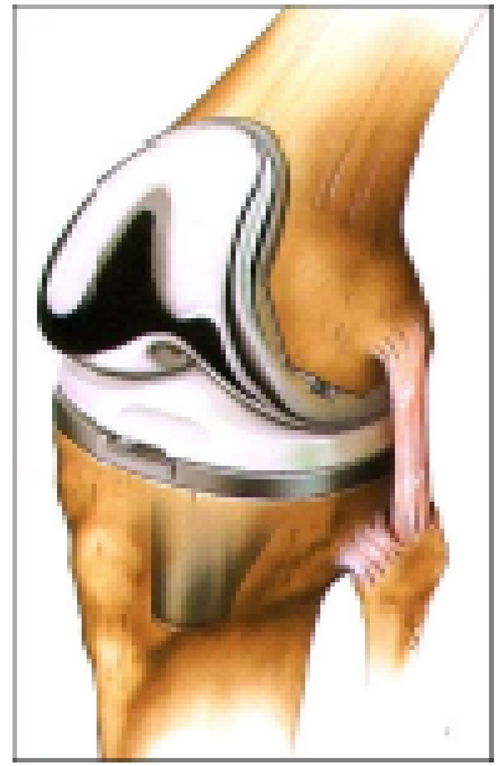
Section 27: Implant Devices and Materials

What joints can be replaced with prosthetics?

- Fingers
- Wrists
- Elbows
- Shoulders
- Temporalmandibular
- Spine
- Hips
- Knees
- Ankles
- Toes



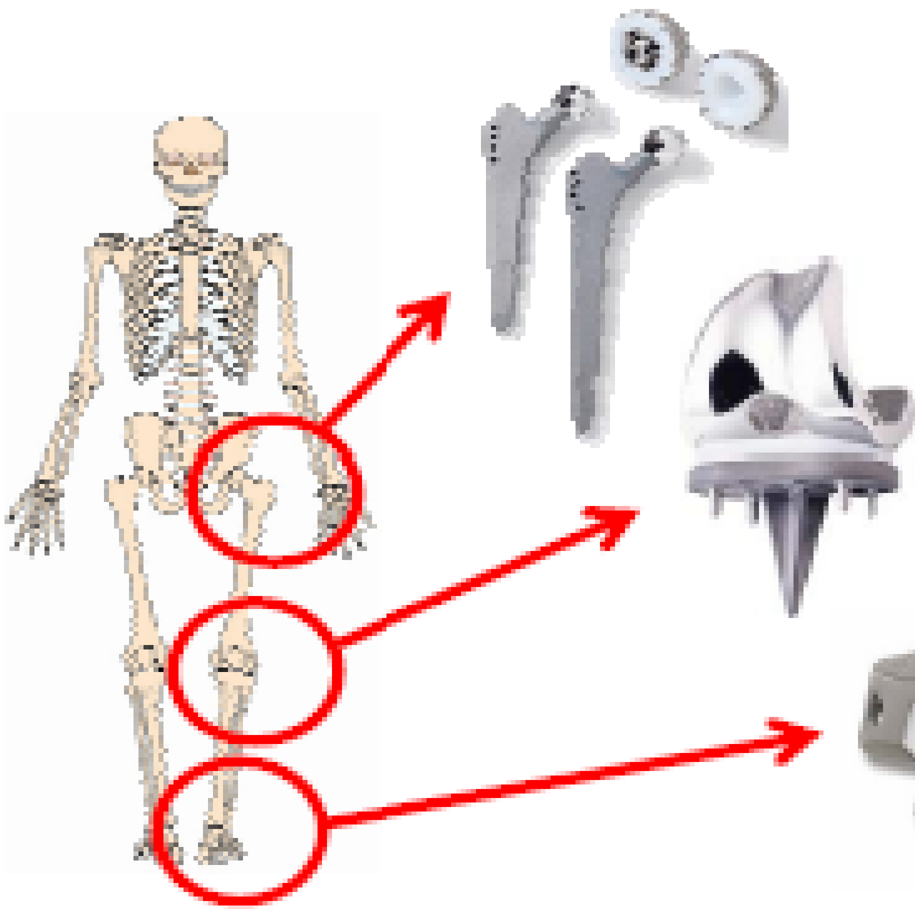
www.medicalmultimediagroup.com www.hipnknee.org

What problems require joint replacement?

