Bio metals applications

Doctors, researchers, and bioengineers use biomaterials for the following broad range of applications as shown in table below

Table (5): Implants division and type of metals used

Division	Example of implants	Type of metal
Cardiovascular	Stent Artificial valve	316L SS; CoCrMo; Ti Ti6Al4V
Orthopedics	Bone fixation (plate, screw, pin) Artificial joints	316L SS; Ti; Ti6Al4V CoCrMo; Ti6Al4V; Ti6Al7Nb
Dentistry	Orthodontic wire Filling	316L SS; CoCrMo; TiNi; TiMo AgSn(Cu) amalgam, Au
Craniofacial	Plate and screw	316L SS; CoCrMo; Ti; Ti6Al4V
Otorhinology	Artificial eardrum	316L SS

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Failure of metals for biomedical devices

1- Corrosion

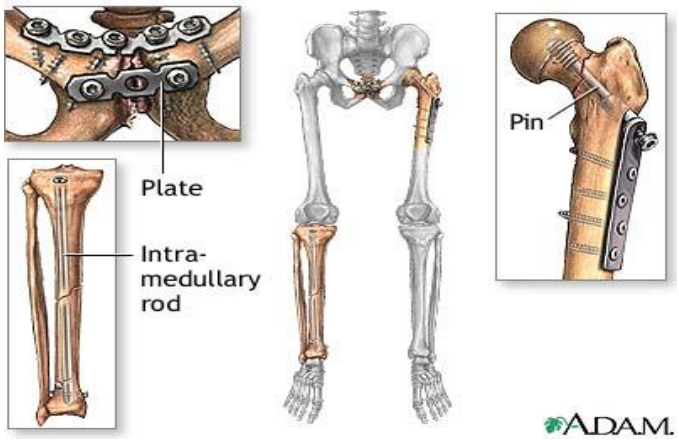
Metal implant is prone to corrosion during its services due to corrosive medium of implantation site. Types of corrosion that frequently found in implant applications are **fretting, pitting and fatigue**.

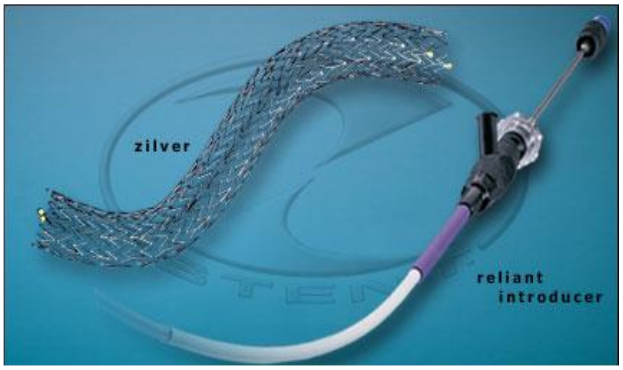
2- Fatigue and fracture

During its service most of metallic implants are subjected to cyclic loading inside the human body which leads to the possibility for fatigue fracture. Factors determine the fatigue behavior of implant materials include microstructure of the implant materials.

3- Wear

Together with corrosion process, wear is among the surface degradation that limits the use of metallic implant such as Ti alloy. Removal of dense oxide film which naturally formed on the surface of this metallic implant in turn caused wear process. In fact, the major factor that causing premature failure of hip prostheses is due to the wear process with multiple variables interact and thus increase the resultant wear rates.





