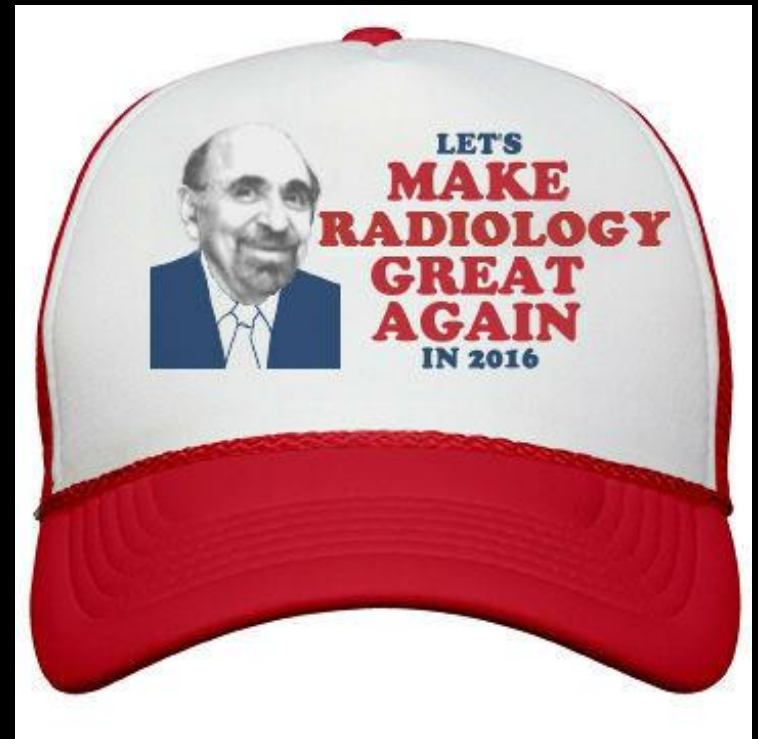




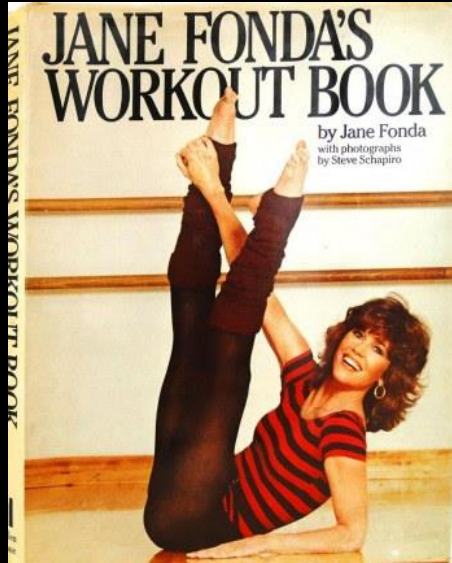
Hip Arthroplasty

Vincent Paul, MD



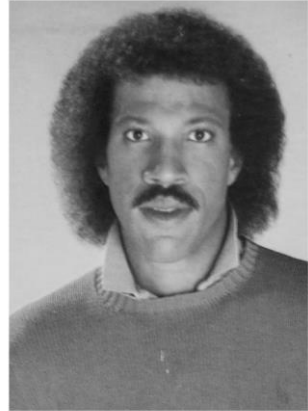
Outline

- History
- Indications
- Equipment /Technique
- Expected Outcomes
 - Imaging
- Unexpected Outcomes
 - Complications
- Future Developments



"I got a double hip replacement, and now I'm twice as hip as I used to be." - Billy Joel

Hello?



Is it me you're looking for?

I can see it in your eyes
I can see it in your smile
You're all I've ever wanted
(find) my arms are open wide
'Cause you know just what to say
And you know just what to do
And I want to tell you so much
I love you
'Cause I wonder where you are
And I wonder what you do
Are you somewhere feeling lonely?
Or is someone loving you?
Tell me how to win your heart
For I haven't got a clue
But let me start by saying
I love you





“Image #4. Lou Gehrig. Ok boss. Give me another one.”



“Michael Jordan?”



“Easy. Twenty-th....”



“No, when he played for the White Sox.”



“45.”



di BARRY LITVINSON regia

SMITAMAN

UN FILM A TRETTA PERSONE

di GEORGE-PETER DEKONINCKO, MICHAEL STUPEL e BARRY LITVINSON con
DINO DI MONTAGNA, SCHERAZADE ADRI, NATH, ENZO ANGILERI,
MELISSA PONSINO, JOE BONOMO, JAMES VAN DER BEEK, STACY KEACH, JEFF
KOPPEL e ANDREW PETERSCHE con JOHN P. FLYNN
MUSIC BY RONALD FELD con JERRY BRONSON / PRODUCED BY MARK ZORNIN
DISTRIBUTOR BARRY LITVINSON

IN CINEMA DA DICEMBRE

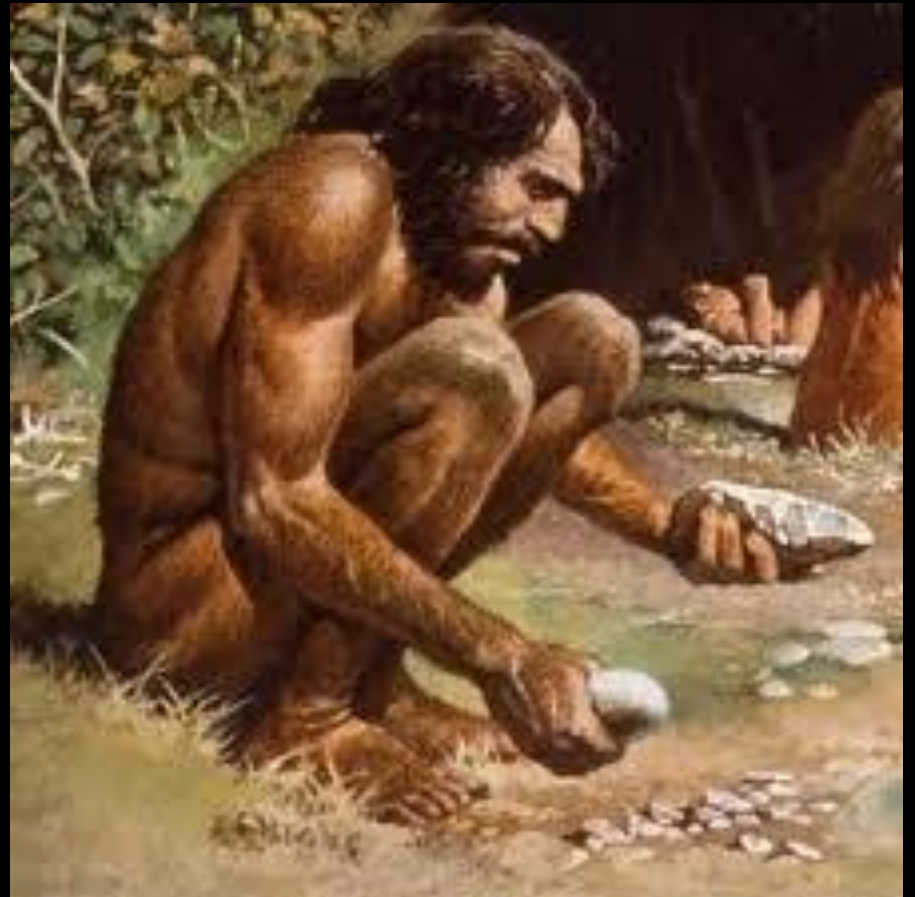


Hip Arthroplasty

- Evolved from a salvage procedure with long-term outcomes reserved for the most infirm patients, to one of the most successful and frequently undertaken elective surgeries
- Among all surgical procedures only coronary bypass compares to THA in terms of effectiveness and improvement in quality of life



“Patients usually do well with conservative therapy. It worked for the cavemen.”



Hip Arthroplasty

- Year 2000 - 138,700 performed
- Year 2010 - 310,800 performed
- Average cost - \$30,124
 - Source: Analysis of Blue Health Intelligence® (BHI®) data 2015
- By year 2010 - 2.5 million in the US were living with a hip replacement
- THA successful in 85-95% of cases

Hip Arthroplasty

- Indications
 - Osteoarthritis
 - Risk factors
 - Female sex
 - Advanced age (\geq to 65 years)
 - Obesity
 - Osteonecrosis
 - Femoral neck fracture
 - Developmental dysplasia of the hip
 - Inflammatory arthritis

History

1821 – Anthony White performed the **first excision arthroplasty**

1826 – John Barton performed the **first osteotomy on an ankylosed hip**

1885 – Leopold Ollier Described the **interposition of adipose tissue** in uninfected joints

1891 – Themistocles Gluck produced an **ivory ball and socket joint fixed to bone with nickel plated screws**

1936 – **Vitallium** is manufactured, a cobalt-chromium alloy

1962 - Sir John Charnley's **hip replacement** becomes a gold standard in treatment as he is considered the pioneer of present day techniques

Sir John Charnley (1911 – 1982)

- Pioneered modern THA in the 1960's.
- *“The cart has been put before the horse; the artificial joint has been made and used, and now we are trying to find out how and why it fails.” - 1956*
- Fully committed himself to the study of hip arthritis
- 1961 - Built a lab at an isolated former TB sanatorium at Wrightington, Manchester, England



Charnley PROSTHESIS

for low-friction Arthroplasty of the Hip-joint.



SOLE AUTHORISED MANUFACTURER

Photo of Charnley prosthesis advertisement, courtesy
Journal of Bone and Joint Surgery

Charnley - Pioneer

- Realized low friction was key
- 1956 – Started using polytetrafluoroethylene (PTFE)
 - Self lubricating
 - Disadvantages
 - Exhibited elevated wear rates in vivo (0.5 mm per month)
 - The wear debris elicited an intense foreign body reaction
- Eventually he started using Ultra High Molecular Weight Polyethylene
 - Excellent wear resistance
 - Low friction
 - High impact strength
- 1962 – He inserted the first UHMWP socket

Charnley Prosthesis

- Implant survivorship
- >80% at 20 years
- 78% at 35 years



--Caton J, Prudhon JL. Over 25 years survival after Charnley's total hip arthroplasty. *Int Orthop* 2011; **35**: 185–88.

--Callaghan JJ, et al. Survivorship of a Charnley total hip arthroplasty. A concise follow-up, at a minimum of thirty-five years, of previous reports. *J Bone Joint Surg Am* 2009; **91**: 2617–21.

<http://luigigentilemd.com/HipKnee/THE%20CHARNLEY%20TOTAL%20HIP%20REPLACEMENT.htm>

Surgical Alternatives

- Amputation
- Excision Arthroplasty
 - Improved pain
 - Preserved mobility at the expense of stability
- Girdlestone resection arthroplasty
- Hip arthrodesis

Girdlestone Procedure

- Developed in 1928
 - Was a lifesaving measure to remove diseased and devitalized TB hips in the preantibiotic era
- Indications
 - Primary – (Septic and TB)
 - Secondary
 - Now reserved for those patients who are not candidates for revision surgery
 - Periprosthetic infection
 - Aseptic loosening
 - Recurrent dislocation
 - Failed ORIF of femoral neck fractures

“If thine femoral head offend thee, pluck it out and cast it from thee.”

