Joint Replacement in 2020: What Will It Look Like?

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Prediction

- Projection of current data
- Evidence based
- Experience based

Prediction Errors

- Random errors
- Systemic errors (bias)
  - information-selection-direction
- Uncertainty

Failed Prediction

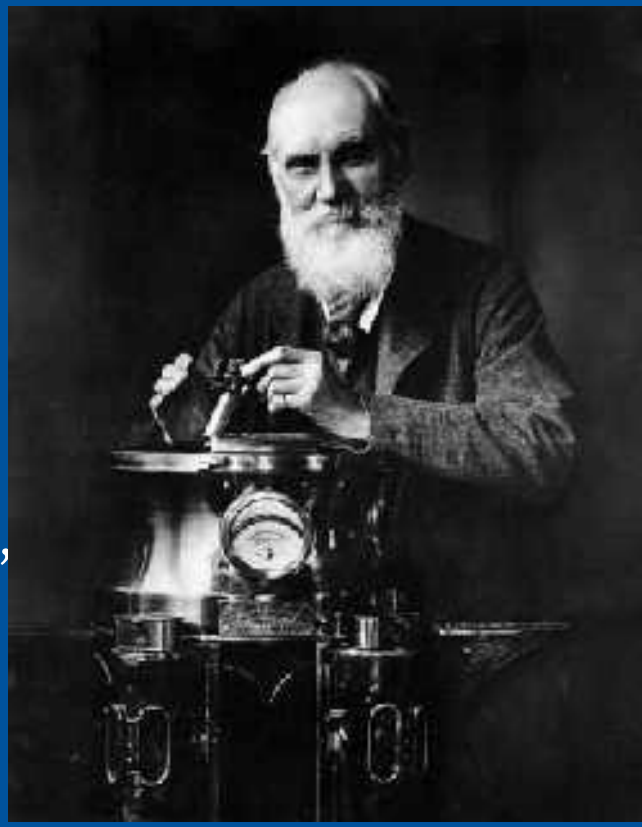
"There is no reason anyone would want a computer in their home."

Ken Olson, president, chairman and founder of Digital Equipment Corp. (DEC), maker of big business mainframe computers, arguing against the PC in 1977.

Failed Prediction

"Heavier-than-air flying machines are impossible."

Lord Kelvin, British mathematician and physicist, president of the British Royal Society, 1895.



Failed Prediction

"Nuclear-powered vacuum cleaners will probably be a reality in 10 years."

Alex Lewyt, president of vacuum cleaner company Lewyt Corp., in the New York Times in 1955.

Joint Replacement in 2050

- Arthritis prevention and cure
- Reduced activity level
- Gene therapy
- Nanomedicine
- Patient-specific drugs
- Repair and growth factors

Joint Replacement in 2020

Mechanisms of TJA failure

Major factors causing failure of total joint replacements include:

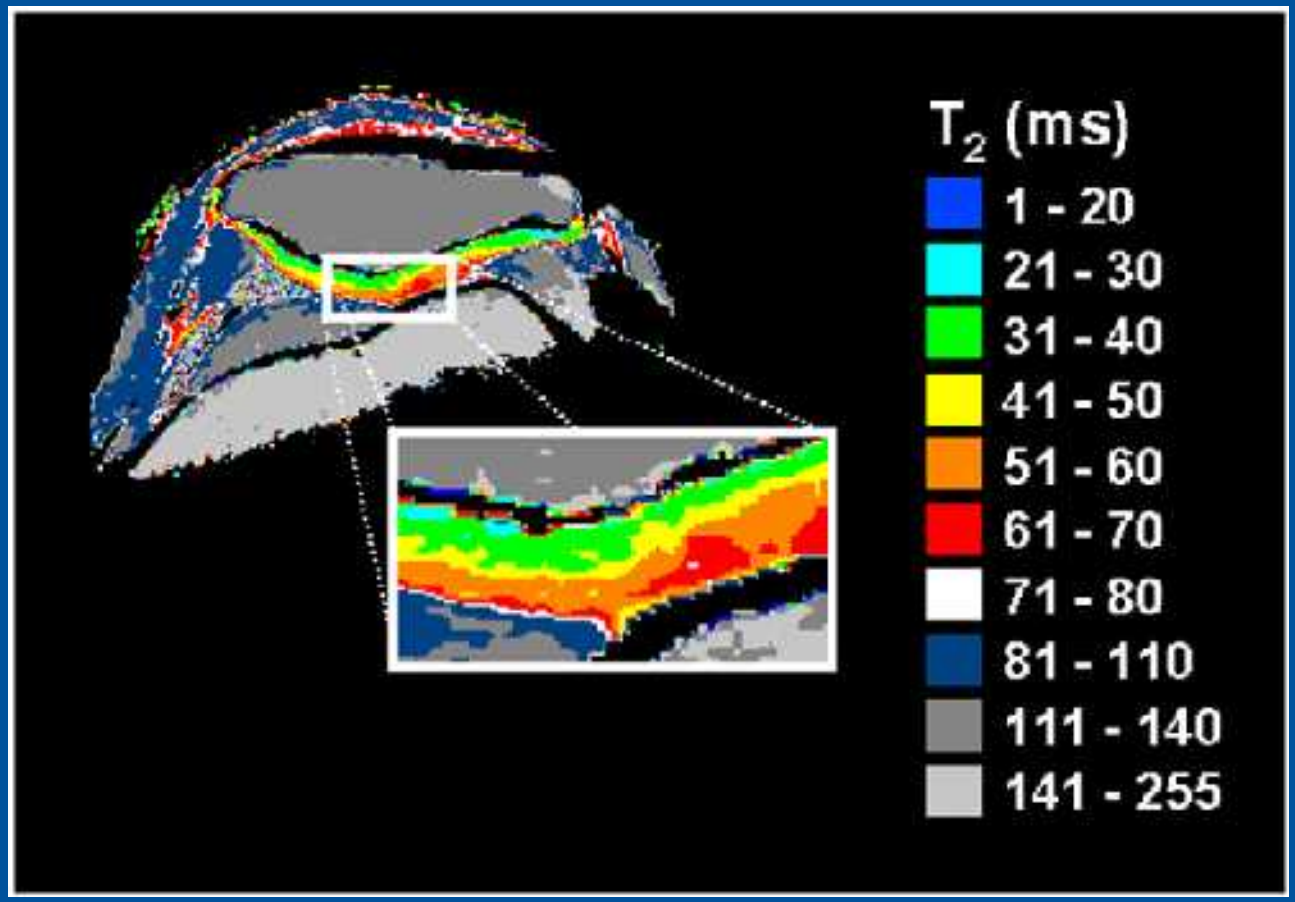
1. Thrombosis
2. Infection
3. Periprothetic bone loss
4. Implant and Bearing Surface Durability
5. Material wear
6. Surgical Technique and soft tissue injury
7. Osseointegration –Loosening
8. Dislocation

What will change in Joint Replacement?

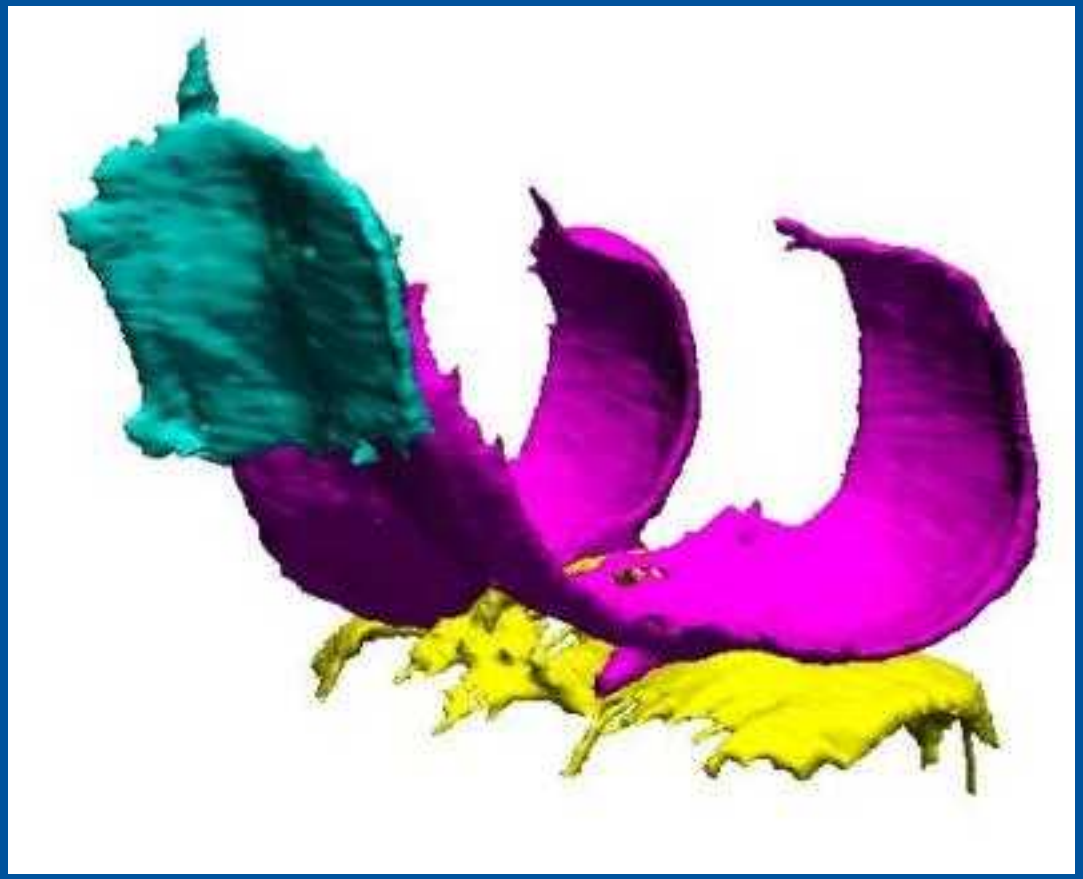
1. Cartilage imaging – Early Intervention
2. Prevention of arthritis
3. Frequency
4. Surgical technique
5. Operating Room Environment
6. Osseointegration
7. Bearings
8. Infection
9. Periprothetic Bone Loss
10. Thromboprophylaxis

