PD233: Design of Biomedical Devices and Systems

(Lecture-13 Medical Implants and Prosthesis)

Dr. Manish Arora

CPDM, IISc

Course Website:
http://cpdm.iisc.ac.in/utsaah/courses/

Medical Implant

- **Medical implants** are devices or tissues that are placed inside or on the surface of the body.
- Many implants are **prosthetics**, intended to replace missing body parts.
- Other implants deliver medication, monitor body functions, or provide support to organs and tissues.
- **Orthotic devices** are applied to body to stabilize or immobilize body part, improve alignment, prevent deformity etc.

FDA.org

Examples:

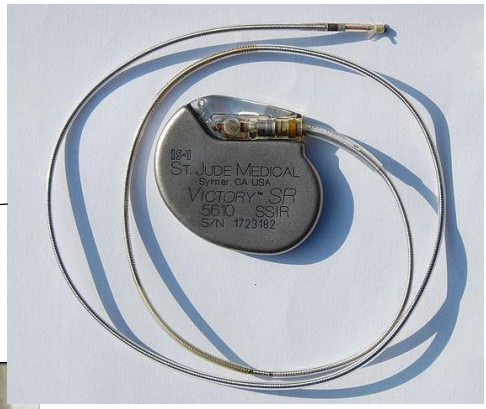
Orthopaedic implants
- Knee
- Hip
- Shoulder

Ophthalmologic
- Intraocular lens
- Contact lens
- Retinal Surgery Implant
- Prosthesis after Enucleation

Imagesources: wikimedia.org

Examples:

Cardiovascular implants
- Vascular graft
- Heart valves
- Pacemakers



Reconstructive
- Breast prostheses
- Nose
- Dental

Via Dr. Vibha Shetty

Imagesources: wikimedia.org

Orthotic Devices:

Foot Orthotic

Braces and Supports for kids with special needs

Factors affecting implant performance

	Wear	**Micro-motion**	**Stress-Shielding**
Fit			
Fixation	Performance over the lifetime of the implants need to be studied		
Stiffness			

M Spector, MIT
For more details See https://ocw.mit.edu/courses/mechanical-engineering/2-782j-design-of-medical-devices-and-implants-spring-2006/lecture-notes/ch6_implant.pdf

Biomaterial Choices for Implants

Biomaterial : Any substance (other than a drug) or combination of substances, synthetic or natural in origin, which can be used at any period of time as a whole or in part of a system which treats, augments or place any tissue, organ or function of the body.

-Boretos and Eden, 1984

Depending on duration of use:

Non-absorbable materials for permanent implants

Absorbable materials for tissue scaffolds

Primary types of materials

Metallic (titanium, stainless steel)

Ceramics (ceramics, calcium phosphate, hydroxy apatite)

Covalent (polymers, biological macromolecules)

Metallic Biomaterials

Stainless steel

Fe-Cr-Ni-Mo-C...

+Strength

+ease of manf.

+availability

-potential of corrosion

-high elasticity modulus

Cobalt Chromium

Co-Cr-Mo-Ni…

+Strength

+Rel. wear resistance

-high modulus of elasticity

Titanium Alloy

Ti-Al-V-Fe

+Strength

+low elasticity modulus

+Corrosion resistance

-low wear resistance

Ceramics

- Compounds of metal and non-metallic elements
  - Alumina (Aluminium oxide)
  - Zirconia (Zirconium oxide)
  - Chromium Oxide
  - Titatium Oxide
- Dense/Hard starch resistant
- Can be polished to ultra smooth surface

Oxinium

- New metal alloy (Zirconium and niobium) developed for implants that has a ceramic surface produced by a special oxidation process.

+scratch resistance

+low modulus

Combines advantages of metal alloys and ceramic materials

Polymer materials

(non-absorbing biomaterials)

UHMWPE (Ultra High Molecular Weight Poly-Ethelene)

PMMA (Poly-methyl methacrylate)

PEEK (Polyether ether ketone) 🡐 3D printable

…

Absorbable biomaterials (synthetic)

- Polylactic acid and Polyglycolic acid
- Polycarbonates
- Polydioxanones
- Polyphosphazenes
- Poly(anhydrides)
- Poly(orthoesters)
- …

Absorbable biomaterials (natural)

- Collagen
- Collagen-GAG copolymer
- Albumin
- Fibrin
- Hyaluronic acid
- Cellulose