- Arthritic pain
- Cartilage damage
- Tumors
- Fractures

From: Ploeg

Orthopedic Implants



- Hips 250,000/a in USA
- TJR 500,000/a in USA
- Hips 800,000/a in NA+EU
- Hips and Knees: 1.2 million/a Worldwide
- Ankles: <50,000 in USA

From: Ploeg

What are the goals of TJR?

- Improve quality of life
- Reduce pain
- Restore function
  - Movement
  - Strength
- Last throughout life

From: Ploeg

Judet Hip

- Hemiarthroplasty
- Acrylic
- First implant: 1946

http://www.maitrise-orthop.com/corpusmaitri/orthopaedic/judet_smith/judet_smthus.shtml

From: Ploeg

Smith & Nephew orthopaedics hip portfolio

From: Kelman

Clinical performance

SPECTRON™ stem

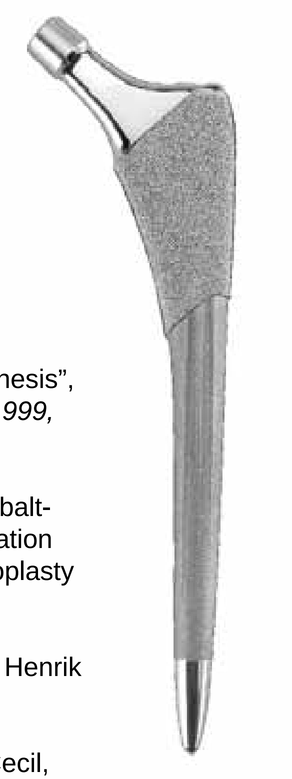
100% survival rate of the SPECTRON stem at 12 years [1]

97.0% survival rate of SPECTRON stem at 9.6 years [2]

99.7% survival rate of SPECTRON EF at 7 yrs [3]

SYNERGY™ stem

99.5% Survivorship [4]



1. The Charnley Versus the Spectron Hip Prosthesis”, *The Journal of Arthroplasty Vol. 14 No. 14 1999,* Goran Garellick, et al MD, PhD.
2. “Hip Arthroplasty With a Collared Straight Cobalt-Chrome Femoral Stem Using Second Generation Cementing Technique”, The Journal of Arthroplasty Vol. 15 No. 2 2000, Ashay Kale, MD et al.
3. Swedish National Hip Registry, 2000 Report, Henrik Malchau, MD, PhD
4. Bourne, Robert, M.D., F.R.C.S.; Rorabeck, Cecil, M.D., F.R.C.S.; The London Health Sciences Centre Experience: Synergy Tapered Hip System; International Hip Meeting. Prague, Czech Republic. May 2001