1. Cartilage Imaging

Quantitative T2 mapping of articular cartilage



Quantitative MRI (qMRI)

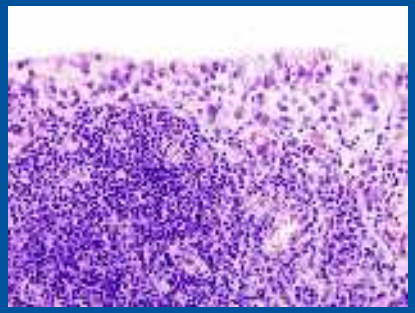


2. Arthritis Prevention

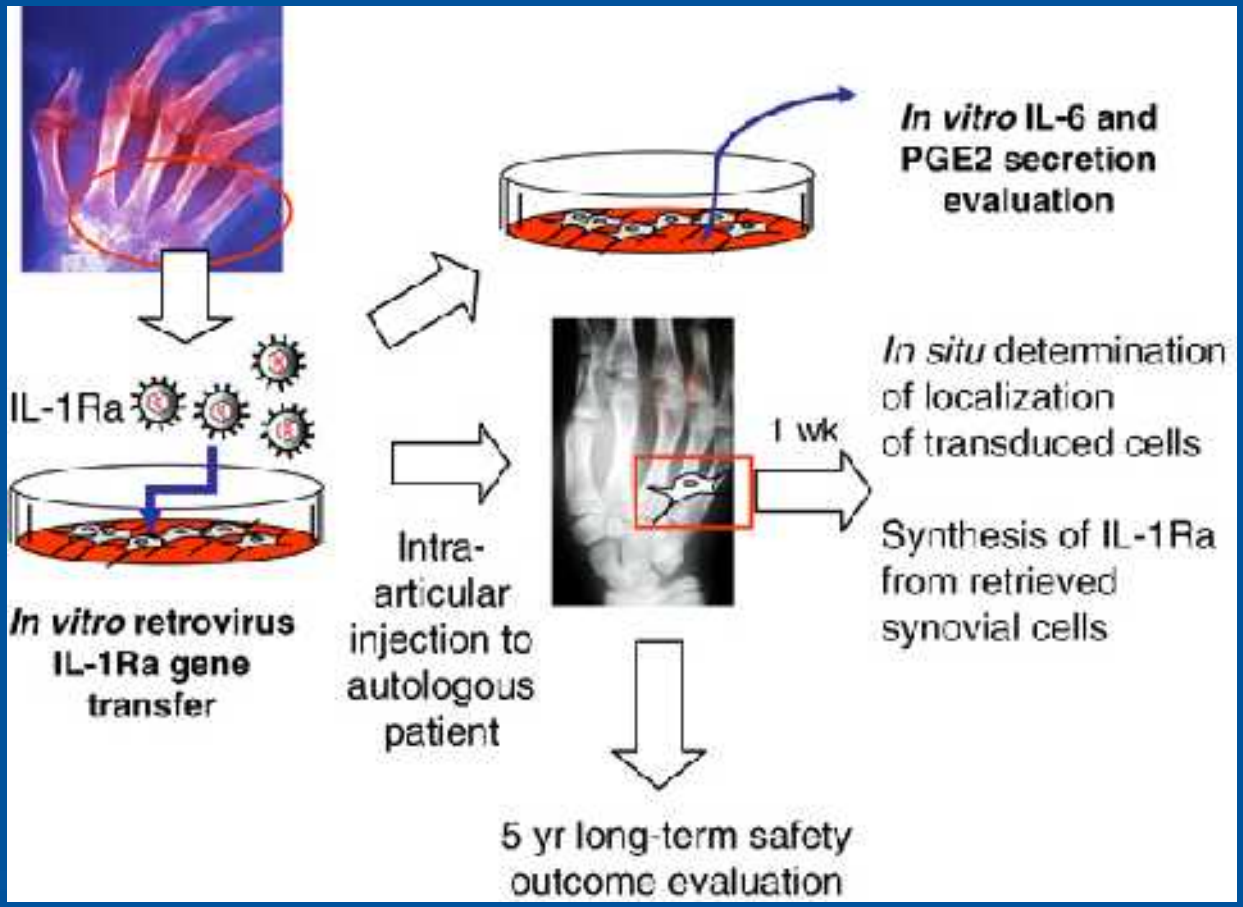
- Inflammatory arthritis
- Osteoarthritis

Inflammatory Arthritides

- Earlier recognition and treatment
- Disease modifying drugs
- Biological agents (Anti-TNFa)
- Combination therapy
- Gene therapy
- Local Anti-TNFα Gene Therapy
- Gene manipulation



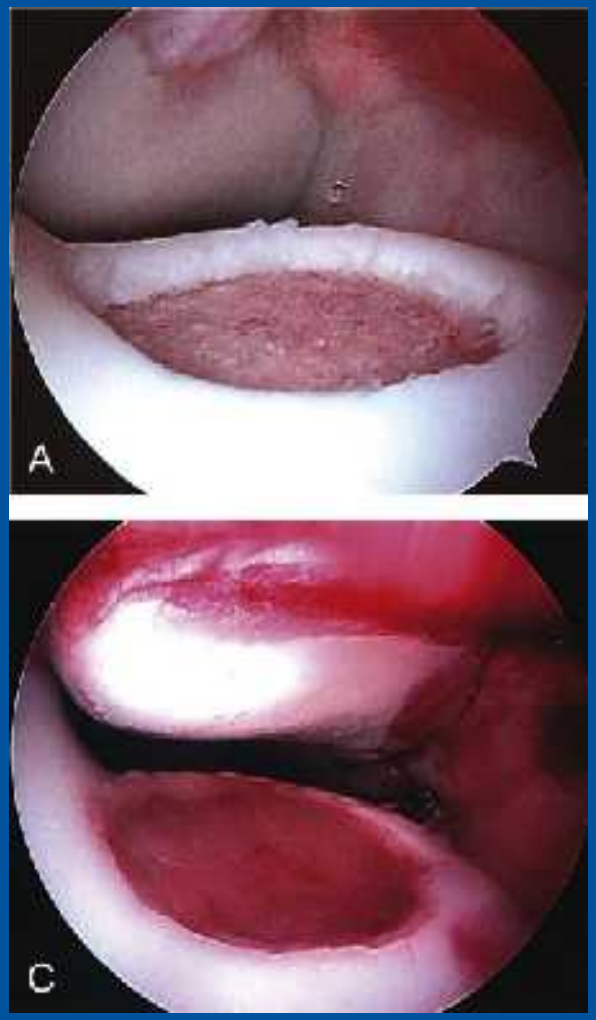
Gene Therapy in RA

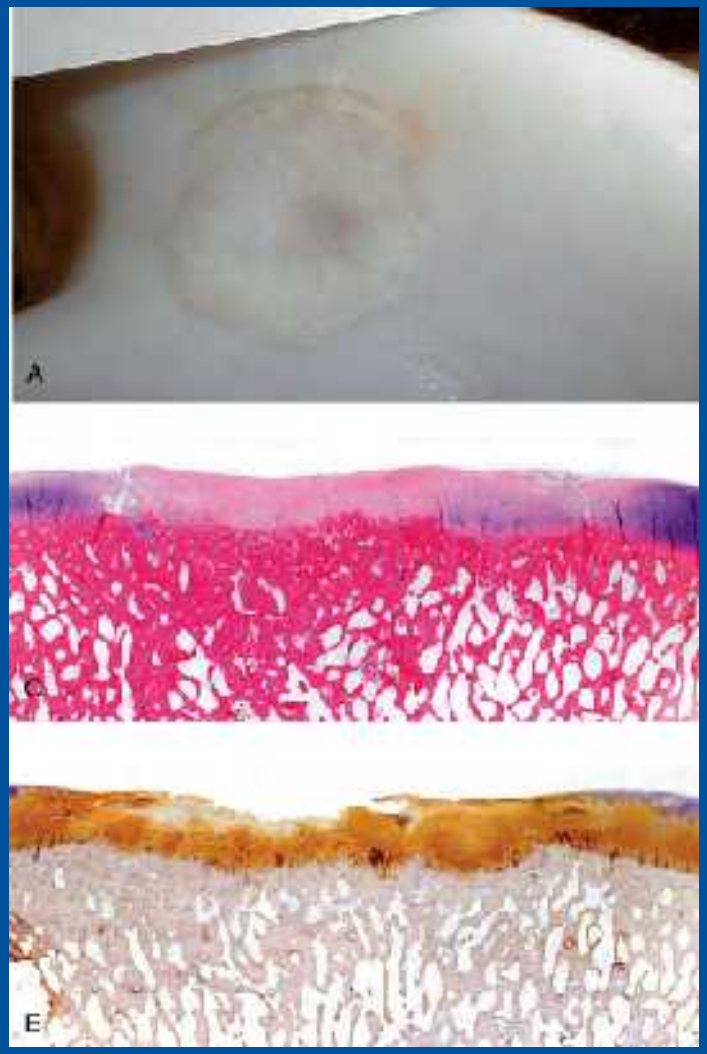


Osteoarthritis

- Complex aetiology
- Mechanical loading
- Cartilage degeneration

Enhanced Early Chondrogenesis in Articular Defects following Arthroscopic Mesenchymal Stem Cell Implantation in an Equine Model





Wilke, JOR 2007

Ultimately!!

