Radiologic Assessment of Total Hip Arthroplasty: Loosening

Grant Garrigues, Harvard Medical School
Gillian Lieberman, MD
Anatomy

www.yoursurgery.com/ProcedureDetails.cfm?BR=5&Proc=27

www.hipandkneesurgery.net/hip_op.html
Patient JQ

- 67 year-old man
- Left THA 10 years ago
- Hip/thigh pain

What do you see?

Position

Lucencies

Density
Implant loosening

- >500,000 THA and TKA each year in US
- 10% are revisions of failed implants
- Overall, very successful
  - Aging population, obesity, more THA, younger patients vs.
  - Improved surgical technique, implant design, and pharmacotherapy

Total Hip Complications

Short-term

• Deep Venous Thrombosis (fatal PE, 0.3%)
• Nerve Palsies (1.7%)
• Vascular Complications (0.25%)
• Fracture/Perforations
• Dislocation (2-2.5%)
• Leg-length Discrepancy

Long-term

• Loosening (10%)
• Infection (1-5%)
• Heterotopic Ossification (significant, 8%)

Radiologic Assessment

• Assessment of long-term complications
  – **Loosening** is the most significant
• Plain films: great bone/metal visualization
• Radiographic features
  – Peri-implant lucency > 2mm
    • Describe using **Gruen Zones** (following slide)
  – Stress views / Interval change in position

Gruen Zones

www.orthoteers.co.uk/Nrujp~ij331m/Orththrloosening.htm
Other Modalities

• Arthrography
  – Effective joint space visualized
  – Aspirate and Biopsy

• CT and MRI
  – Metal artifact

• US and Nuclear medicine
  – Select applications

Ddx of Radiographic Loosening

• Peri-implant bone loss
  – Aseptic loosening
  – Infection
  – Stress Shielding / Adaptive remodeling
  – Aging / Osteoporosis

• Mechanical Failure
  – Catastrophic
  – Interfacial

Aseptic Loosening

- Most common cause of TJR failure
- Wear debris
  - Most generated at the articulating surface
  - Submicron UHMWPE, HA, TiAlV, CoCr particles
  - Spread throughout the “effective joint space”
  - Phagocytosed by macrophages
    - Induces bone resorption (osteolysis)
    - Formation of fibrous, granulomatous tissue

Willert and Semlitsch *JBMR* 1977.
Aseptic Loosening

Macrophages phagocytose wear debris, leading to two processes.

FBGC with wear debris

Osteoclast in Howship’s lacuna

Interfacial Membrane

Bone Resorption

Courtesy of Arun Shanbhag, MD
Head displacement: Millions of submicron polyethylene particles created with each step
Aseptic Loosening

- Wear debris is the prevailing theory
- Hydrodynamic pressure may also contribute to aseptic loosening
  - Early loosening from periprosthetic bone loss
    - Trauma, chemicals, and thermal damage
  - Joint pressures >700 mmHg
    - “Pumping action” of loosened implants
    - May cause aseptic loosening without particles
    - Similar to mechanism of subchondral cysts in OA

Aseptic Loosening

Sequellae
- Painful loosening
- Revision arthroplasty
- Pathologic fractures

Osteolysis leading to pathologic avulsion fracture


Grant Garrigues, 2004
Gillian Lieberman, MD
Septic Loosening

• Less common today
  – Laminar flow OR
  – UV lights
  – Prophylactic Antibiotics

• Foreign body nidus
  – Pathogens adhere to biomaterials
  – S. epidermidis produces glycocalyx
Septic Loosening

- Radiographs mimic aseptic loosening
- Dx often with arthrogram and clinical correlation
  - Peri-implant bone loss
  - Sinus tracts
  - Joint fluid aspiration: (culture, gram stain, etc.)
  - Synovial biopsy
- Nuclear Med
  - Tc-99m nonspecific
  - In-111 leukocytes preferred

Septic Loosening

Sequellae

• Painful implant loosening
• Revision arthroplasty
  – Sterilize site before reimplantation
  – Antibiotic impregnated cement spacers
• Sepsis, osteomyelitis, sinus tracts

Stress Shielding

- Loading transferred from bone to stiffer prosthesis


Stress Shielding

• Stress transferred through stem
  – Metal is stiffer than bone
  – Bypasses proximal periprosthetic bone

• Resorption of bone around proximal femoral shaft (Wolff’s Law)

• More common in uncemented
• Increased risk of pathologic fracture

Friedman RJ et al. JBJS, 1993.

Mechanical Failure

• Catastrophic failure is rare
  – Fractured stem
  – Shattered Zirconia ceramic heads
• Interface failure most common
  – Cement fatigue fracture
  – Debonding of cement-implant interface
  – Porous coating fracture
Mechanical Failure

Cement Fracture

Debonding: implant-cement interface is disrupted

Subsidence: implant slides into medullary canal

Cortical Reaction
Porous Coating Fatigue

Porous coatings, fiber-metal mesh, and other surfaces allow bone in-growth to cementless implants.

Cross-section through fiber-metal mesh shows bone in-growth.

Multiple loose beads.
Summary: JQ

- 67 year-old man
- Left THA
- Hip/thigh pain

- Osteolytic Lesions
- Volumetric wear
- Varus shift
- Subsidence

- Cortical Reaction
- Stress Fracture

Aseptic Loosening of uncemented femoral component
Other THA Complications

• We have discussed *loosening*, the most common complication of THA, in detail.

• Bonus cases of other radiographically assessable complications follow…
This is a powerful reminder of the possibility of fat emboli forced through bridging veins by manipulation in the medullary canal.

Heterotopic ossification:
This patient had a h/o spondylitis but any joint procedure has a small chance of this complication.
References

- Willert and Semlisch. *JBMR*, 1997
Acknowledgements

Special Thanks to:
• Ferris Hall, MD
• Arun Shanbhag, PhD
• Harry Rubash, MD
• Pamela Lepkowskki
• Larry Barbaras
• Gillian Lieberman, MD