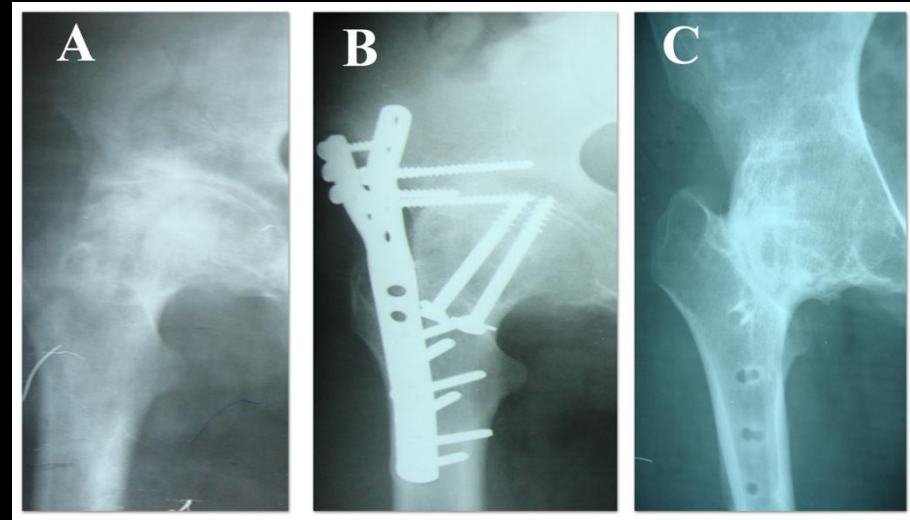
-Gathrone Girdlestone



Case courtesy of Dr James Sheldon, Radiopaedia.org, rID: 25420

Hip Arthrodesis

- Role has diminished since introduction of THA
- Potential candidates
 - Patients <40 years
 - Noninflammatory monoarticular endstage hip arthrosis



Hoekman, Patrick, et al. "Hip arthrodesis with the anterolateral plate: an innovating technique for an orphaned procedure." *PLoS one* 9.1 (2014): e85868.

Modern Hip Arthroplasty

- Hemiarthroplasty
- Total Hip Arthroplasty

Hemiarthroplasty

- Femoral side only
- Less complicated procedure
- Indications
 - Fracture
 - AVN
- Unipolar
- Bipolar

Moore Unipolar



Miller, Theodore T. "Imaging of hip arthroplasty." *Seminars in musculoskeletal radiology*. Vol. 10. No. 1. Thieme, 2006.

Bipolar Hemiarthroplasty

- There are two articular sites:
 - The outer cup with the native acetabulum
 - The metallic femoral head with the polyethylene inside the outer cup



Total Hip Arthroplasty

- Modular Systems
 - Intended to allow a more accurate reproduction of patient anatomy
 - Adjusts for leg length discrepancies
 - Easier revision
- Disadvantages
 - Increased fatigue failure
 - Fretting and crevice corrosion



Rejuvenate Stem

- MoM Implant
- Recalled 2012
- Risks associated with modular neck stems



Bearing Surfaces

- Ideal
 - Low friction
 - Minimize wear
 - Resist fracture
 - No immune response to debris
- No perfect surface exists

- Metal



- Ceramic



- Plastic



MoP – Metal on Polyethylene

- Majority of procedures
- UHMWPE – Ultra-high Molecular Weight Polyethylene
- Highly Cross-linked Polyethylene (HXLPE)
 - Recent products to improve durability and wear rates
 - Promising – in vitro
 - Mixed results – in vivo
 - ↑Immune response



Acetabulum

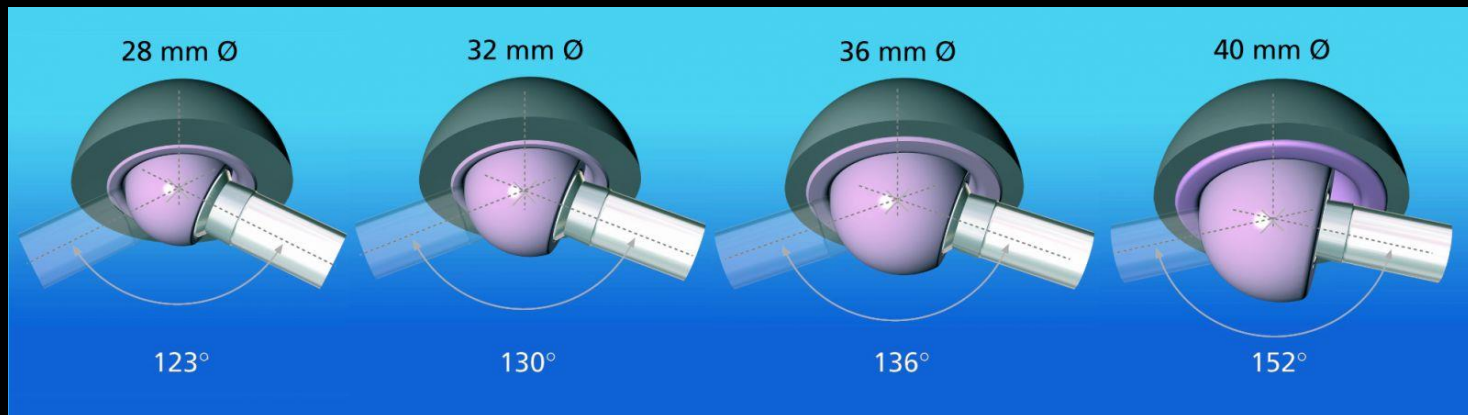
- Monoblock
 - Single piece
 - Poly or metal
- Modular
 - Shell and Liner
- Cement v. Cementless
 - Benefits controversial
 - Multiple meta-analyses have failed to show benefit of 1 or the other
- Porous Coating
 - Allows Ingrowth



Femoral Component

- Diverse set of options to complement complexity between anatomy
- Head
 - Metal
 - Ceramic
- Head size
- Recent trend to increase head size
 - Allows greater ROM
 - Decrease dislocation rates
 - Increased wear
 - 🙄 Not recommended in MoM

↑Image courtesy of Ron Kapil



Femoral Stem

- Metal stem
 - Chromium cobalt
 - Titanium



<http://www.zimmer.com/medical-professionals/products/hip/zmr-hip.html>

Femoral Stem

- Stem Fixation
 - Cement
 - Cementless with porous coating
 - Allows for bone ingrowth

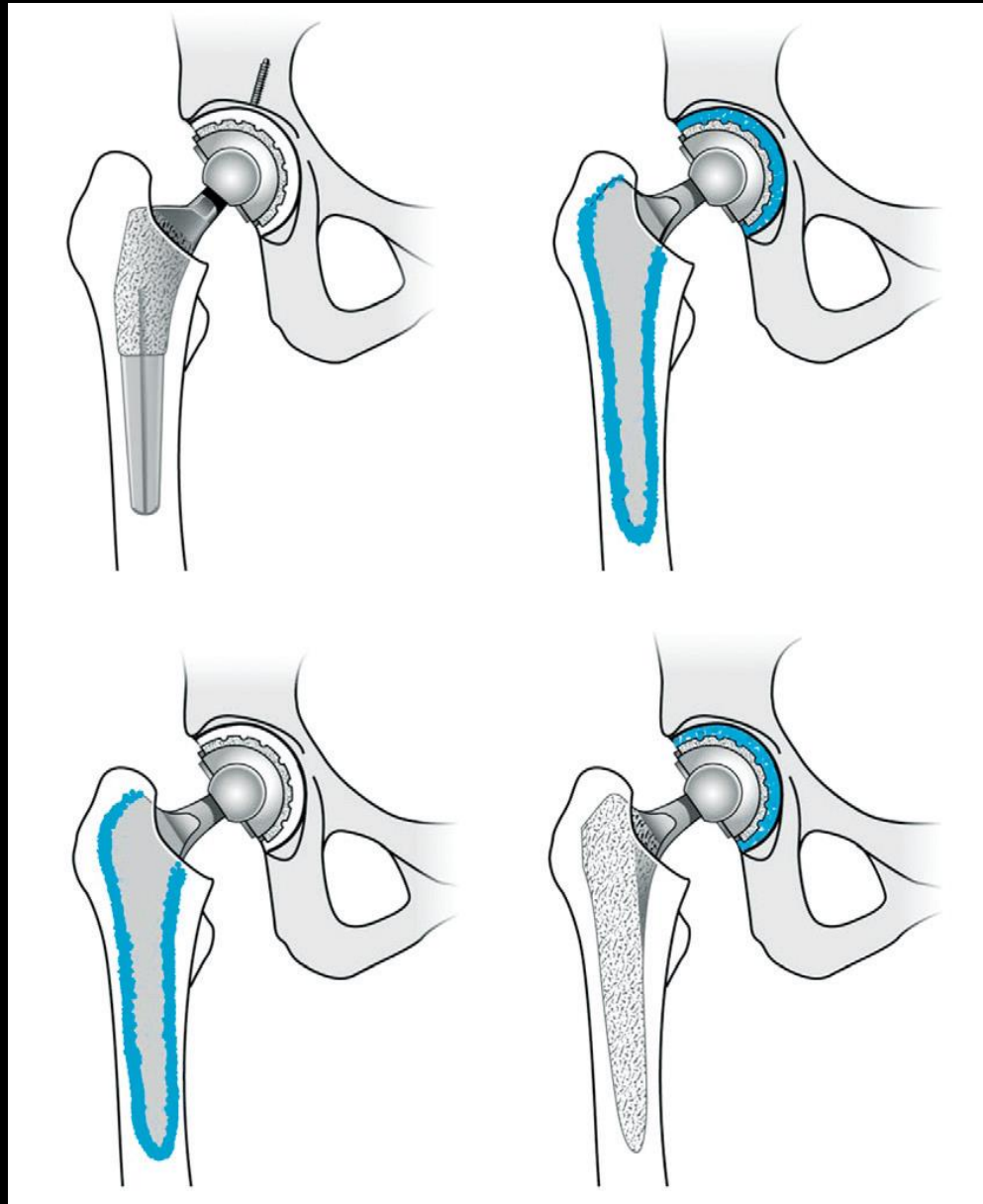
Cementless

- Typically uses a porous coating to enhance stability and encourage tissue ingrowth
- Osseointegration
- Confirmed histiologically



CEMENTLESS

CEMENTED



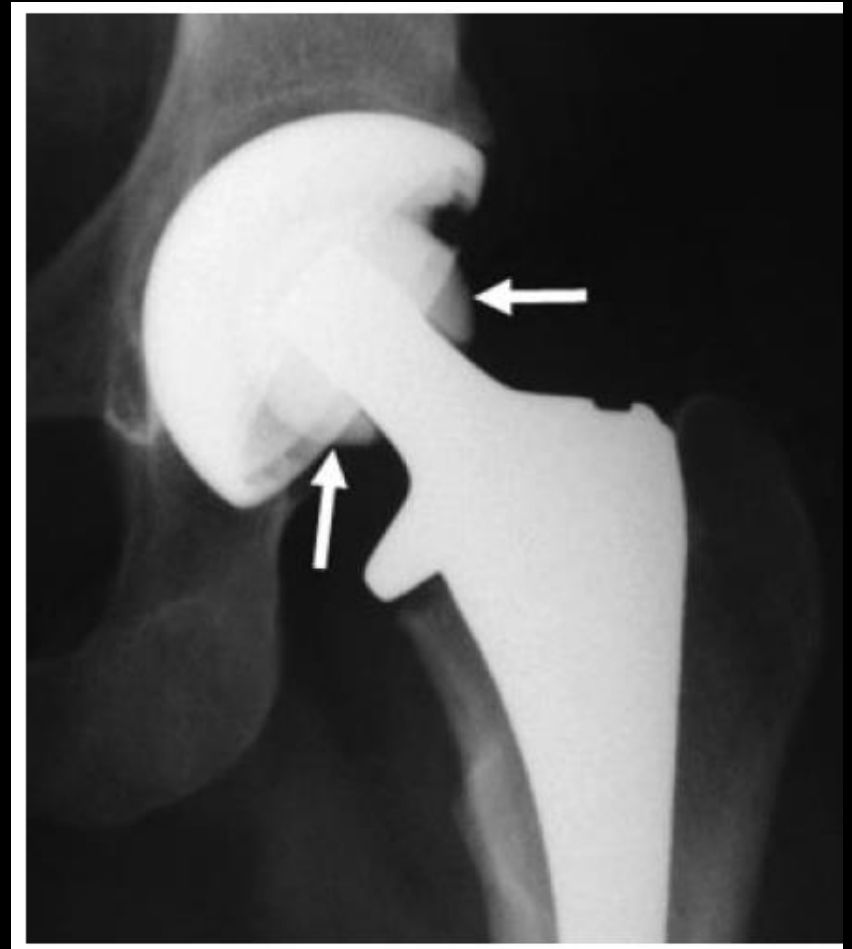
HYBRID

REVERSE HYBRID

Pivec, Robert, et al. "Hip arthroplasty." *The Lancet* 380.9855 (2012): 1768-1777.