- Gene therapy
- Local application of GF

3. Demographics

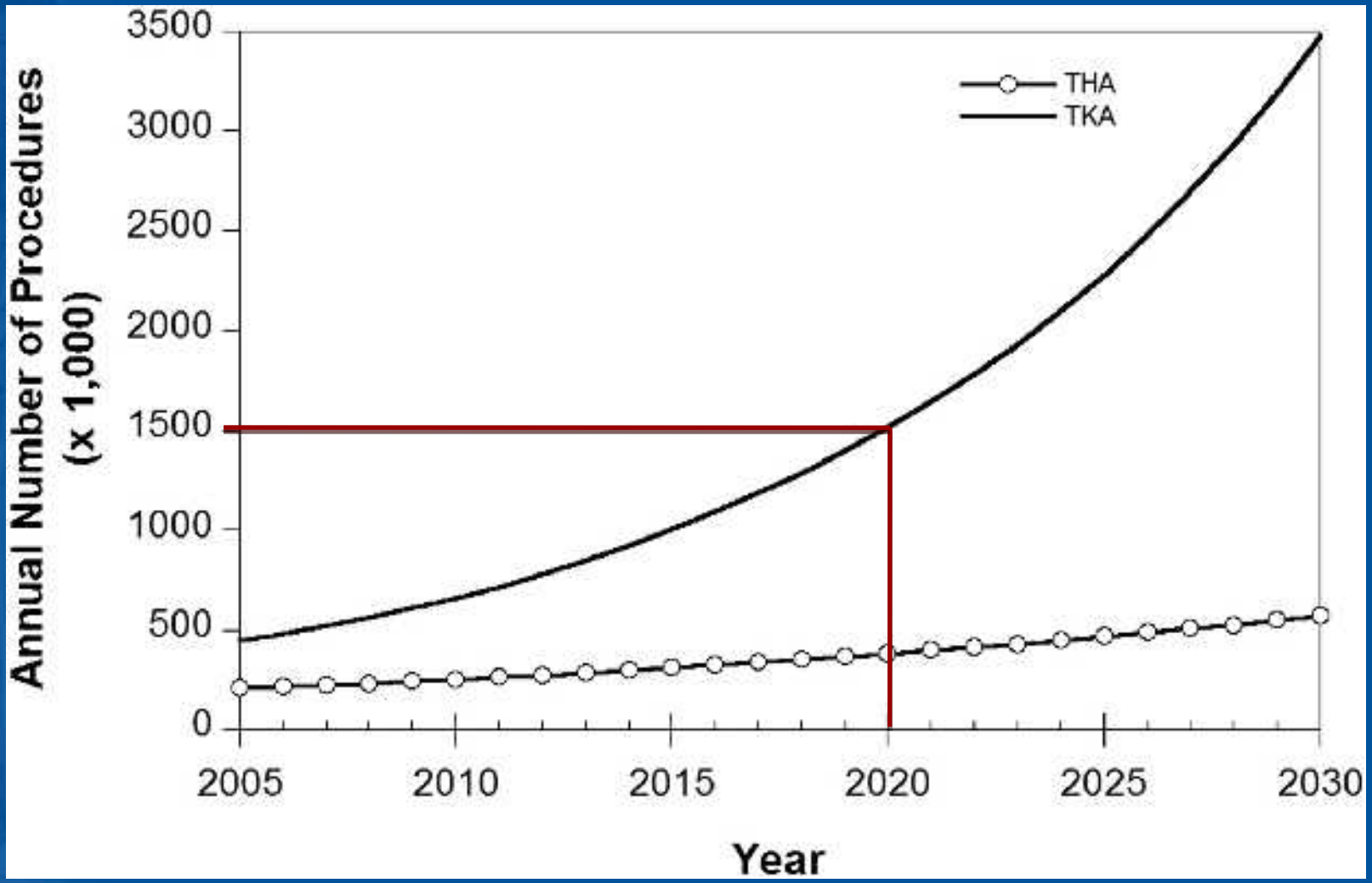
What will change in the following years?

Total Joint Demographics

2030

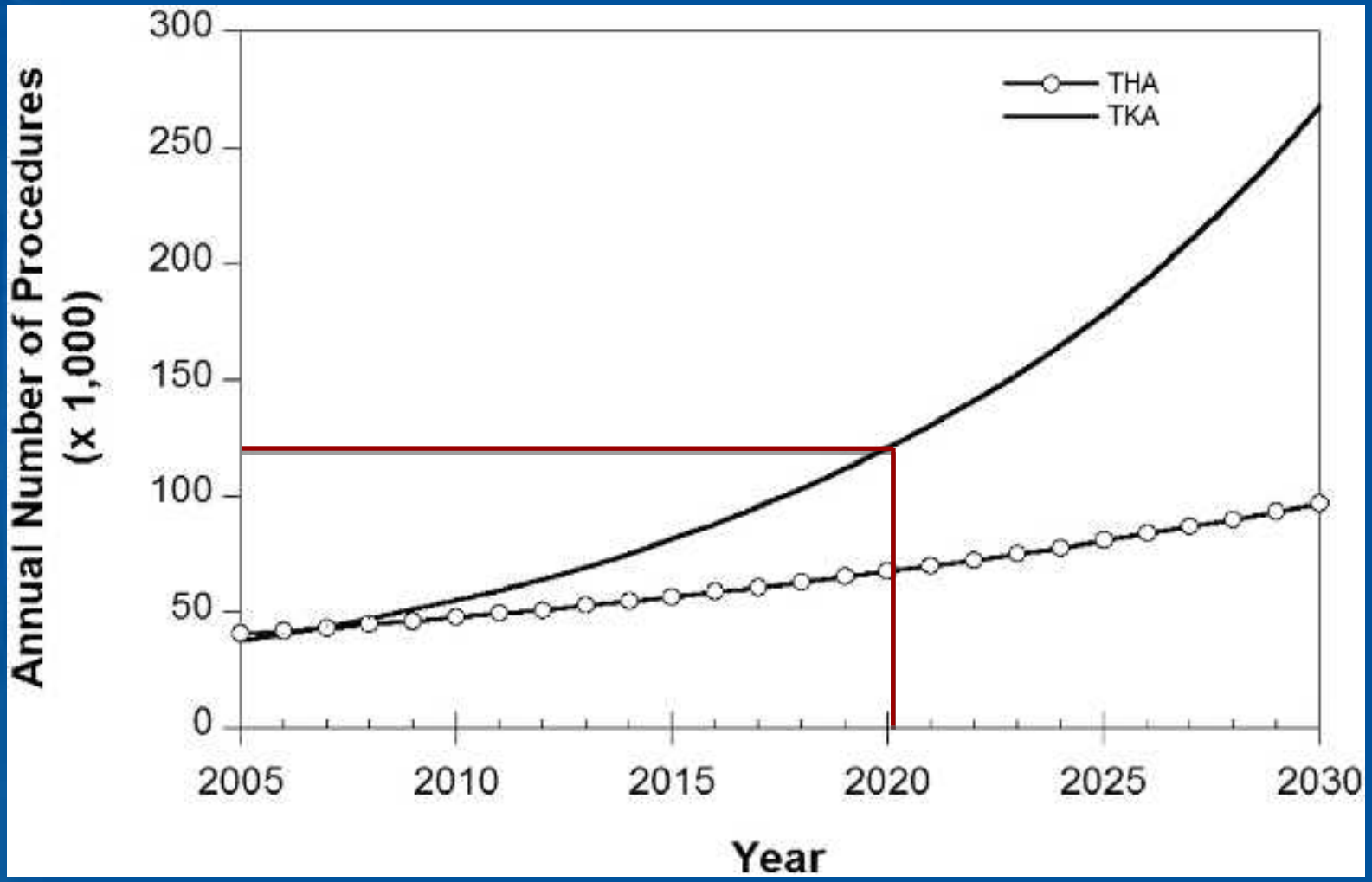
- 70 million in USA over age 65
- 41 million with arthritis

The projected number of primary THA and TKA procedures in the United States from 2005 to 2030



Kurtz, JBJS, 2007

The projected number of revision THA and TKA procedures in the United States from 2005 to 2030