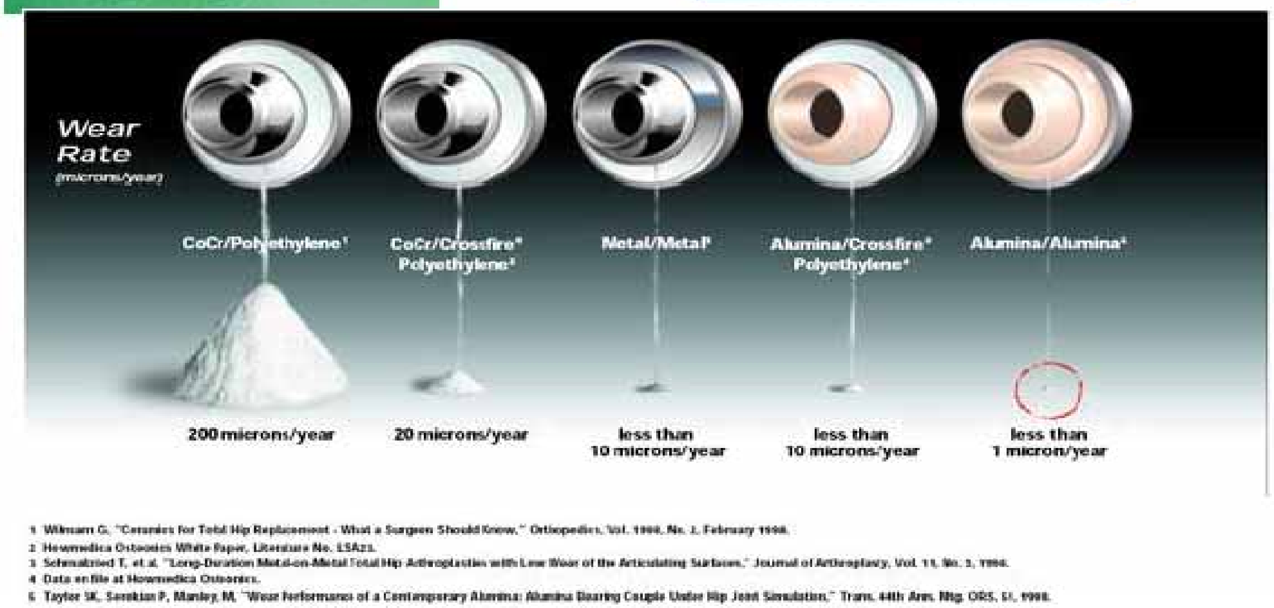
From: Kelman

ANTHOLOGY™ Hip System

- Value proposition
  - The ANTHOLOGY™ system provides the surgeon a press-fit implant that is optimum for all femur types
  - It is designed to be MIS friendly, reduce dislocations, and be more bone and tissue conserving than previous primary implant designs