Ceramic-on-Ceramic

- Pioneered in France in 70's
- Advantages
 - Smoother surfaces
 - ↓Potential to become abraded
 - ↓Polyethelene wear (CoP)
 - Ceramic particles have less propensity for osteolysis
- Disadvantages
 - ↑Fragility
 - ↑Cost



Miller, Theodore T. "Imaging of hip arthroplasty." *Seminars in musculoskeletal radiology*. Vol. 10. No. 1. Thieme, 2006.

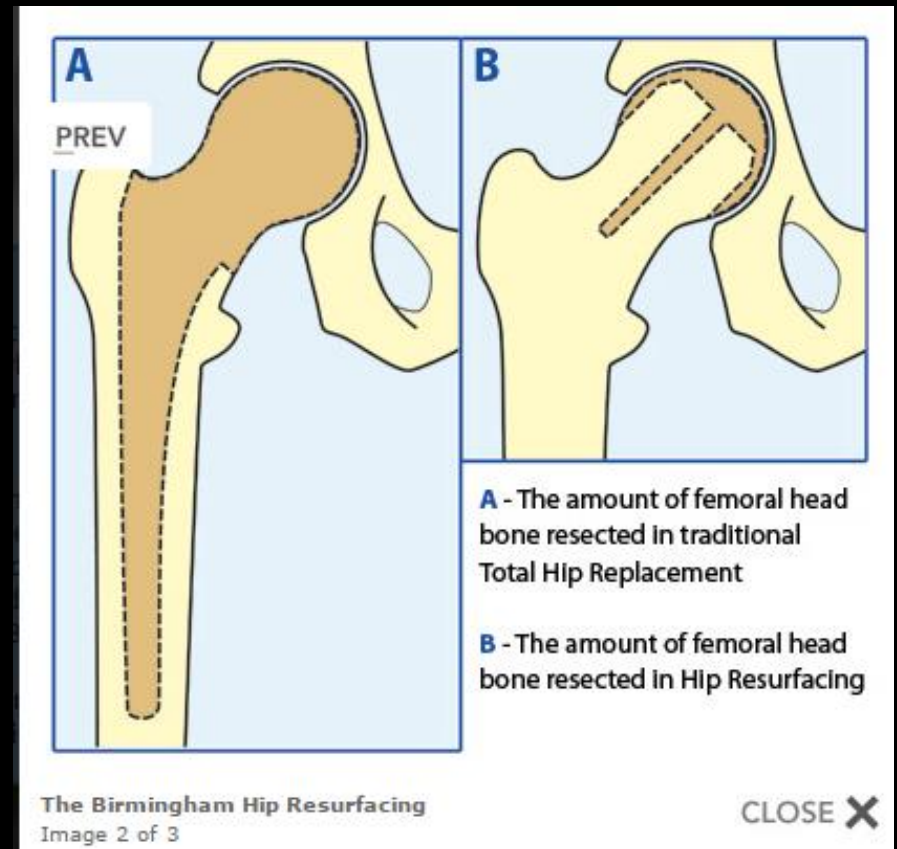
Metal on Metal

- Proposed as an alternative in the relatively young population
- Cobalt-Chrome alloy metal on metal THA in use since 1960s



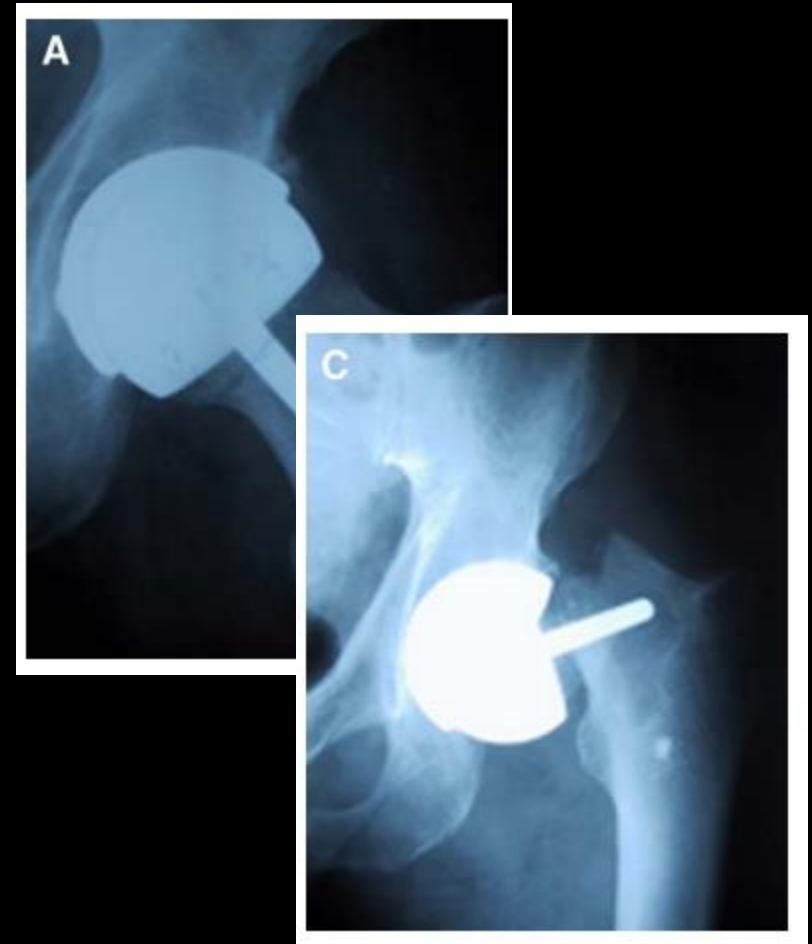
Metal on Metal Bearing Hip Resurfacing

- Younger (<60)
 - Active patients
 - Expected to outlive any current conventional prosthesis
 - Normal proximal femoral bone geometry and quality
- Contraindications:
 - Osteoporotic, metal hypersensitivity, impaired renal function



Metal on Metal Bearing Hip Resurfacing

- Many surgeons believe it to be a better alternative to THA
- Disadvantage – Risk of fracture of femoral neck



Shimmin, A. J., J. Bare, and D. L. Back. "Complications associated 2005): 187-193. with hip resurfacing arthroplasty." *Orthopedic Clinics of North America* 36.2 (

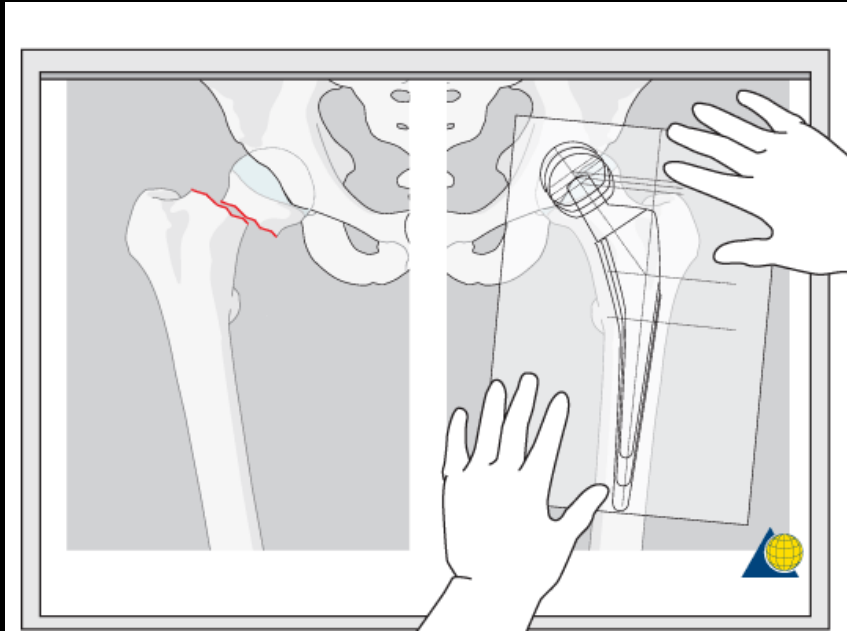


“You always use at. You’re filled with ats.”

“Alright no more ats from this room. I’ve never had so many ats come at me. I dream of ats at night.”



Preoperative Planning



**Measure with calipers,
cut with an axe.**

Surgical Approach

- Surgeon Preference
- Patient specific
 - Obese, muscular

Approach

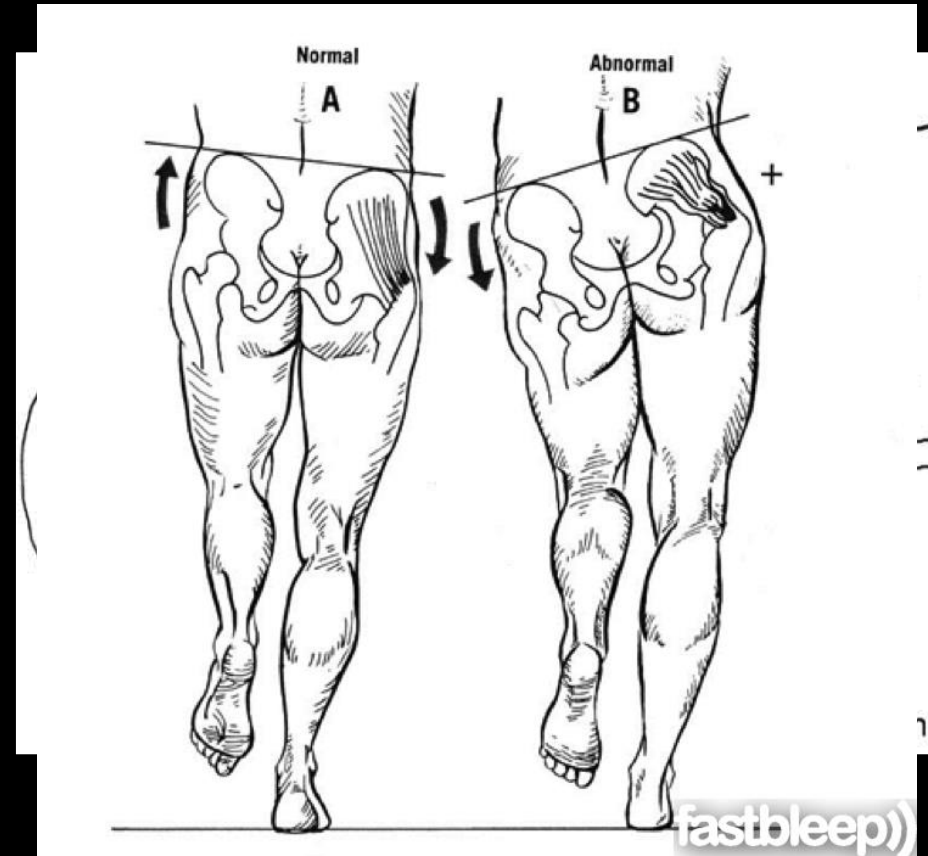
- Posterolateral

- Most popular –Easiest to master
- Less technically demanding
- Does not violate abductor mechanism
- ↓Post op Trendelenburg gait
- Disadvantages
- Releases short external rotators (obt. internus, piriformis)
- Violates the posterior capsule
- ↑Risk for posterior dislocation (?)

A Posterior Approach to Primary Total Hip Arthroplasty With Soft Tissue Repair.