Kurtz, JBJS, 2007

4. Surgical Technique

- MIS
- Computer guided surgery
- Surgical Robots

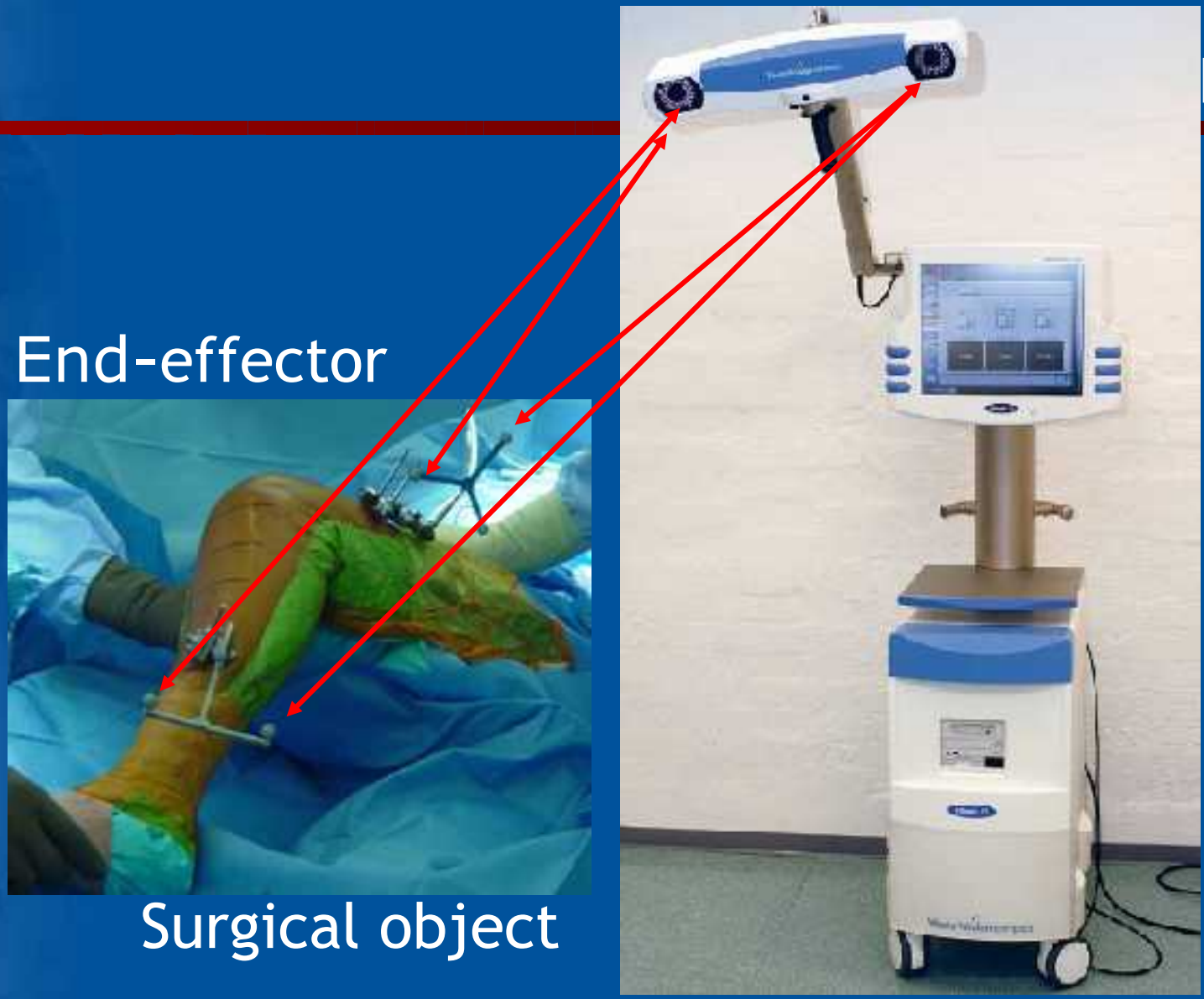
What are the potential benefits of MIS ?

- Less soft tissue disruption
  - Faster discharge
  - Quicker rehab and recovery
- Less blood loss
- Reduced pain
- Smaller scar

Computer-guided cutting systems

- Precision bone preparation
- No overcutting
- Perfect visibility
- Conformity between resections and implant

Intraoperative Navigation



Position sensor

Monitor

End-effector

Surgical object

Robotic Surgery: CASPAR

Decking, AOS 2004

5. The Operating Room of the Future

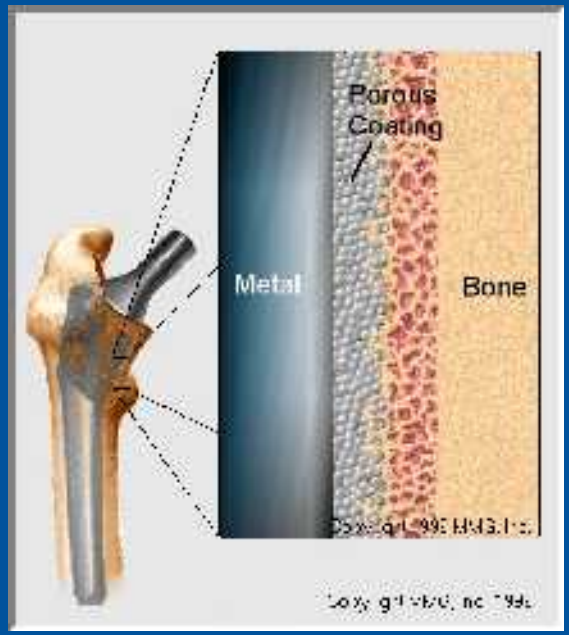
6. Osseointegration

Osseointegration

An implant is osseointegrated if it is stable under functional loads, without pain, inflammation, or loosening.

6. Cemented vs Cementless

All joint replacements will be cementless

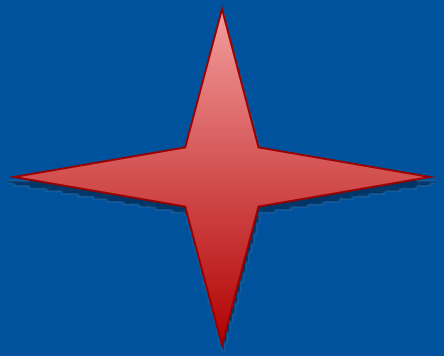


Hip Resurfacing

Factors Affecting Bone Ingrowth

Prosthetic Design Factors

- Mechanical stabilization
- Pore characteristics



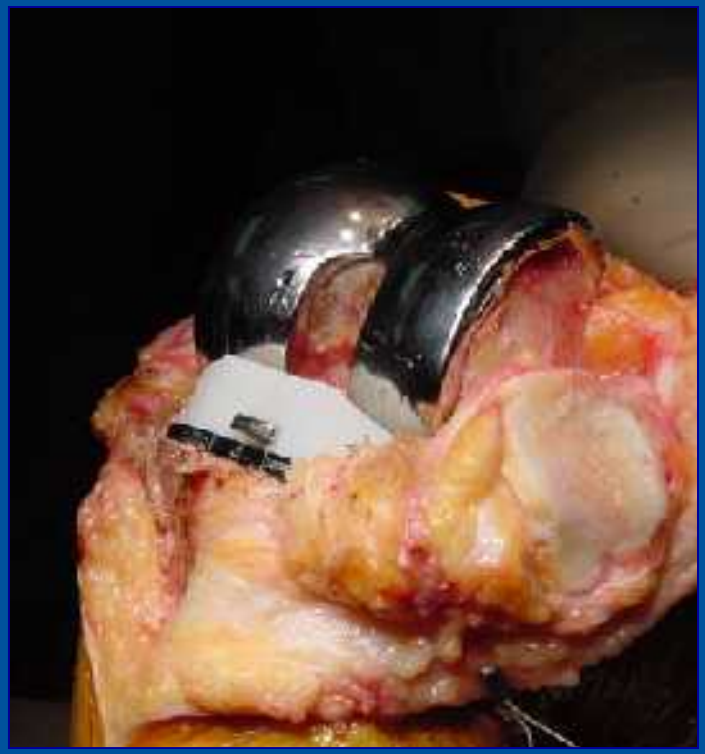
Host Factors

- Available bone stock
- Disease
- Aging

Adjuvant Therapies

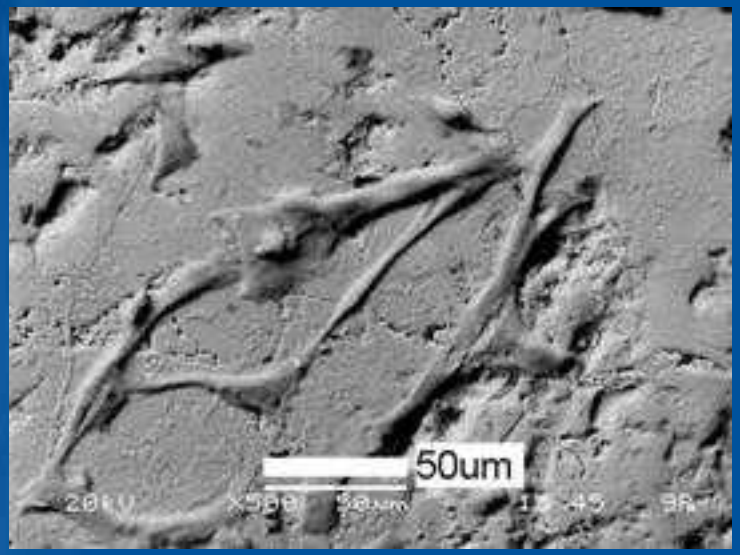
- bone graft material
- synthetic calcium phosphate
- collagen implants
- demineralized bone matrix
- bone growth factors
- electricity

Methods to Improve Bony Ingrowth



HA coating – surface improvement

- Rapid osseointegration
- Biointegration in 4 weeks – 90% of implant-bone contact at 10 months.