From: Kelman

http://www.strykerceramics.com/stryker/about_hip.php



From: Materials and Textiles

Failure Modes

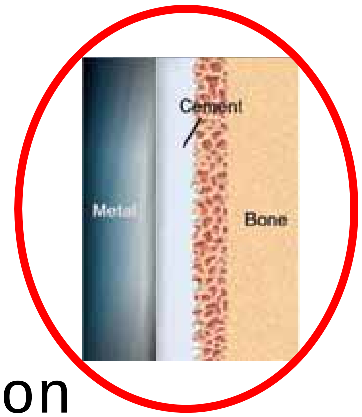
<u>Central Zone</u>

•Stem Fracture

<u>Proximal Zone</u>

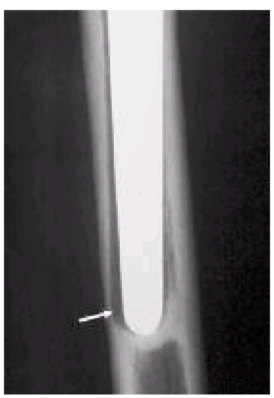
•Cement Fracture

•Bone-cement interface



<u>Distal Zone</u>

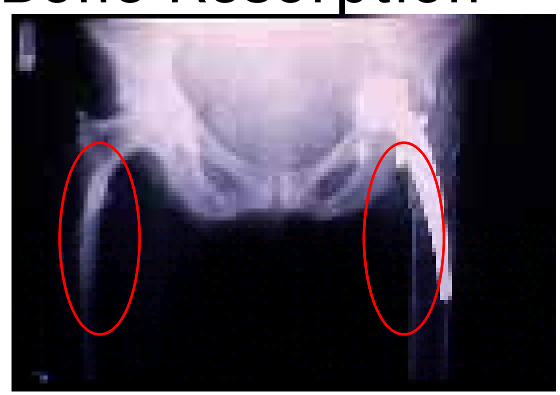
•Cement Fracture

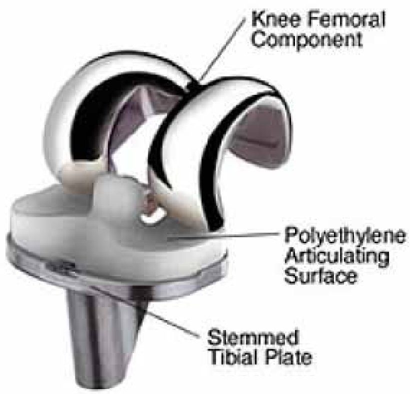


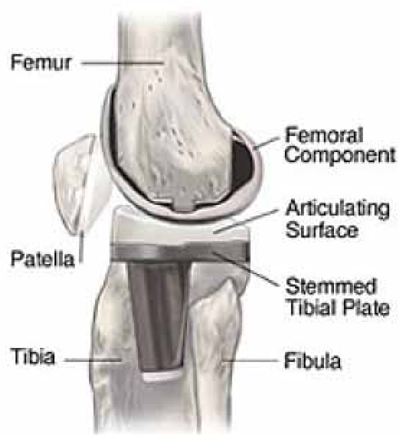
27-11

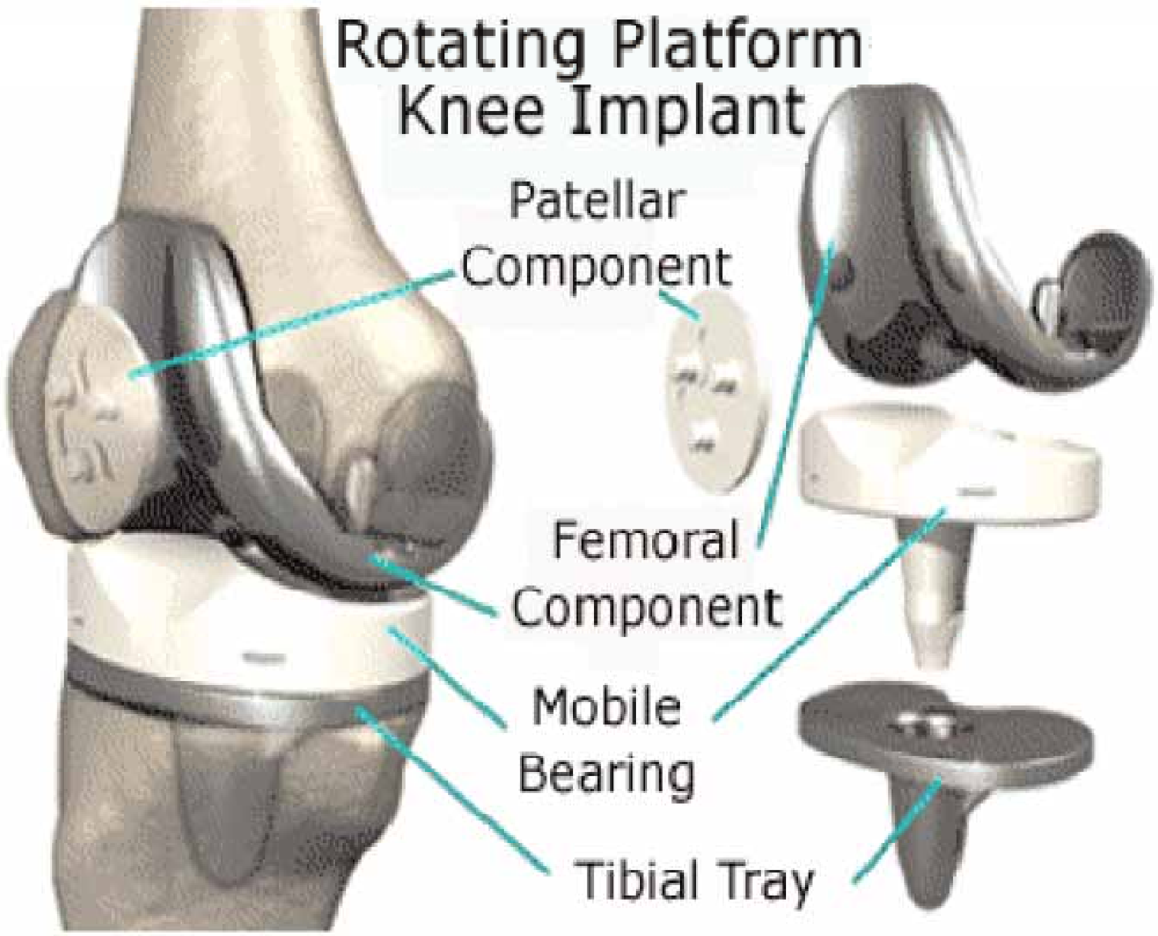
•Bone Fracture ↔ •Bone Resorption