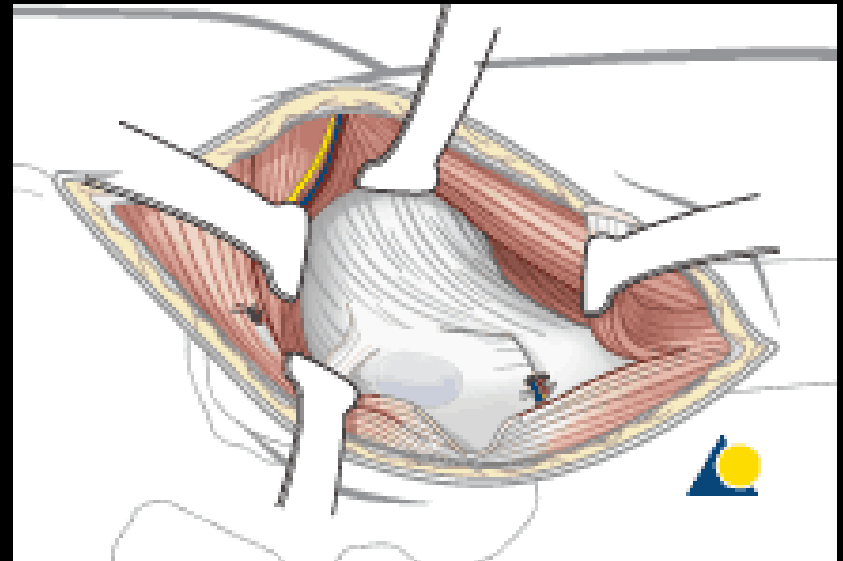
Suh, Kuen; Park, Byung; Choi, Young

Clinical Orthopaedics & Related Research. 418:162-167, January 2004.



Approach

- Anterior
 - Recent interest
 - Using intermuscular planes of dissection
 - No muscles are incised
 - Spares external rotators
 - Belief that this decreases risk for dislocation



https://www2.aofoundation.org/wps/portal/surgery?showPage=redfix&bone=Femur&segment=Proximal&classification=31-B3&treatment=&method=Arthroplasty&implantstype=&approach=&redfix_url=1284974569031&Language=en

Expected Outcomes

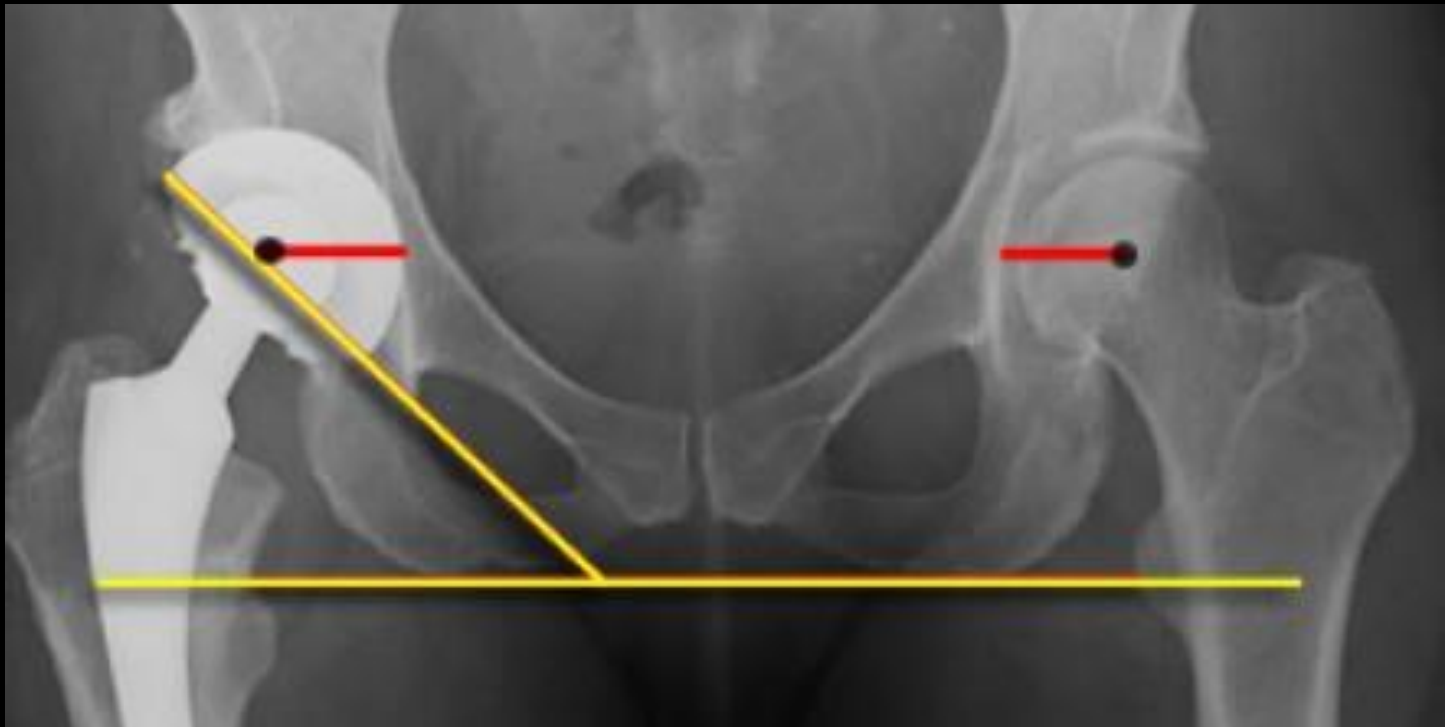
- Excellent clinical outcomes
- >95% survivorship at 10 years
- >80% implant survivorship at 25 years
- 1% revision rate per year

Pivec, Robert, et al. "Hip arthroplasty." *The Lancet* 380.9855 (2012): 1768-1777.

Labek, G., et al. "Revision rates after total joint replacement." *J Bone Joint Surg Br* 93.3 (2011): 293-297.

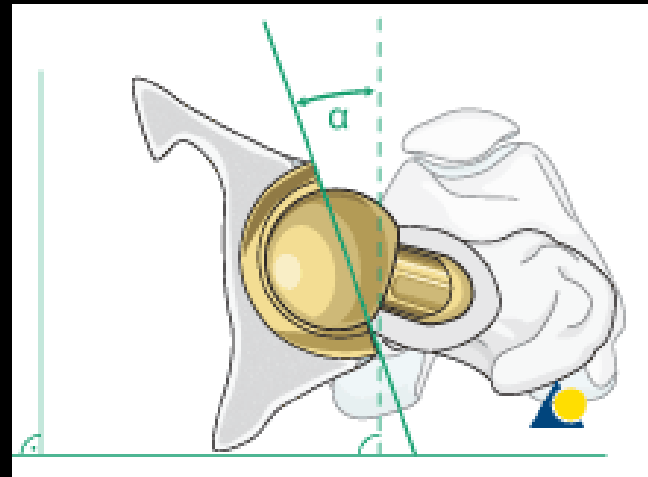
Alignment

- Acetabular inclination – Normal is 30–50 degrees
- Horizontal Center of Rotation – Head → Teardrop
 - Equal Bilaterally
 - ↑Lateral → Dislocation, limping
- Leg length discrepancy up to 1 cm is tolerated
 - ↑Length → Muscle spasm → Dislocation
 - ↓Length → Hip muscles ineffective → Dislocation



Alignment

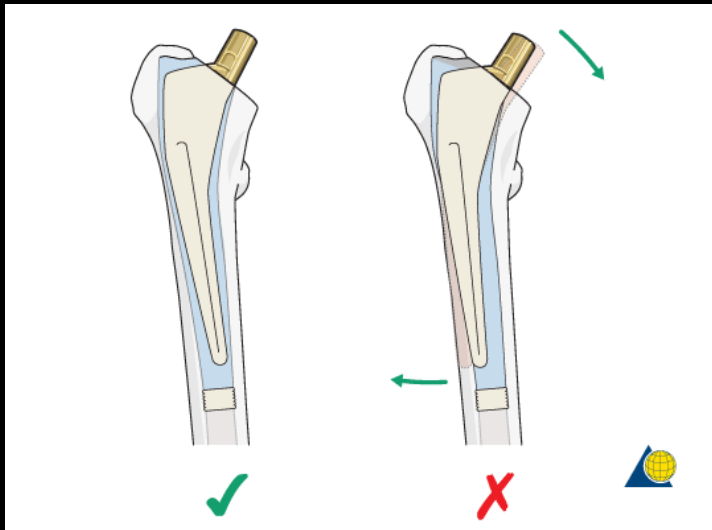
- Acetabular anteversion
- Best measured on CT
- Have to adjust for any pelvic tilt
- Normal is 5-25 degrees



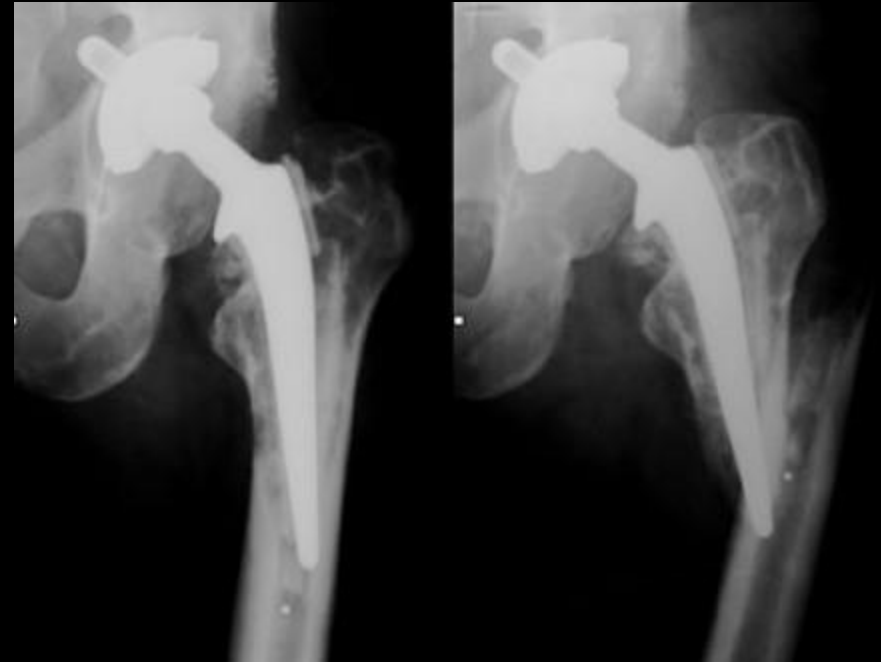
https://www2.aofoundation.org/wps/portal/surgery?showPage=redfix&bone=Femur&segment=Proximal&classification=31-B3&treatment=&method=Arthroplasty&implantstype=&approach=&redfix_url=1284974569031&Language=en

Femoral Component

- Stem Centered
- A valgus position is preferred
 - Varus Positioning → loosening, fx



https://www2.aofoundation.org/wps/portal/surgery?showPage=redfix&bone=Femur&segment=Proximal&classification=31-B3&treatment=&method=Arthroplasty&implanttype=&approach=&redfix_url=1284974569031&Language=en



Stress Shielding

- Bone resorption
- Areas of low stress
- Can increase risk for fx



- Medially → Calcar resorption/round off

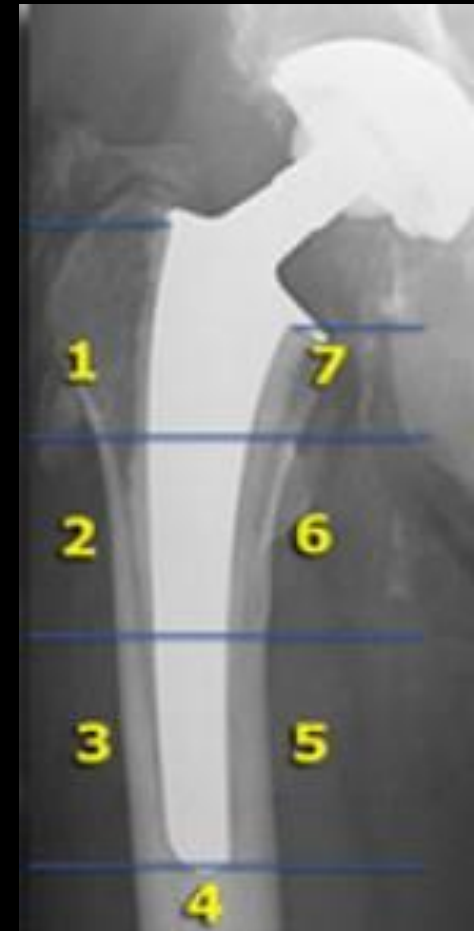


Standard Zones

Charnley Zones



Gruen Zones



AWKWARD SEAL

**WHEN YOU'RE TELLING A STORY AND
HALF WAY THROUGH**

**YOU REALIZE NOBODY'S
LISTENING**



Interfaces

- Metal-Cement Interface
 - Lucency along proximal lateral aspect femoral stem
 - Femoral Zone I
 - Immediate post-op
 - Suboptimal metal cement contact
 - May be stable over time
 - Stable by 2 years
 - New lucency at follow up is not normal