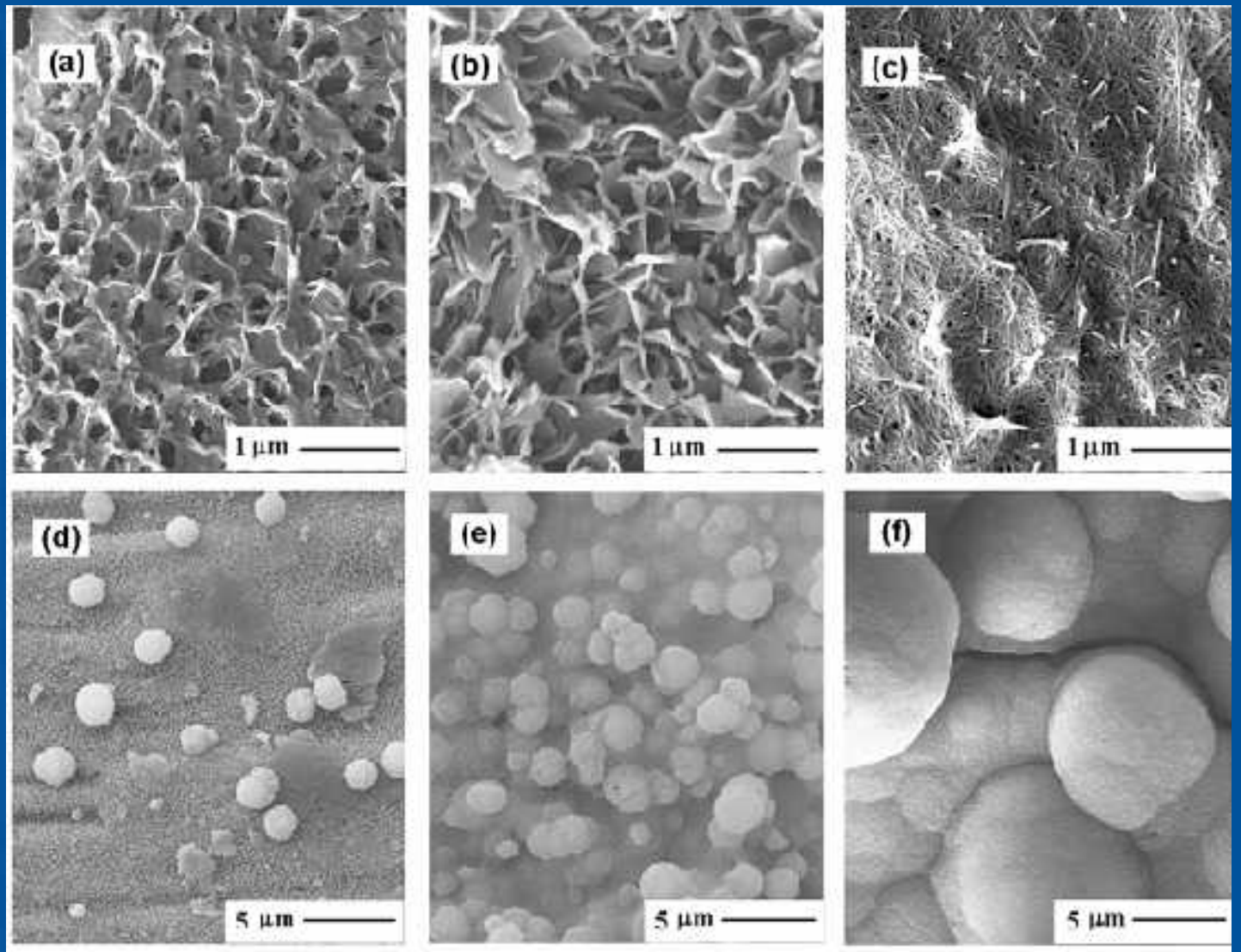
New Biomaterials

new frontiers in biomaterials engineering include:

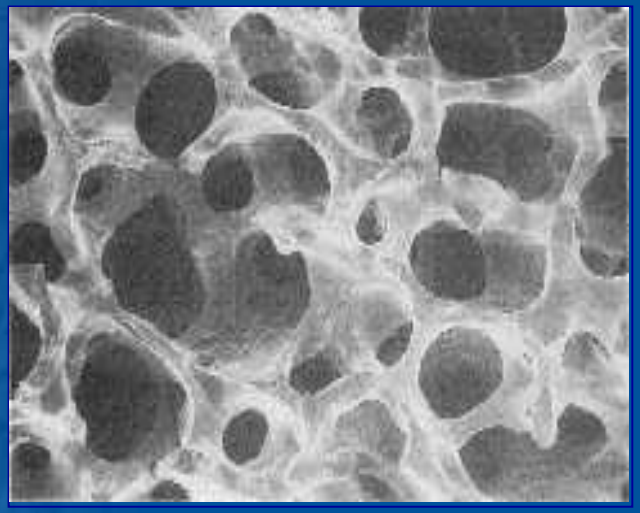
- Porous Coatings
- Bioactive Ceramics
- Bulk Metallic Glasses
- Tissue Engineering

- New substrates and coatings with enhanced biocompatibility
- Bioresorbable and biocompatible coatings with a graded interface and tailored porosity
- Biofilm inhibitors incorporated in the coating
- Biomimetics

Developing Novel Surfaces for Implant Materials

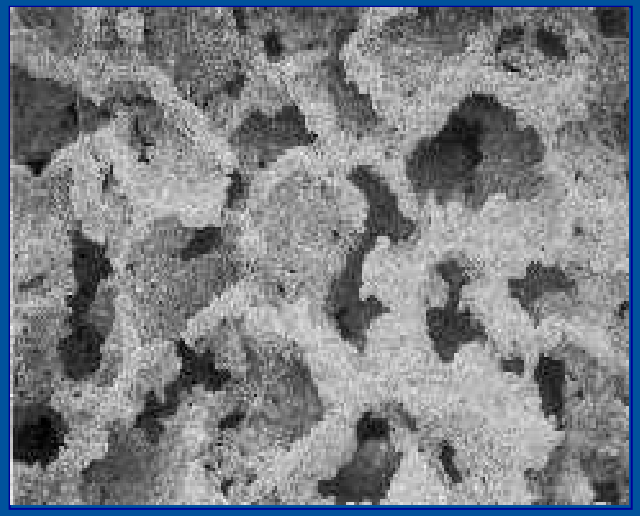


CSTi™ Interface Microstructure



Cancellous bone

Pores : 4 - 500 microns



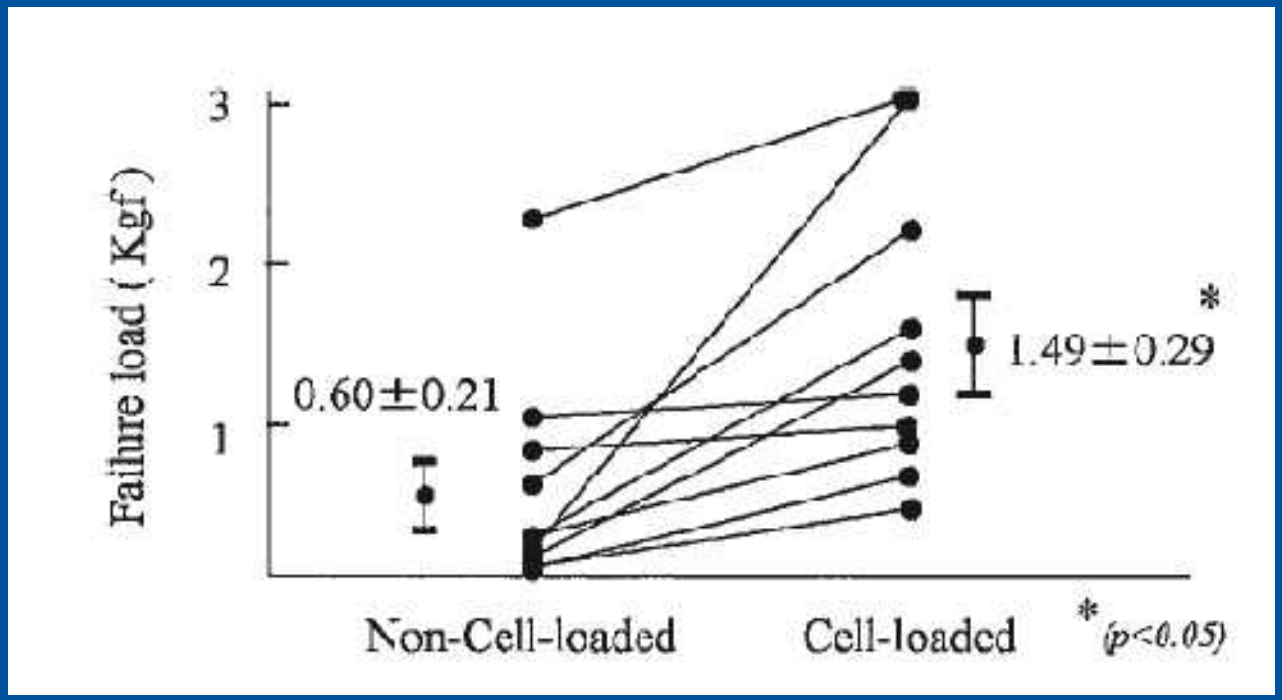
CSTi ™ (Natural - INNEX)

Pores : 4 - 500 microns

Porous Tantalum

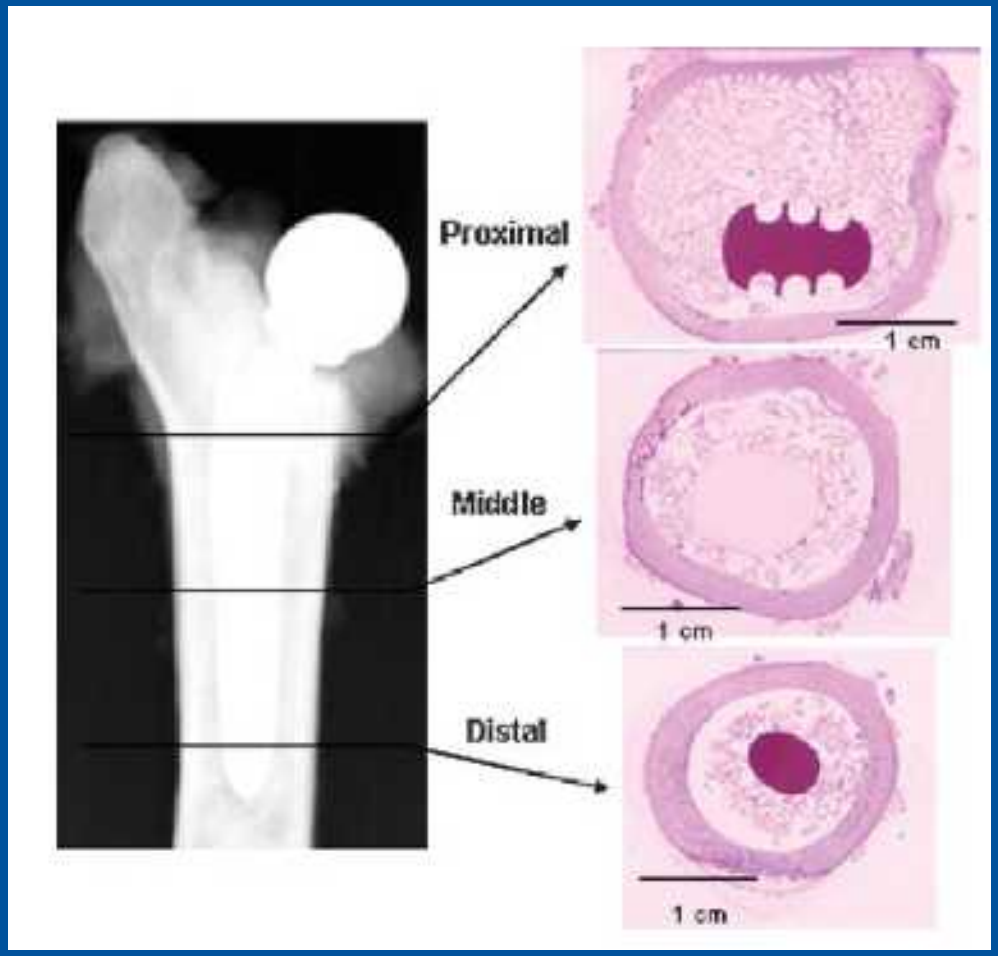
- alternative metal
- high volumetric porosity (70% to 80%)
- low modulus of elasticity (3 MPa)
- high frictional characteristics
- excellent biocompatibility