From: Ploeg



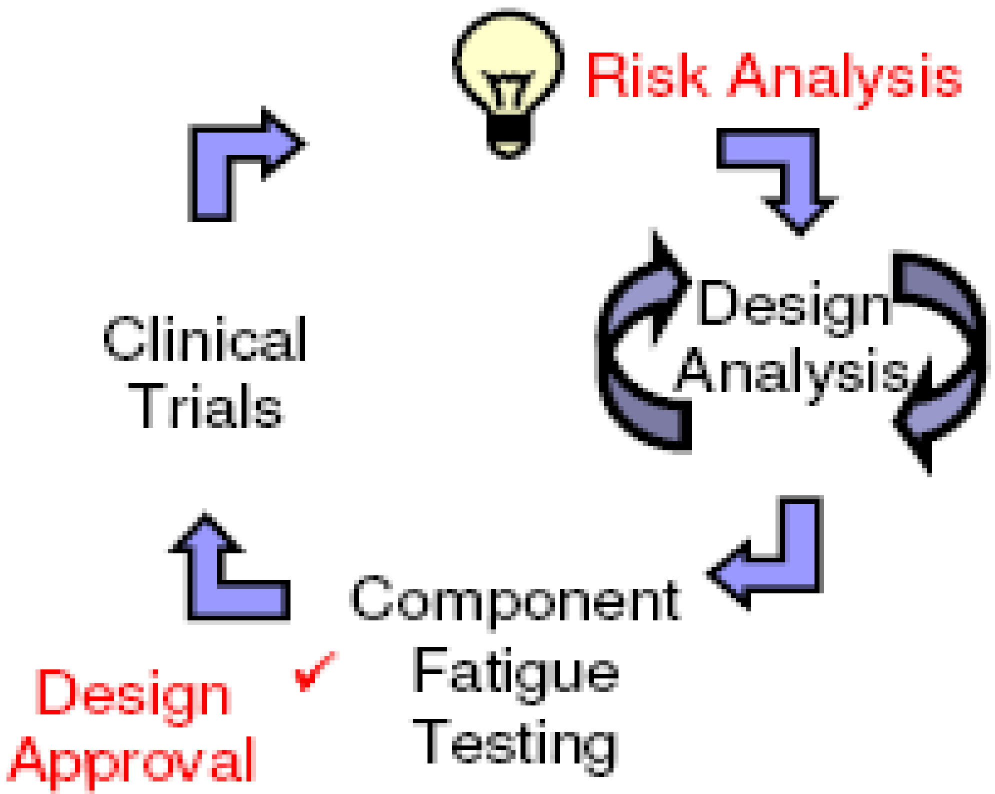






From: Materials and Textiles

TJR Design Process



- Geometry
- Strength
- Modularity
- Kinematics
- Wear
- Stiffness
- Fixation

 From: Ploeg

How successful are prosthetic joints?

- Relieve pain
- Restore function
- Most (>90%) last for >10 years

What artificial biomaterials are most commonly used?

- Metals
  - Stainless steel
  - Cobalt chrome
  - Titanium alloy
- Ceramics – aluminum oxide
- Polymers
  - Bone cement (PMMA)
  - UHMWPE (polyethylene)