Initial

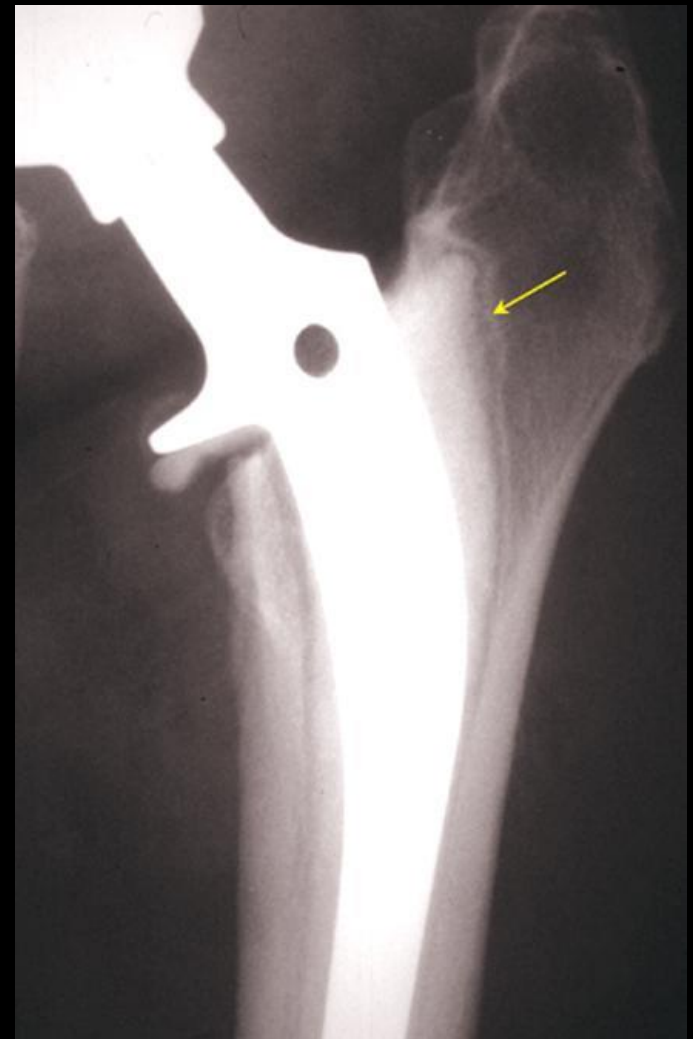


Follow-up



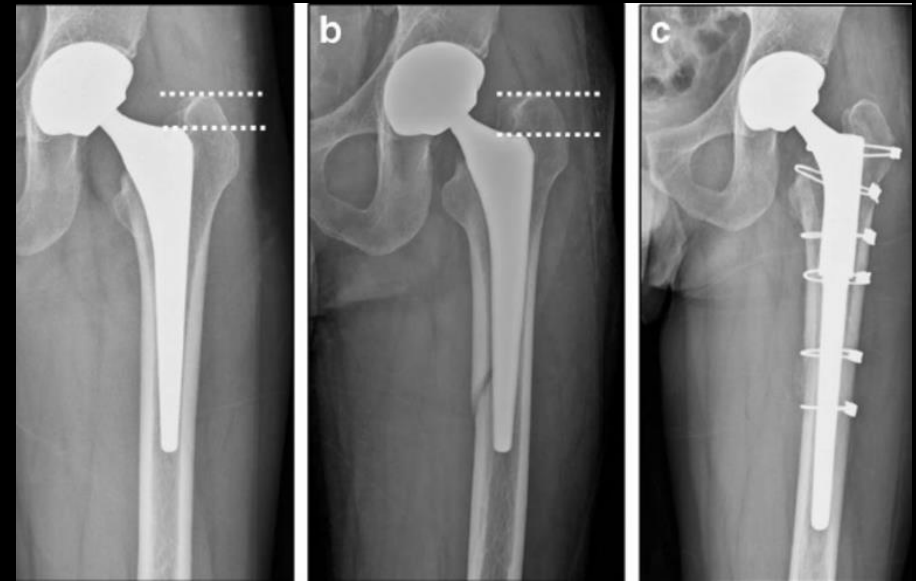
Bone-Cement Interface

- Fibrous membrane
 - Thin lucency
 - 1-2 mm
 - Stable by a period of 2 yrs
 - Any change should be reported as loosening
 - May be normal
 - Acetabular zone I
 - Femur zones 1 & 7



Subsidence

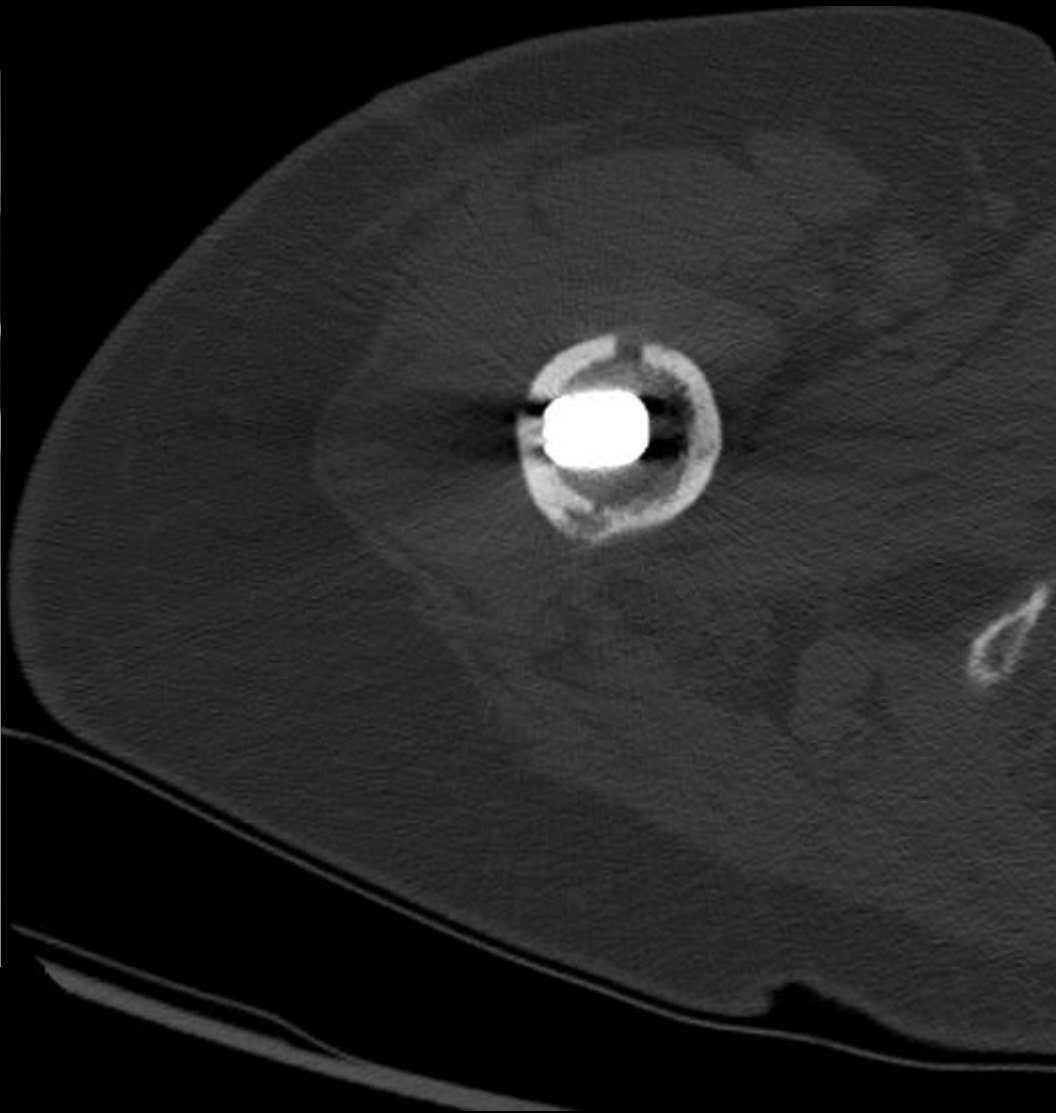
- Femoral Component
- Reference
 - Greater trochanter → Shoulder of stem
- May be normal / expected
 - Up to 2 years post-op
 - Up to 2-5 mm
- Abnormal
 - >2 years
 - > 5 mm (some references allow 10 mm)
 - Varus tilting















Subsidence



Subsidence



Vancouver Classification & Treatment

Type	Description	Treatment	Image
A	Fracture in trochanteric region	Commonly associated with osteolysis and often requires treatment that addresses the osteolysis. Consider ORIF in displaced fractures.	 
B1	Fracture around stem or just below it, with a well fixed stem	ORIF using cerclage cables and locking plates ?	 
B2	Fracture around stem or just below it, with a loose stem but good proximal bone stock	Revision of the femoral component to a long porous-coated cementless stems and fixation of the fracture fragment. Revision of the acetabular component if indicated ? ? ? ? ? ? ?	  
B3	Fracture around stem or just below it, with proximal bone that is poor quality or severely comminuted	Femoral component revision with proximal femoral allograft or proximal femoral replacement ?	 
C	Fracture occurs well below the prosthesis	ORIF with plate - leave the hip and acetabular prosthesis alone	  

Additional Unexpected Outcomes

Loosening

- Mechanical loosening
- Particle disease, osteolysis
- Infection

- Most common reason for revision
 - Aseptic loosening

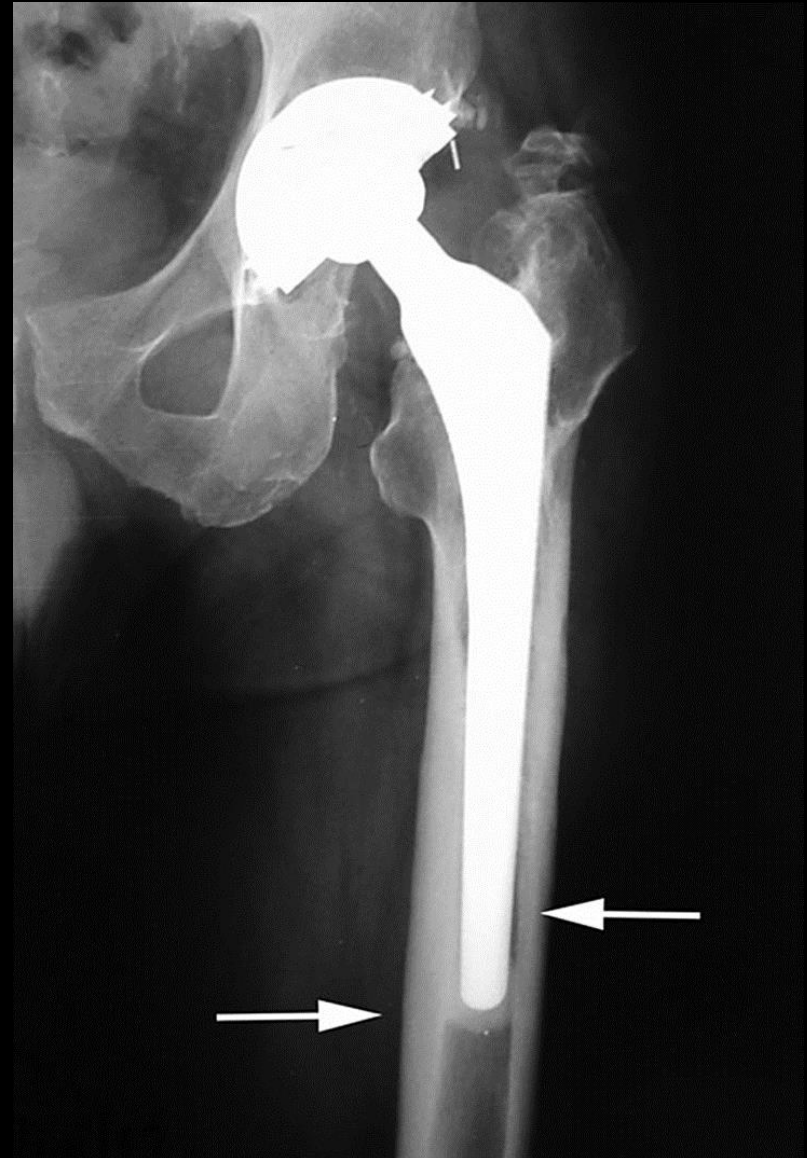
- Radiolucencies >2 mm
- Review comparison radiographs



Pluot, E., et al. "Hip arthroplasty. Part 2: normal and abnormal radiographic findings." *Clinical radiology* 64.10 (2009): 961-971.