Seeding the implant surface with bone marrow mesenchymal cells



Tohma, JOR 2006

Mesenchymal Stem Cells to Enhance Bone Formation around Revision Hip Replacements



Korda, JOR 2008

7. Bearing Surfaces

Wear and Osteolysis

Bearing Options

THR

- metal or ceramic on compression molded or highly cross-linked polyethylene
- ceramic-on-ceramic
- metal-on metal articulations

TKR

metal-on-polyethylene

Wear Mechanism in TJR

TKR

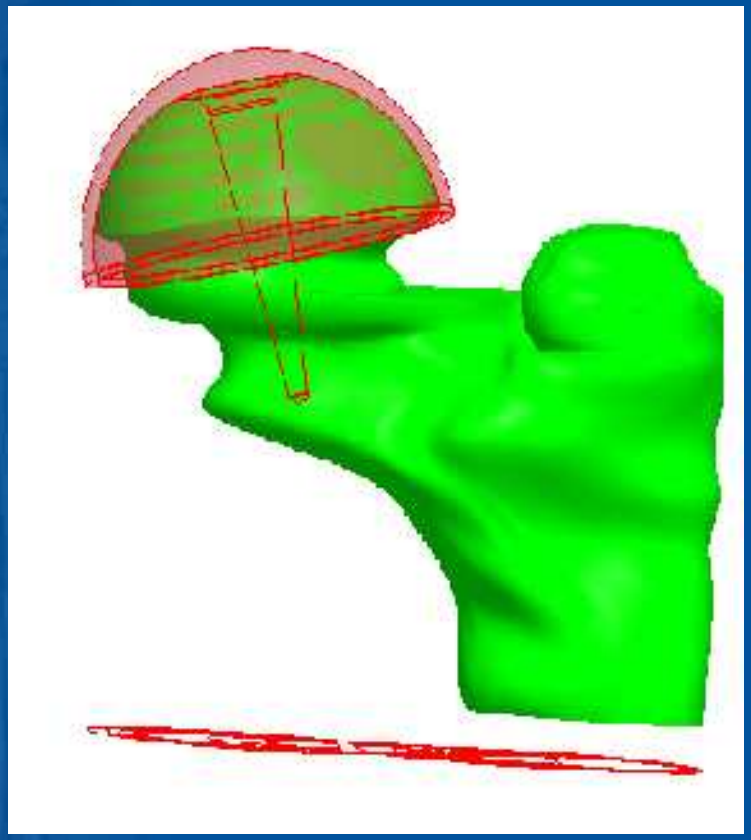
- Highly conforming
- Dominated by abrasion/ adhesion

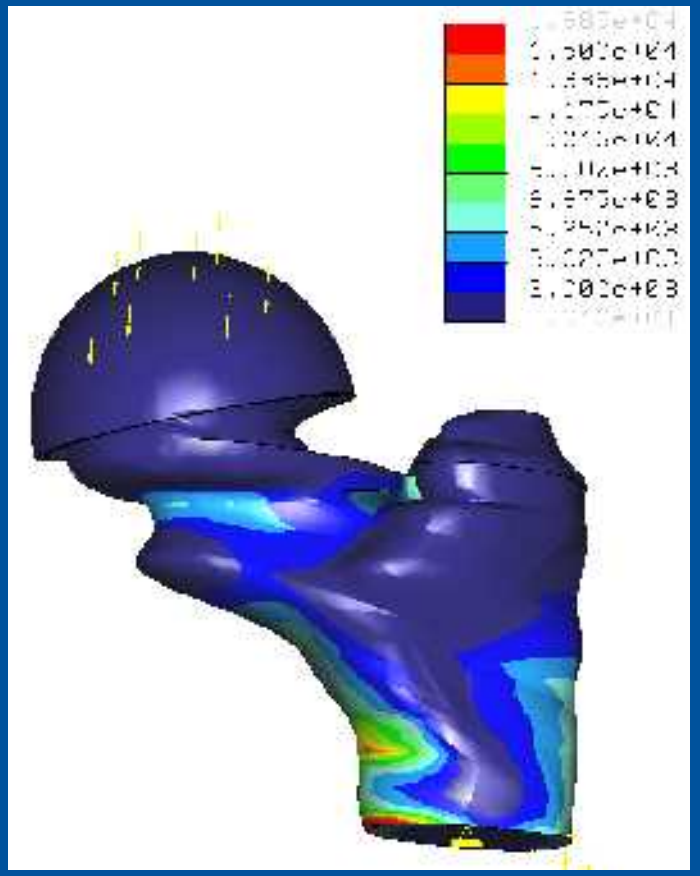
- Sliding
- Fatigue/Delamination

Wear

- Patient-specific
  - weight, activity level, joint kinematics
- Implant-specific
  - implant design and material factors
- Surgical factors
  - component position, orientation

Computer Simulation of Wear

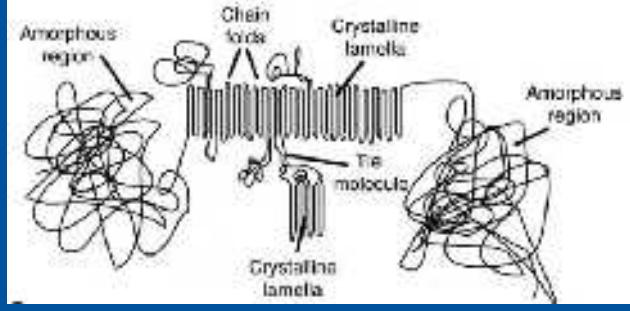




Improvements in Polyethylene

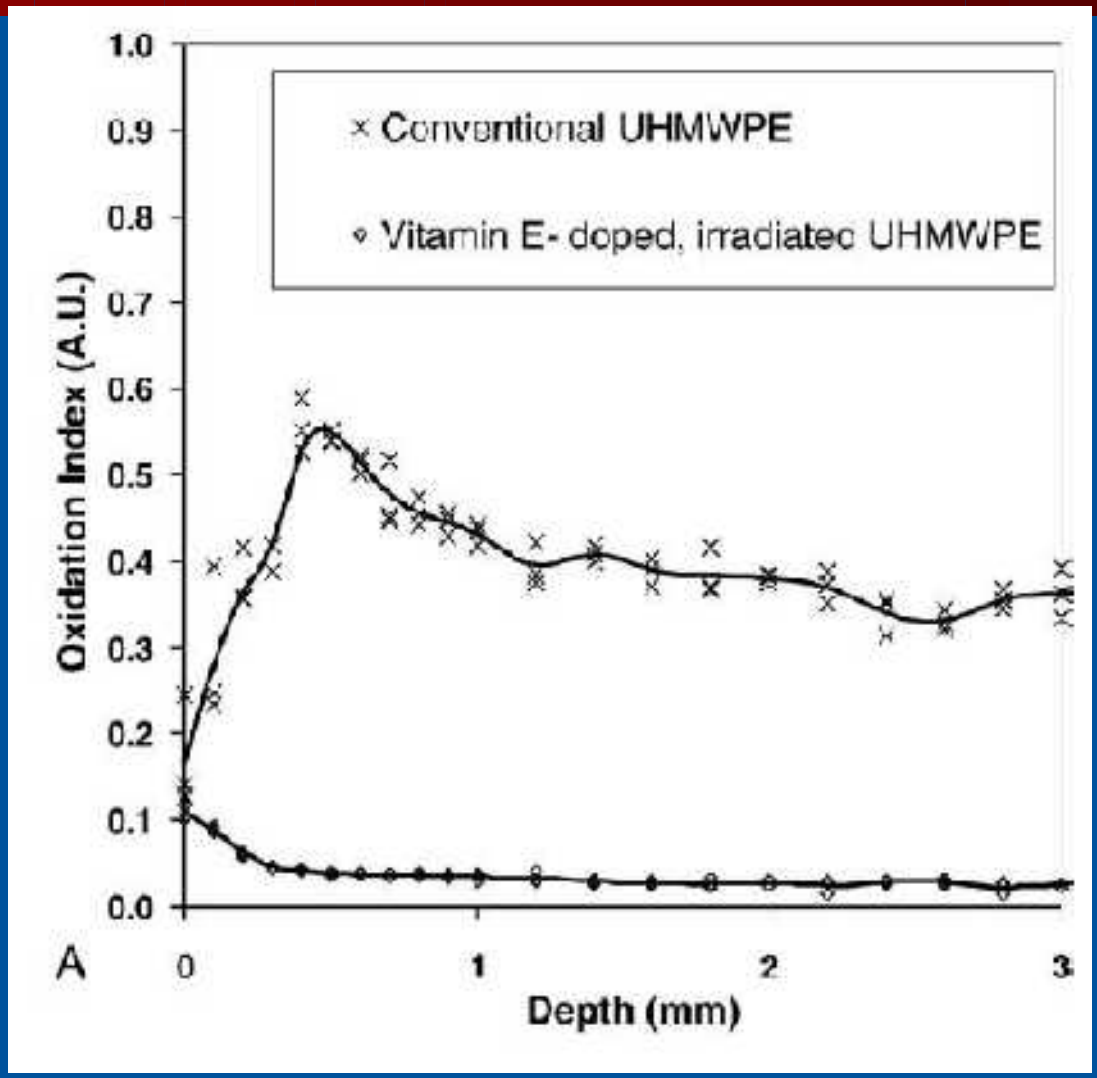
- Superior wear performance in laboratory testing
- Even the “routine” plastics have 90% less wear
- Even better with some of the “specialty” inserts
- Durability approaches “lifetime” even in younger patients
- An excellent alternative for both hips and knees