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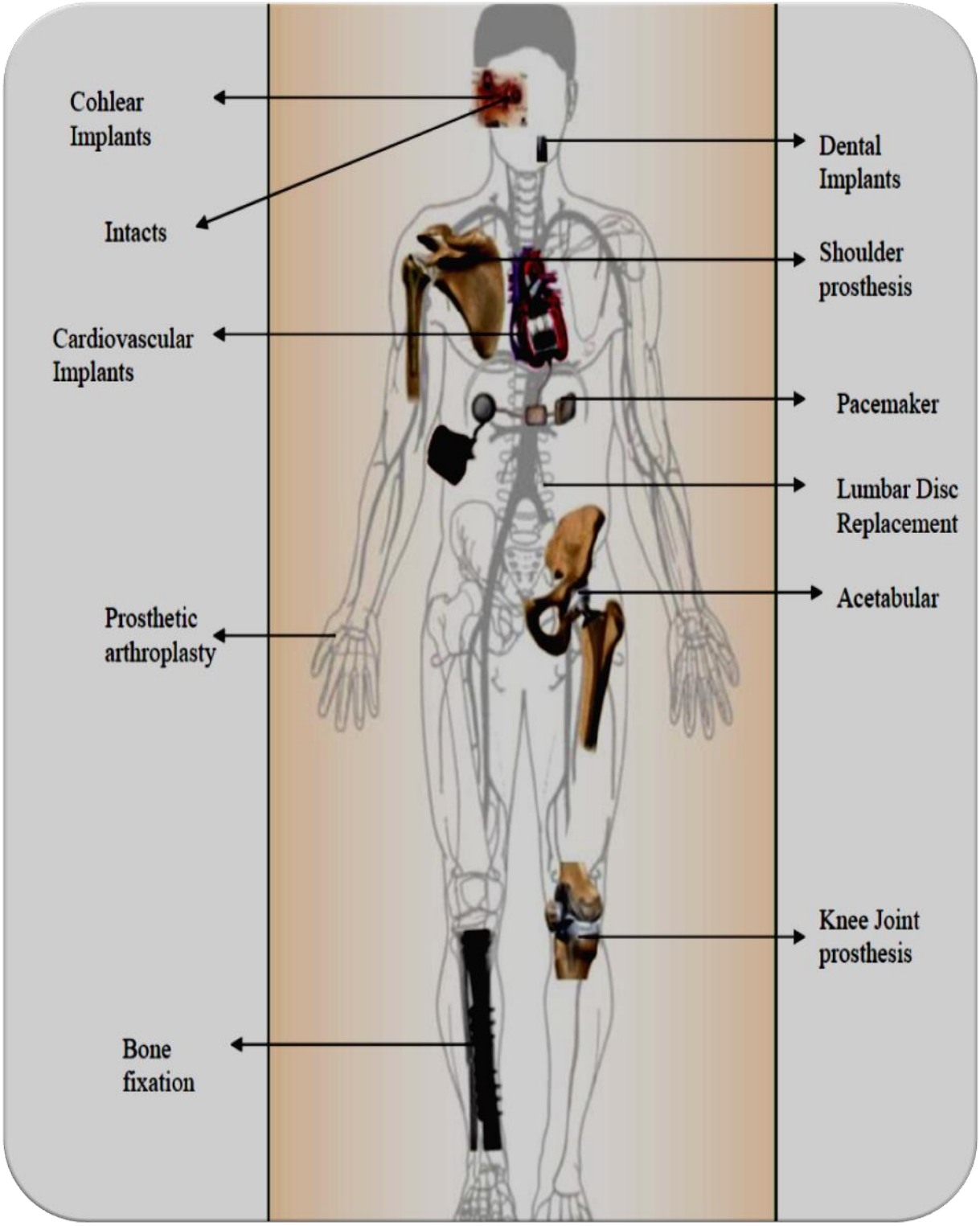

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Polymers

There are a large number of polymeric materials that have been used as implants or part of implant systems. The polymeric systems include acrylics, polyamides, polyesters, polyethylene, polysiloxanes, polyurethane, and a number of reprocessed biological materials.

Some of the applications include the use of membranes of ethylene-vinyl-acetate (EVA) copolymer for controlled release and the use of poly-glycolic acid for use as a resorbable suture material. As bioengineers search for designs of ever increasing capabilities to meet the needs of medical practice, polymeric materials alone and in combination with metals and ceramics are becoming increasingly incorporated into devices used in the body.

Advantages of biopolymers

- Not expensive.
- Easy to fabricate.
- Resistance to corrosion.
- Wide range of physical, chemical and mechanical properties.
- Low density (low weight).
- May be biodegradable.
- Good biocompatibility.
- Low coefficients of friction.

Disadvantages of Polymers

- Low mechanical strength.
- Thermo sensitive.
- Easily degradable.

- Absorb water & proteins etc.
- Wear & breakdown.
- Sensitive to sterilization techniques because of their permeability and porous structures.
- Bacterial colonization because of their organic structure.

In orthopedic applications (screws…)

- Metal alloys present greatest load bearing.
- Polymers present lower load bearing.