Pedestal Sign

- Seen in cementless THA
- New bone formation below just the tip
 - Zone 4
- Usually %50 of canal
- May be seen in stable and unstable components
- Look for other signs of loosening





“What do you want tot say about the labrum?”



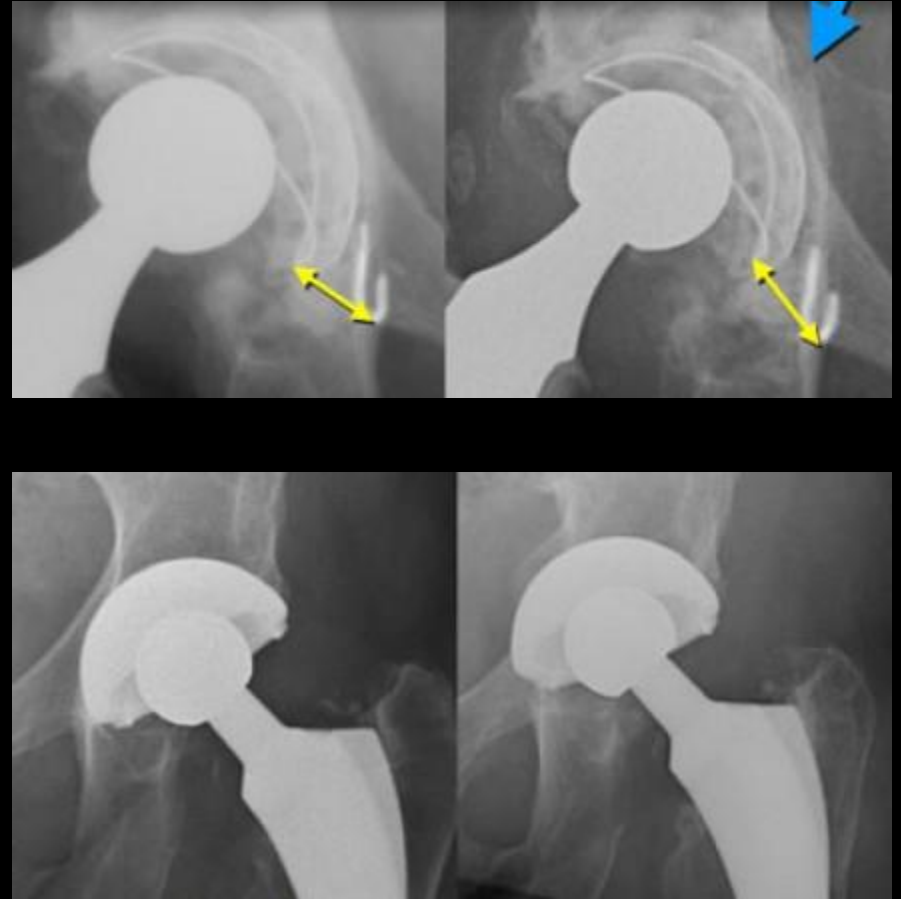
“It looked a little ratty to me.”



“How big was the rat?”

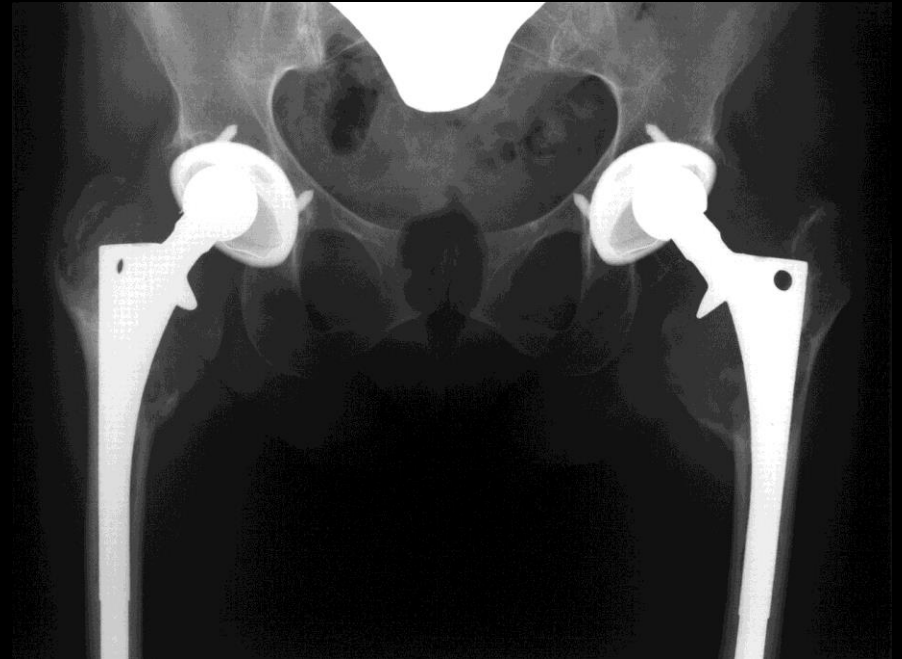
Migration

- Acetabular Migration
- Never normal



Advanced Wear

- Polyethylene wear
- Wear rate is highest at the beginning and reaches a steady state later 16-18 months



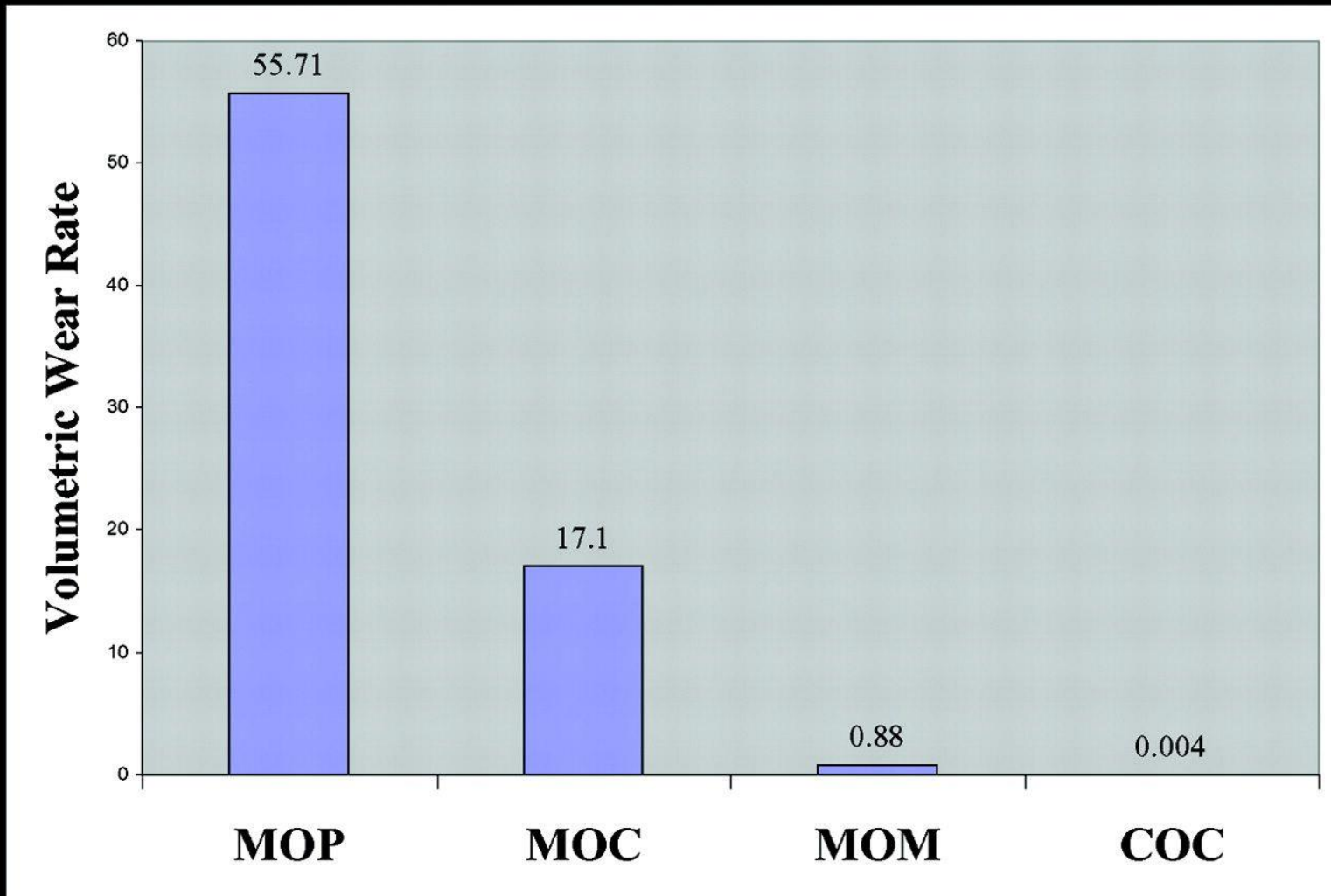
Christian Heisel et al. J Bone Joint Surg Am 2003;85:1366-1379

Creep vs. Wear

- Creep
 - Normal remolding and slight thinning
 - Superomedial
- Wear
 - Due to abnormal loading
 - More lateral



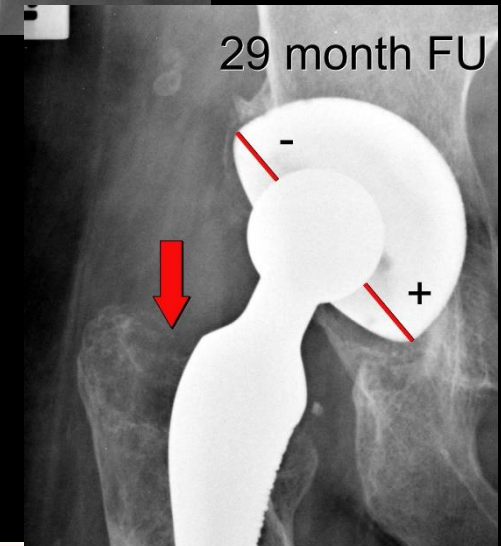
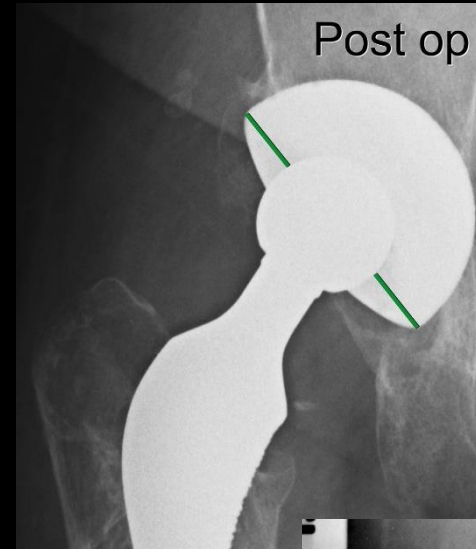
Wear rates (in cubic millimeters per year) of different bearing combinations tested in a hip simulator 116.