Cross-Linked UHMWPE

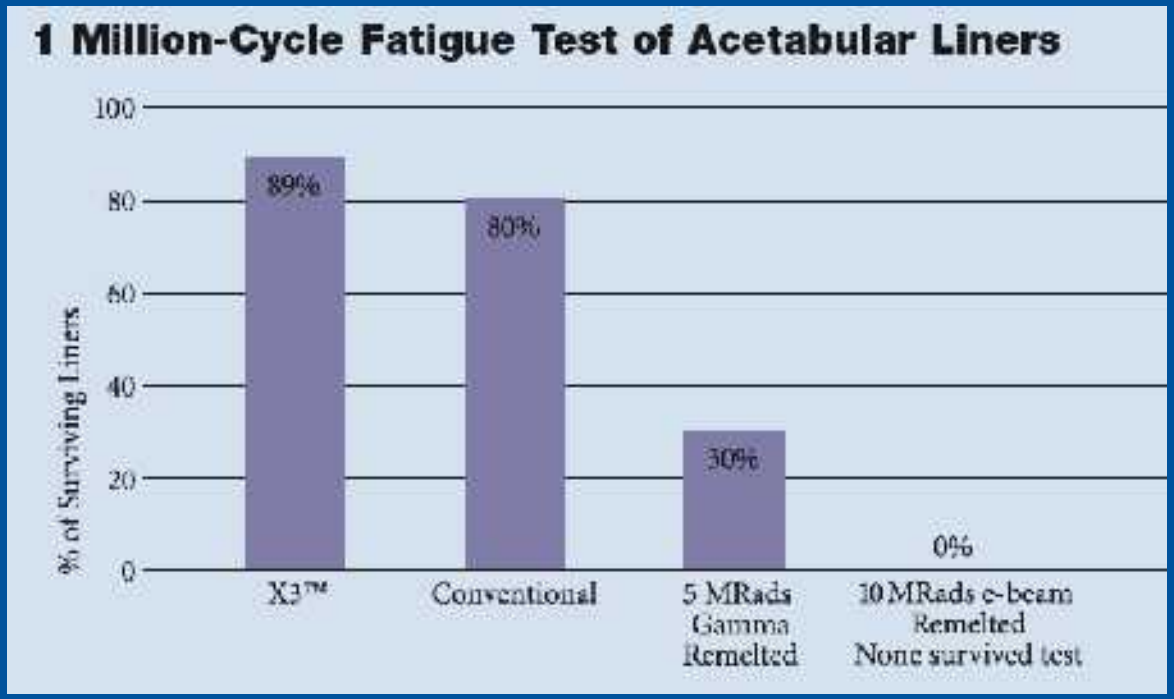


- impressive wear reduction
- it becomes more difficult for adhesive forces to separate molecules from each other
- harder than non cross-linked
- extreme cross-linking leads to brittleness

Vit E doped UHMWPE Oxidation Profile



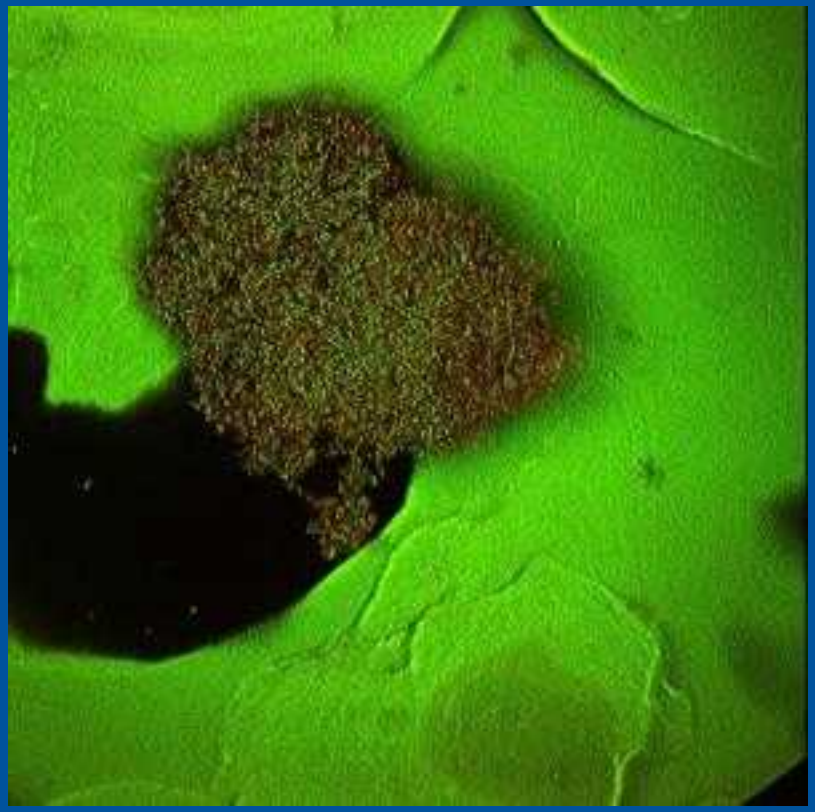
X3™ Sequentially Annealed Irradiated Polyethylene



- Superior Structural Fatigue Strength
- Greater Wear Reduction than first generation highly crosslinked polyethylene
- Oxidation Resistance

8. Infection

Infection: The Race for the Surface



Staphylococcus epidermidis

Stategies to eradicate infection

Implant optimization

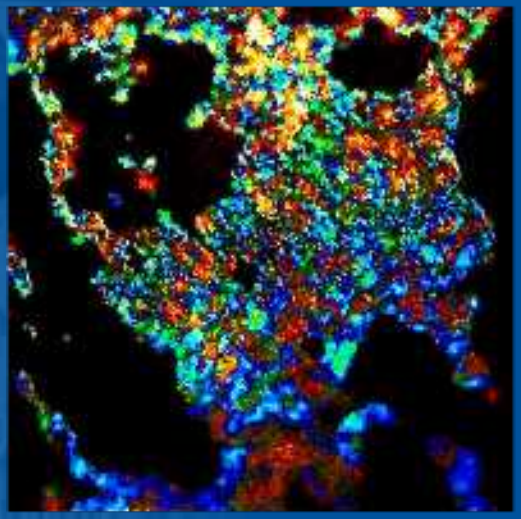
- Reduction of bacterial adherence
- Slow-release systems

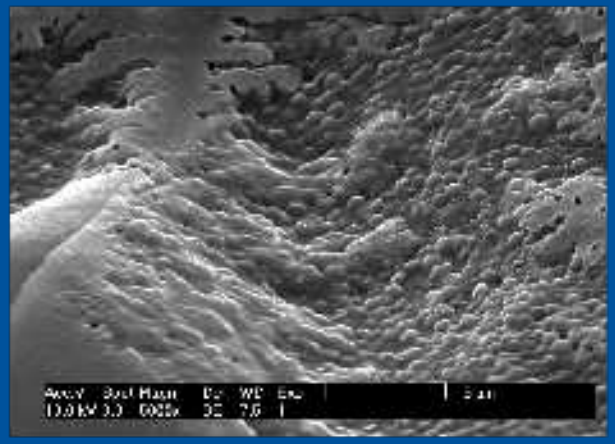
- ceramics [tricalcium phosphate, HA]
- biodegradable polymers

[PLA, PLLA, PDLLA, PGA, phosphate-PLA, poly-lactide-co-glycolide (PLGA)]

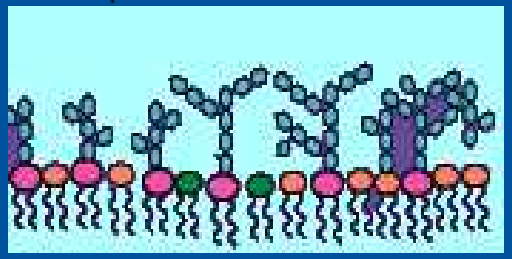
- polyanhydride
- collagen
- chitosan
- polyhydroxyalkanoate