In vascular applications (stents…)

- Magnesium alloys degrade too fast in biological environment and they dissolve in the body.
- Polymers degrade slower than magnesium alloys.

Biodegradable Polymers

Biodegradable polymers are designed as temporary structures having the desired geometry and the physical, chemical, and mechanical properties required for implantation.

Biodegradable polymeric biomaterials have been experimented with as (1) vascular grafts (2) vascular stents, (3) nerve growth conduits, (4) defected bone, (5) ligament/tendon prostheses.

Mechanisms causing degradation

Physical

- sorption/swelling,
- softening,
- dissolution,
- stress cracking,
- fatigue cracking.

Chemical

- hydrolysis,
- oxidation
- enzymatic

Polymers used as biomaterials

Although hundreds of polymers are easily synthesized and could be used as biomaterials only ten to twenty polymers are mainly used in fabrication of medical device from disposable to long-term implants.

1-Polyvinylchloride (PVC)

The PVC is an amorphous. PVC sheets are used in blood and solution storage bags. PVC tubing is commonly used in intravenous (IV), dialysis devices, catheters, and cannulae (i.e. mostly for external use).

2- Polyethylene (PE)

HDPE is used in pharmaceutical bottles.

LDPE is used for flexible container applications, disposable for packaging.

LLDPE(linear low density) is employed in bags due to its excellent puncture resistance.

UHMWPE(**Ultra-high-molecular-weight polyethylene)**Also known as **high-modulus polyethylene**, (**HMPE**), or **high-performance polyethylene** (**HPPE**), has been used for fabrication of orthopedic implant, especially for load bearing applications such as an acetabular cup of total hip and the surfaces of patellar of knee joints.

3- Polypropylene (PP)

This is a very simple polymer whose structure is almost similar to PE. It's mechanical properties are also balanced. The one thing that sets this one apart is the hing property that it has.PP is used to make disposable syringes, packaging for devices, solutions, and drugs, suture, artificial vascular grafts, etc.

4- Polymethylmetacrylate (PMMA)

PMMA is used broadly in medical applications such as a blood pump and reservoir, membranes for blood dialyzer, and in vitro diagnostics. It is also found in contact lenses and implantable ocular lenses due to excellent optical properties, dentures, and maxillofacial prostheses due to good physical and coloring properties, and bone cement for joint prostheses fixation.

Bone cement: Mixture of polymethylmethacrylate powder and methylmethacrylate monomer liquid to be used as a grouting material for the fixation of orthopedic Joint implants.

5- Polystyrene (PS)

PS is commonly used in roller bottles.

6- Polyesters

It's used for artificial vascular graft, sutures as a soft matrix or coating.

7- Polyurethanes

They are widely used to coat implants and arteries, cardiovascular prostheses, catheters and pacemakers (as insulator).

8- polycarbonates

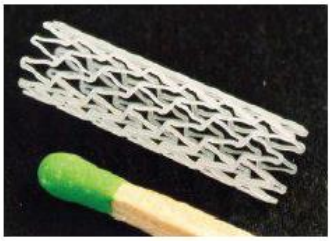
Polycarbonates have found their applications in the heart/lung assist devices, food packaging.

9- Polyethylene terephthalate, called Dacron,

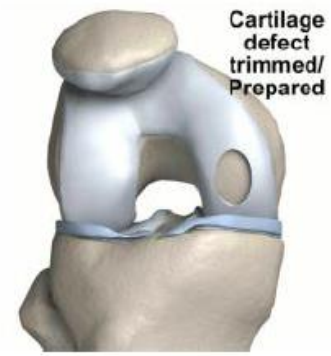
Is used in the artificial heart valves. Dacron is used because tissue will grow through a polymer mesh. Dacron is used for large arteries.

Spinal cage for spine fusion

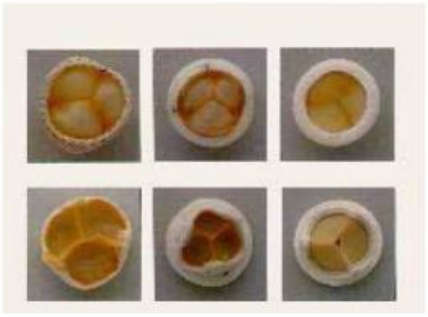
Vascular Implants & Stents



Cartilage



Artificial heart valve



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