Christian Heisel et al. J Bone Joint Surg Am 2003;85:1366-1379

Particle Disease

- Dependent on
 - # of particles shed
 - Histiocytic reaction
- Particles $<0.5 \mu\text{m}$ in diameter
 - Greatest immune response
- Highly Crosslinked Polyethylene
 - Reduced wear compared with conventional poly
 - ?Greater immune response



Particle Disease

- Particles shed into joint fluid
 - Migrate
 - Screw holes
 - Channels around prosthesis
- Radiographs may underestimate
- CT more sensitive and accurate
 - Especially at the acetabulum



ALVAL

- Aseptic lymphocyte-dominated vasculitis-associated lesion
 - Type of adverse local tissue reaction (ALTR)
 - Associated with MoM components
 - High wear
 - Low wear - ↑Metal hypersensitivity
 - Aggressive soft tissue damage
 - Early detection minimizes potential for soft tissue damage and poor outcomes following revision

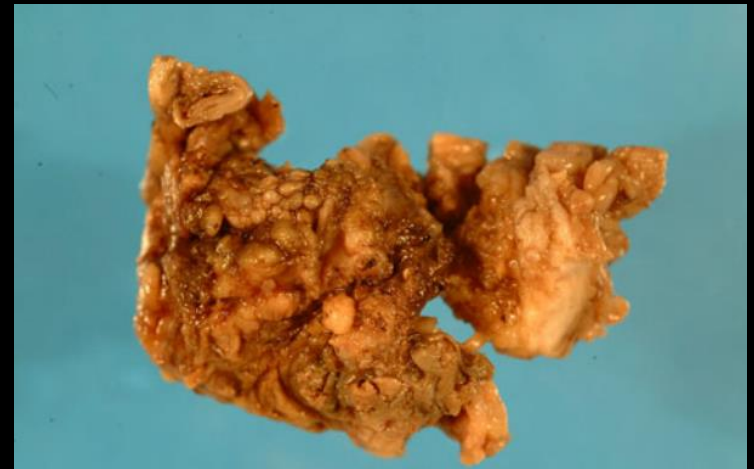
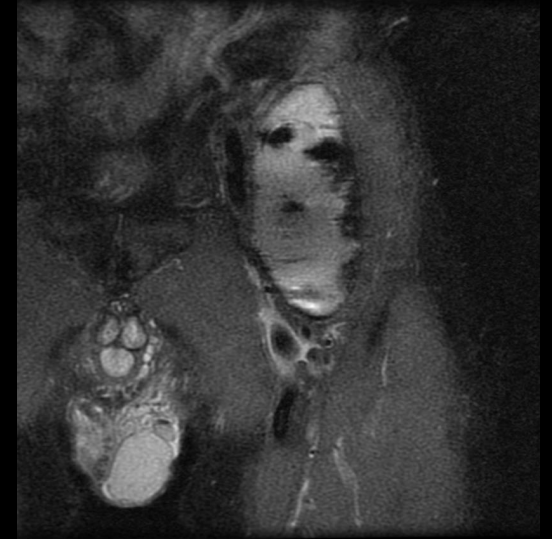
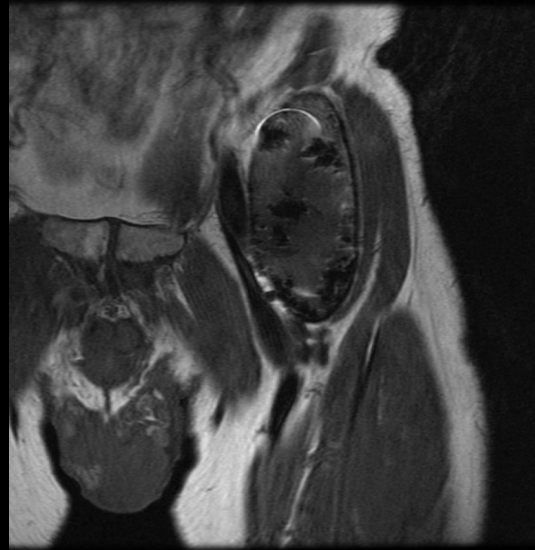
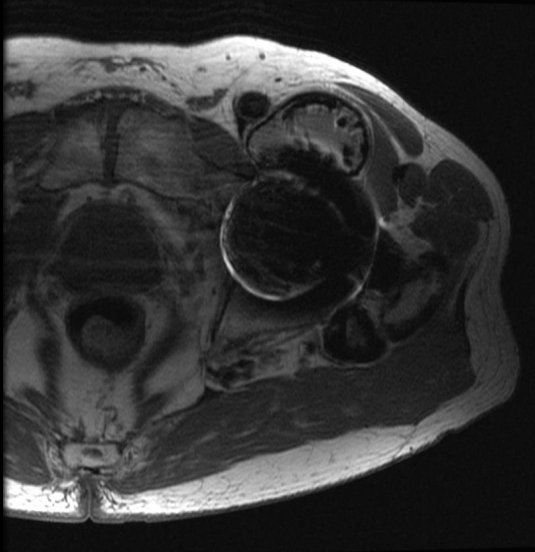


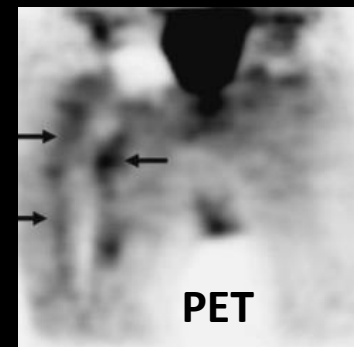
Fig. 1 An enlarged fluid-filled bursa excised from the hip of a male patient during revision surgery for acetabular malpositioning 13 months after metal-on-metal hip resurfacing arthroplasty is shown.

MRI



Infection

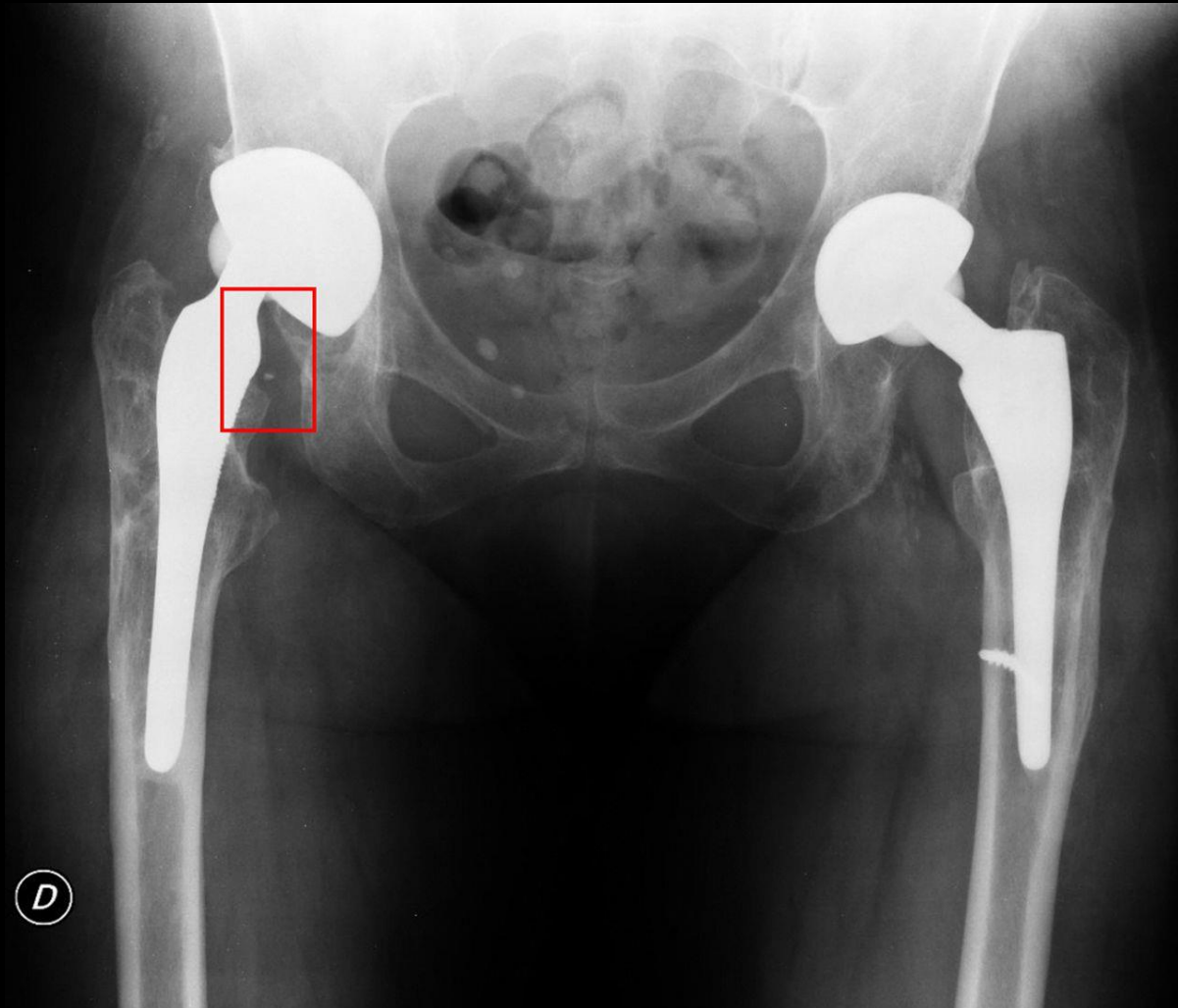
- 3rd most common reason for revision
- 1-5% of THA
- Lucencies
- Frank bone destruction
- Findings may develop more rapidly compared with aseptic loosening
- Aspiration is gold standard
- Lamellated synovium – Indication of infection



Squeaking Hip

- First generation models 1980's-90's
- Caused by many possibilities
 - Multifactorial?
 - Ceramic liner fracture
 - Cup malposition and impingement
 - Mismatched ceramic couples
- 1-10% of ceramic hips
- Likely to persist
 - 30% may resolve





Francesco Traina et al. J Bone Joint Surg Am 2011;93:e147

Heterotopic Ossification

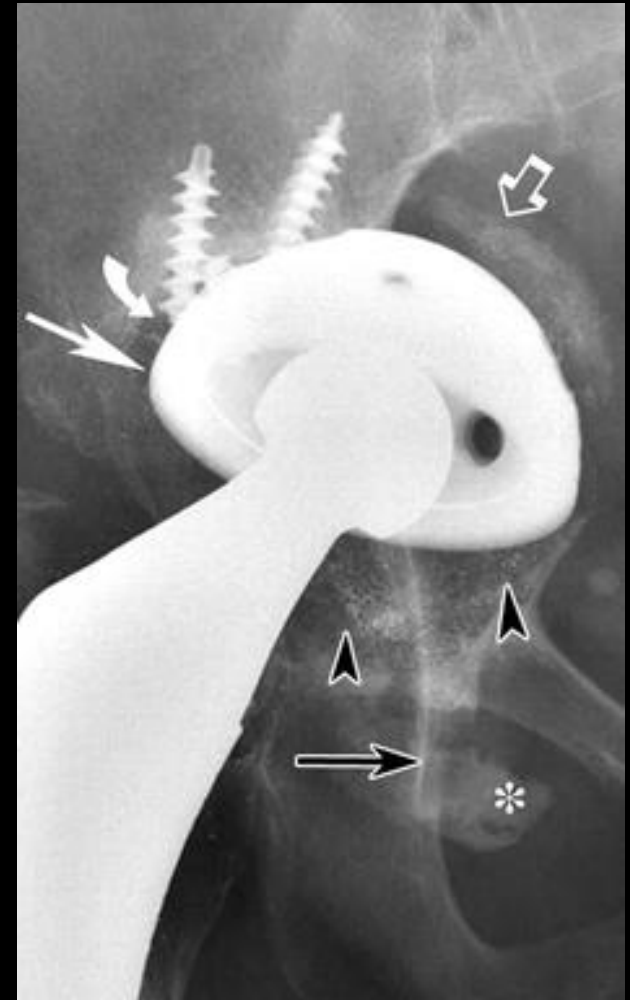
- Risk factors
 - Male
 - Age >65
 - Previous hx of HO
 - Ankylosing Spondylitis
 - DISH
 - Postoperative prophylaxis
 - Low-dose radiation
 - Anti-inflammatory drugs
 - Immature HO can be challenging at imaging



Choplin, Robert H., et al. "Total Hip Arthroplasty in Patients with Bone Deficiency of the Acetabulum 1." *Radiographics* 28.3 (2008): 771-786.

