2O_3$ , used for acetabular and femoral components
- Zirconia,  $ZrO_2$ , used for acetabular and femoral components
- Hydroxyapatite,  $Ca_{10}(PO_4)_6(OH)_2$ , used for coating stem femoral components to integrate the surface material to the bone

##### (3) Composites:

Composite biomaterials are made with a filler (reinforcement) addition to a matrix material in order to obtain properties that improve every one of the components. This means that the composite materials may have several phases. Some matrix materials may be combined with different types of fillers. Polymers containing particulate fillers are known as particulate composites. The following composites are considered in the orthopedic devices:

- Fiber-reinforced polymers
- Aggregates to polymethyl methacrylate (PMMA)

## PHYSICAL CHARACTERISTICS OF MATERIAL:

### • Biocompatibility:

Biocompatibility refers to the way materials interact with your body. Some materials, lead and mercury for example, are naturally harmful when taken into the body, so are not suitable for implanting. Other materials are not suitable to implant because the body fluids cause them to break down, either weakening them, or causing corrosion or other byproducts. Some materials may cause irritation or, rarely, may cause an allergic reaction. If this happens, the implant site may experience some inflammation which may involve swelling, redness and pain. Fortunately, all biomaterials used in medical devices, in the U.S. and in most other countries, must be extensively tested for biocompatibility before they are approved for use. Because some few people may have an allergic reaction, even to materials that are generally safe for the general public, it is important to tell your doctor about any allergies you may have.

### • Strength:

Certainly, an orthopedic implant should be designed to be as strong as possible. Even in everyday activities, you will place high levels of mechanical stress on your bones and joints. An implant must be able to withstand these stresses day to day without breaking or permanently changing its shape. It should also be designed to withstand the accumulated effect of repeating these stresses.

### • Flexibility:

While strength characteristics of implants are important, they must also be somewhat flexible to avoid shielding of bones from stress (what doctors call "stress shielding"). To understand stress shielding, you have to understand that the human body may tend to reduce or eliminate its own parts when they are not used. Your muscles, for example, can be built up by lifting weights. But when you stop lifting weights, you will eventually begin to lose the extra muscle that you have built up.

Similarly, your bones can remain strong only if they are regularly placed under a reasonable stress. And if they are never stressed, your body will actually begin to lose bone tissue, causing the remaining bone to become weak.

When stress is applied to an orthopedic implant that is very stiff, the implant absorbs most of the stress. But when stress is applied to a more flexible implant, some of the stress passes through the implant so it can be shared with the surrounding bone. That's good because your bones need to be stressed. That's why flexibility is important.

- **Resistance to Wear:**

Some of the parts that make up an orthopaedic implant must touch each other or rub together, especially in the case of an artificial joint. Any time two parts rub together, friction is created and the parts may possibly wear over time. When an implant wears, tiny particles of the material are removed from the surface and remain in the tissues that surround the implant. In some patients, these particles may cause a reaction that could lead to inflammation. If the inflammation is severe, or continues for too long, the implant may become loose.

Generally, the harder the material, the more resistant it is to wear. Also, the choice of the two materials that rub together in an implant is important in minimizing wear. Many combinations of materials are used today for implants, including metal on polyethylene, metal on metal, ceramic on ceramic, and ceramic on polyethylene.

- **Resistance to Corrosion:**

Some of the normal chemicals that make up the fluids in your body can damage certain materials. Corrosion occurs as these chemicals react with the implant material, creating particles similar to small wear particles. Not only can corrosion weaken the implant, but the particles produced can remain in the tissues that surround the implant. This could eventually lead to implant failure or, in severe cases, damage to the bone.

## COMMON MATERIALS USED IN ORTHOPEDIC IMPLANTS:

- **Stainless Steel**

Stainless steel is a very strong alloy, and is most often used in implants that are intended to help repair fractures, such as bone plates, bone screws, pins, and rods. Stainless steel is made mostly of iron, with other metals such as chromium or molybdenum added to make it more resistant to corrosion. There are many different types of stainless steel. The stainless steels used in orthopedic implants are

designed to resist the normal chemicals found in the human body.

- **Cobalt-chromium Alloys**

Cobalt-chromium alloys are also strong, hard, biocompatible, and corrosion resistant. These alloys are used in a variety of joint replacement implants, as well as some fracture repair implants, that require a long service life. While cobalt-chromium alloys contain mostly cobalt and chromium, they also include other metals, such as molybdenum, to increase their strength.

- **Titanium Alloys**

Titanium alloys are considered to be biocompatible. They are the most flexible of all orthopedic alloys. They are also lighter weight than most other orthopedic alloys. Consisting mostly of titanium, they also contain varying degrees of other metals, such as aluminum and vanadium.

- **Titanium**

Pure titanium may also be used in some implants where high strength is not required. It is used, for example, to make fiber metal, which is a layer of metal fibers bonded to the surface of an implant to allow the bone to grow into the implant, or cement to flow into the implant, for a better grip.

- **Tantalum**

Tantalum is a pure metal with excellent physical and biological characteristics. It is flexible, corrosion resistant, and biocompatible.

- **Polyethylene**

Polyethylene is a type of plastic commonly used on the surface of one implant that is designed to contact another implant, as in a joint replacement. You may recognize polyethylene as the material used to make milk cartons. But don't worry; your implant is not made from recycled milk cartons. The polyethylene used in orthopedic implants is a much higher grade. In fact, a special type of medical-grade polyethylene was developed specifically for use in orthopedic implants.

Polyethylene is very durable when it comes into contact with other materials. When a metal implant moves on a polyethylene surface, as it does in most joint replacements, the contact is very smooth and the amount of wear is minimal.

Patients who are younger or more active may benefit from polyethylene with even more resistance to wear. This can be accomplished through a process called cross linking, which creates stronger bonds between

the elements that make up the polyethylene. The appropriate amount of cross linking depends on the type of implant. For example, the surface of a hip implant may require a different degree of cross linking than the surface of a knee implant..

## CONCLUSIONS

It is observed that selection of implant material is very crucial process. Though there are number of materials available for the implant due to there limitations there is a huge scope for development of new implant materials.

Development of new implant materials is the important need of medical industry, new efficient, corrosion resistant and durable implant material is essential.

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