Biofilm inhibiting coating





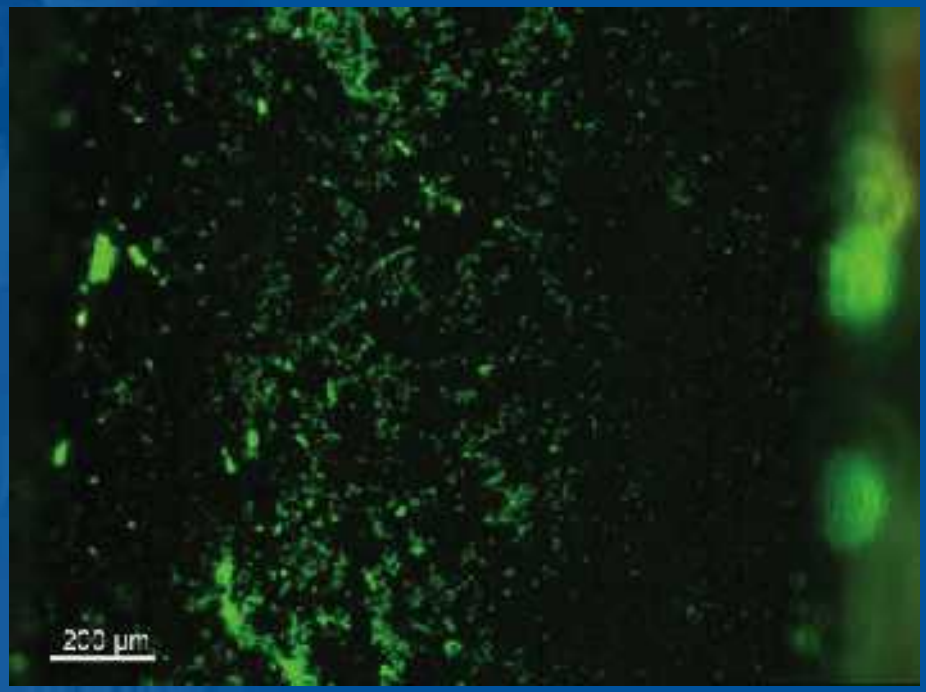
Staphylococcal biofilms



Drug delivery platform

Antiseptic and Antibiotic Coating

Kaelicke,JOR 2006

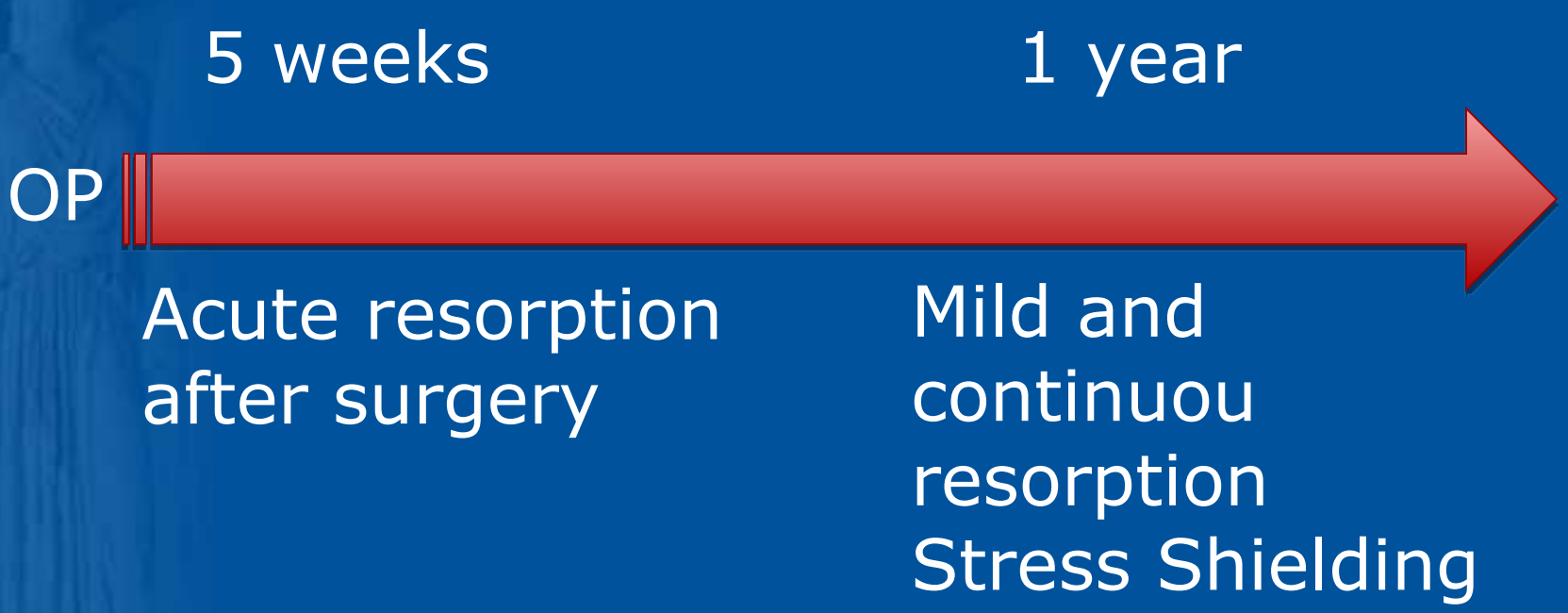


Ti plates without coating with adherent bacteria

Antibiotic-coated Ti plate with reduced bacterial adherence

9. Periprothetic Bone Loss

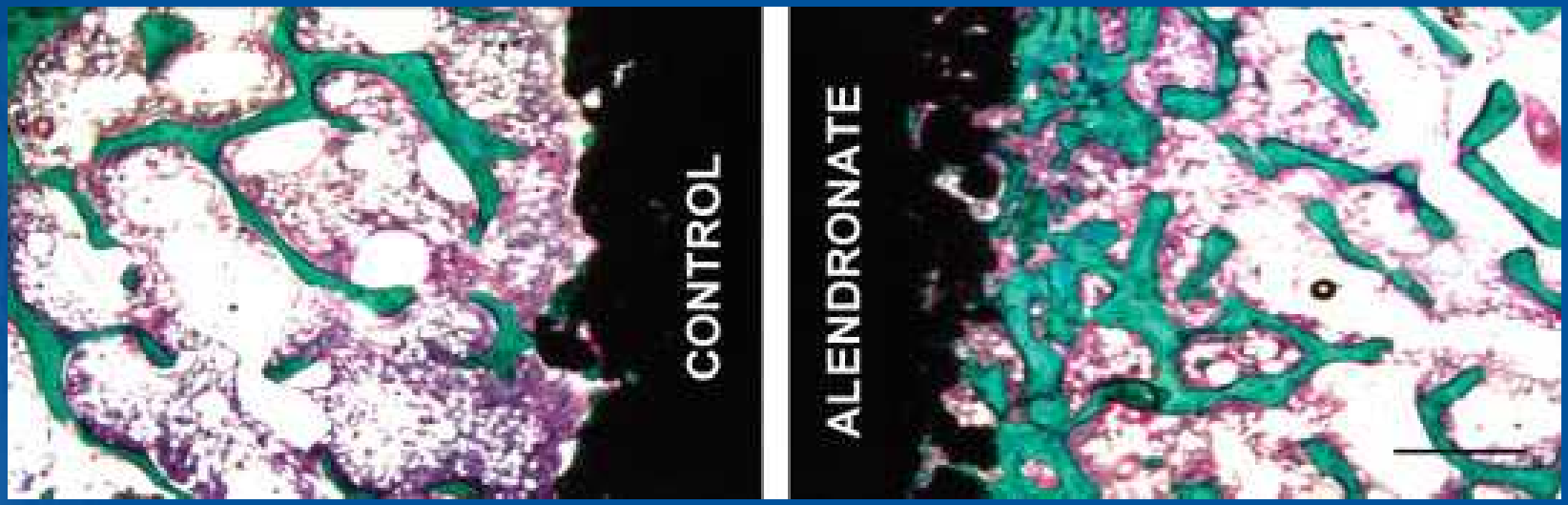
Bone Resorption after Cementless THR



Biphosphonates

Systemic bisphosphonate use may prevent periprosthetic bone loss associated with osteolysis and aseptic loosening around TJR's.

Local Bisphosphonate Treatment



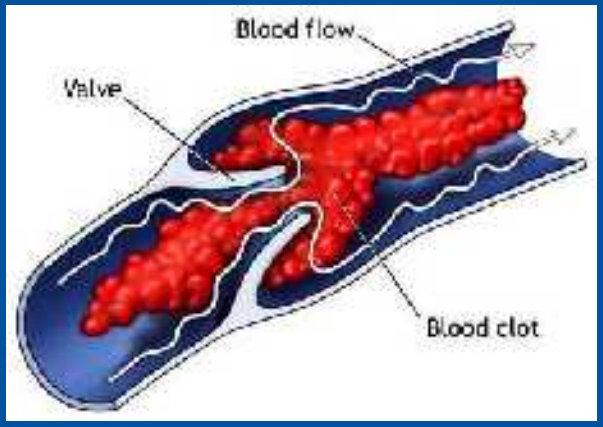
Jacobsen, JOR 2009

10. Thromboprophylaxis

10. Thromboprophylaxis

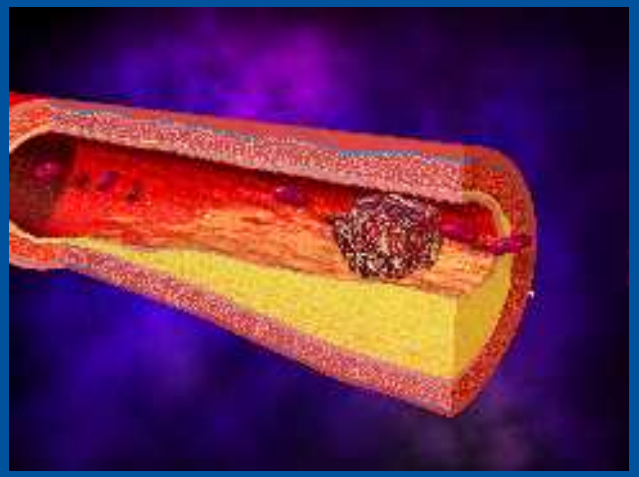
venographically proven VTE
in absence of a thromboprophylaxis

- THR: 45%-57%
- Hip #: 36%-60%
- TKR: 40%-84%



Thromboprophylaxis

- Extended pharmacological thromboprophylaxis is standard
- Complications 2-7%



Thromboprophylaxis

- Single dose
- Oral anticoagulant