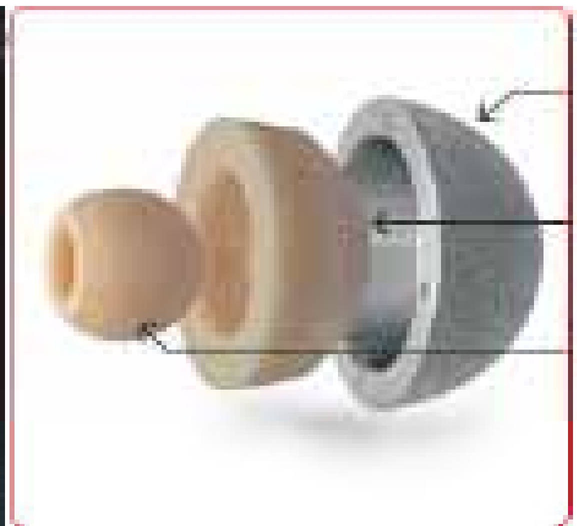
From: Ploeg

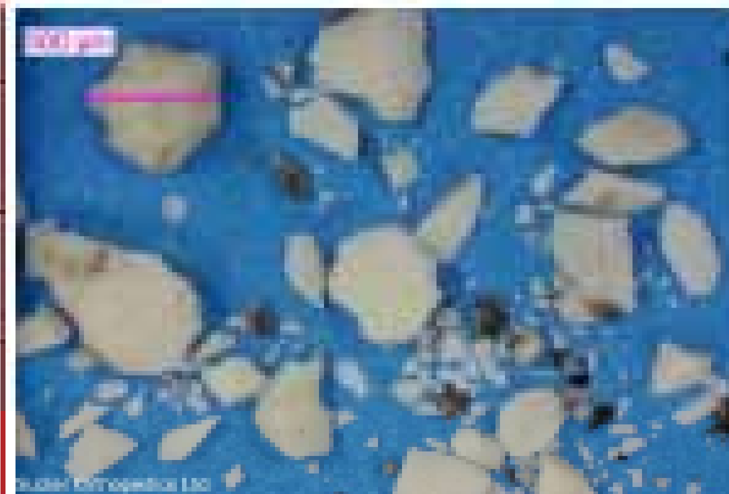
Material	E (MPa)	Static S (MPa)	Fatigue S (MPa)
Ceramic	300,000		
SS	200,000	480-1,300	240-700
CoCr	220,000	800-1,000	310-950
Ti Alloy	110,000	800-1,500	350-600
PMMA	3000	T: 25-40 C: 90-100	14
UHMWPE	500-1000		
Cortical B.	10-20,000	T: 51-133 C:133-195	
Cancel. B.	100-1000	C: 3-10	
Soft Tissue	1		

From: Ploeg

Ceramics

- Issues
  - Hard and biocompatible but brittle





http://www.wmt.com/ceramic/physicians/yliner.asp

http://www.questacon.edu.au/innovaus/c1s9_063.html

Polymers

- Bone cement (PMMA)
  - Exothermic
  - Toxic effects of monomer
  - Shrinkage with polymerization
  - Grout, not adhesive
- UHMWPE (polyethylene)
  - Lipid absorption
  - Wear particles
  - Low coefficient of friction and creep resistant

From: Ploeg

Polymers in Orthopedics

- Swanson Finger
- Wright Medical Technology
- Silicone and Titanium
- First implant: 1969

PRE-OP

POST-OP

http://www.wmt.com/

From: Ploeg

What are key design criteria for artificial biomaterials?

- Restore mechanical function
- Biocompatibility
- Chemically Stable

From: Ploeg

Requirements for Biomaterials

- Must re-establish mechanical function with healing or replacement:
  - Structural and mechanical criteria
  - Strength
  - Stiffness
  - Fatigue life
  - Wear
  - Wear debris

From: Ploeg

Requirements for Biomaterials

- Must be biocompatible
  - No inflammatory response
  - Inflammation causes lymphocyte invasion, vascular occlusion, tissue necrosis, fibrous tissue formation, prosthesis / implant loosening
  - Not carcinogenic
  - Not toxic
  - Not mutagenic, No immunogenic response

From: Ploeg

Requirements for Biomaterials

- Must not be adversely affected by biological environment, i.e. stable
  - Non-corrosive (metals) to minimize:
  - Stress corrosion
  - Galvanic corrosion
  - Crevice corrosion
  - Lipid absorption (polymers) causing property degradation

From: Ploeg

Requirements for Biomaterials

- Manufacturing and Use
  - Machinability
    - Ductility (plates must be contoured during use)
  - Cost and supply
  - Requisite size (determined by mechanical properties) versus available space
  - Sterilizable
  - Size of material (i.e. wear debris) biocompatibility doesn’t fix things

From: Ploeg