Metal bead shedding

- Opaque microfragments
- Noncemented Components
- Separated from the porous-coated surface of an ingrowth prosthesis
- Presence
 - Immediately
 - Stem insertion
 - Follow-up
 - Seen in adjacent soft tissues
 - Increase in # indicates loosening



Choplin, Robert H., et al. "Total Hip Arthroplasty in Patients with Bone Deficiency of the Acetabulum 1." *Radiographics* 28.3 (2008): 771-786.



“By the way that finding did not make it into the IMPRESSION in your report.”



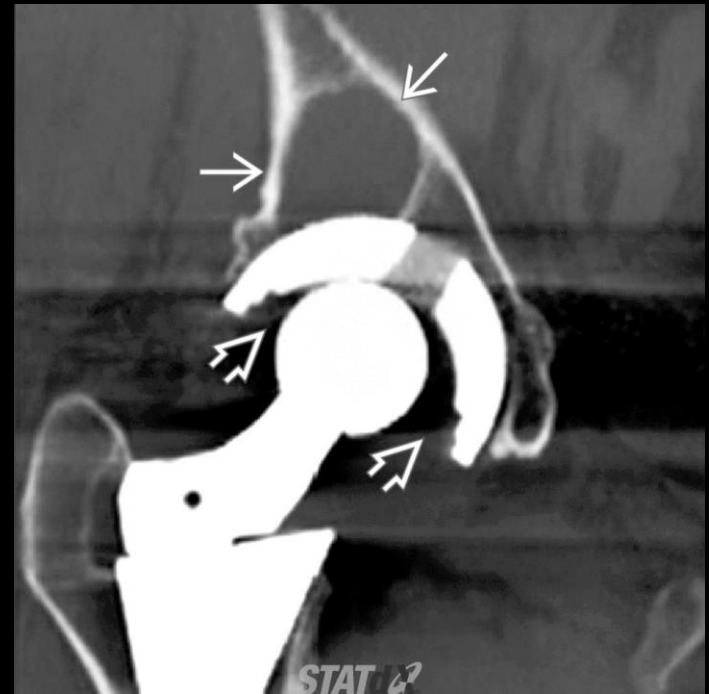
“Oh OK. Did you move it into the impression?”



“Yeah. I moved it to number 1.”

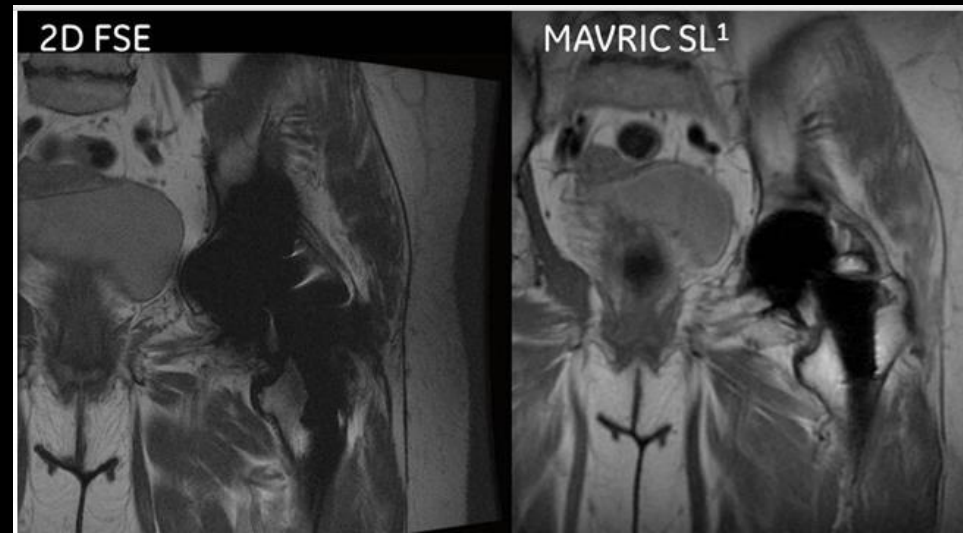
Advanced Imaging

- CT
- Acetabular version in frequent dislocators
- Loosening/osteolysis evaluation
- Evaluate bone stock if revision is planned
- MRI
- Useful for problem solving
- MARS
- Suggested for evaluation of painful MoM implants



MARS

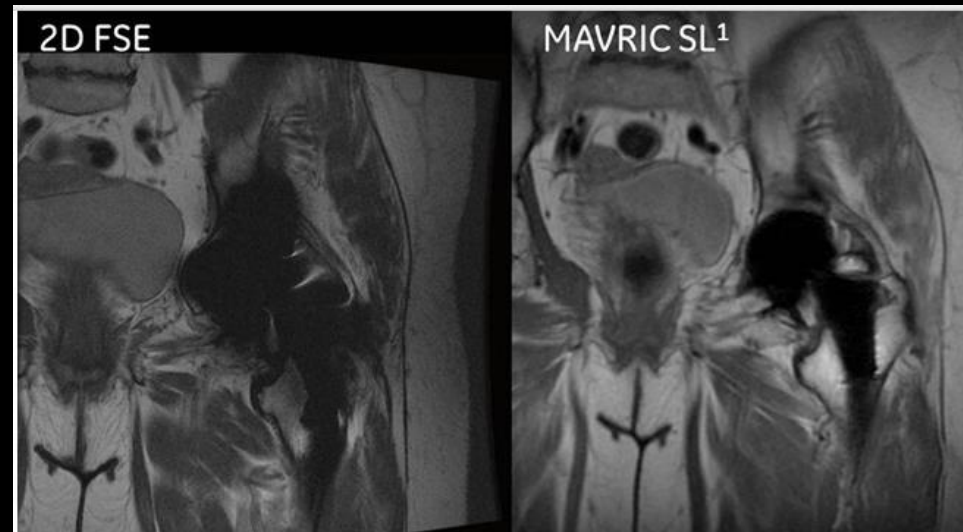
- Metal Artifact Reduction Sequence
- ↓Magnet Strength
 - Susceptibility is proportional to field strength
- ↑Bandwidth (Increases strength of readout gradient)
- ↓Slice thickness
 - ↑Exam time
 - ↓SNR



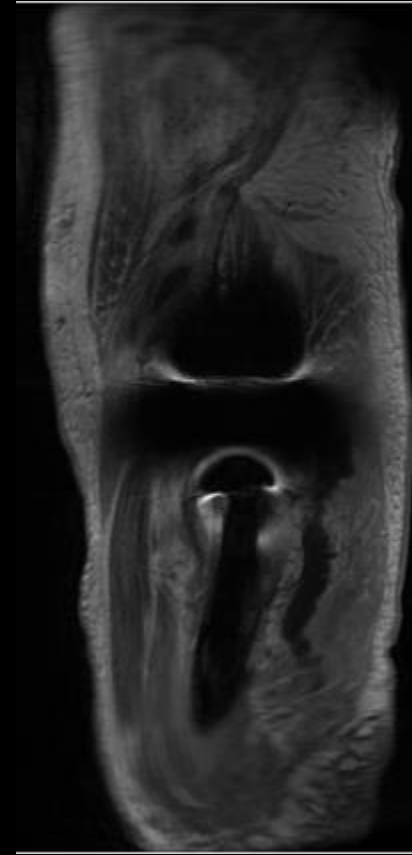
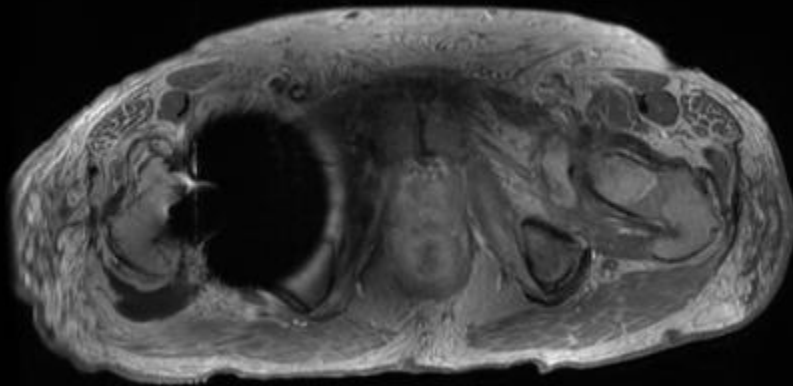
http://www3.gehealthcare.com/en/products/categories/magnetic_resonance_imaging/musculoskeletal_imaging/mavric_sl

MARS

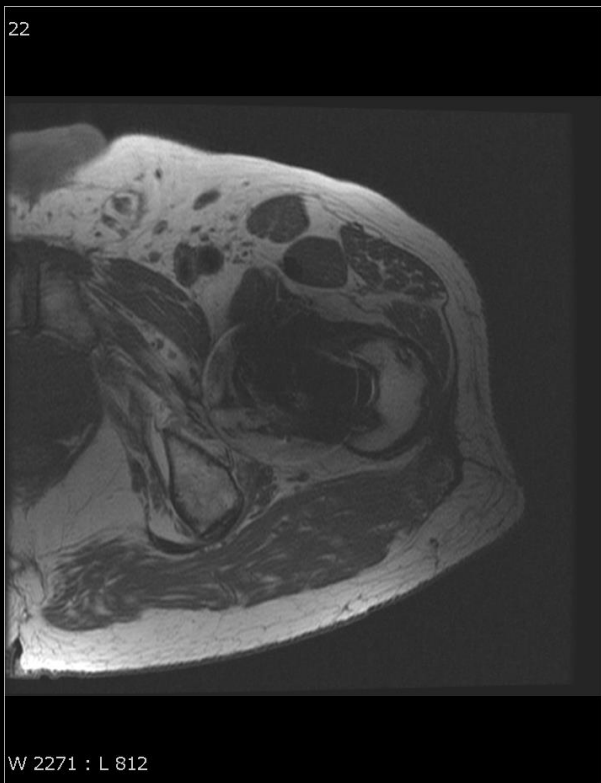
- \uparrow Matrix e.g. 512 pixels
→ \uparrow Spat. Resolution
- \uparrow NEX to \uparrow SNR
 - Offsets \downarrow SNR by
 \uparrow Bandwidth &
 \uparrow Matrix
- Avoid fat suppression –
use STIR
 - \downarrow SNR



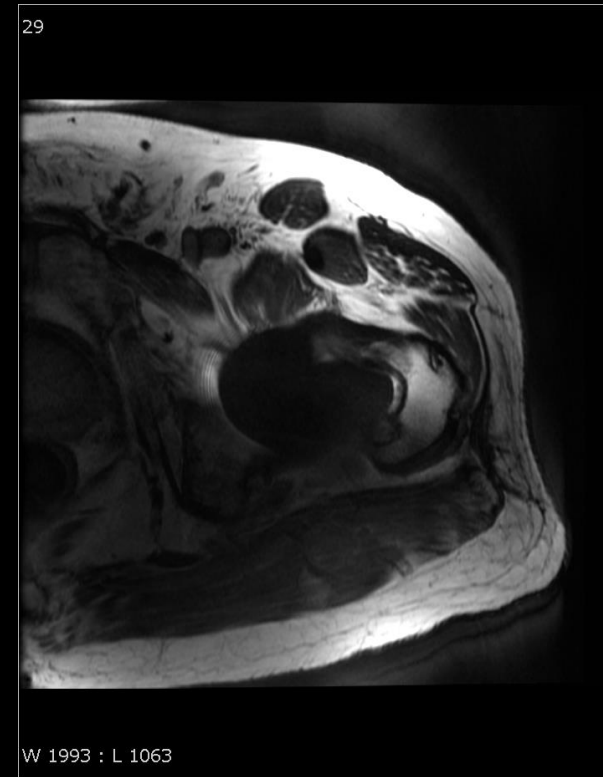
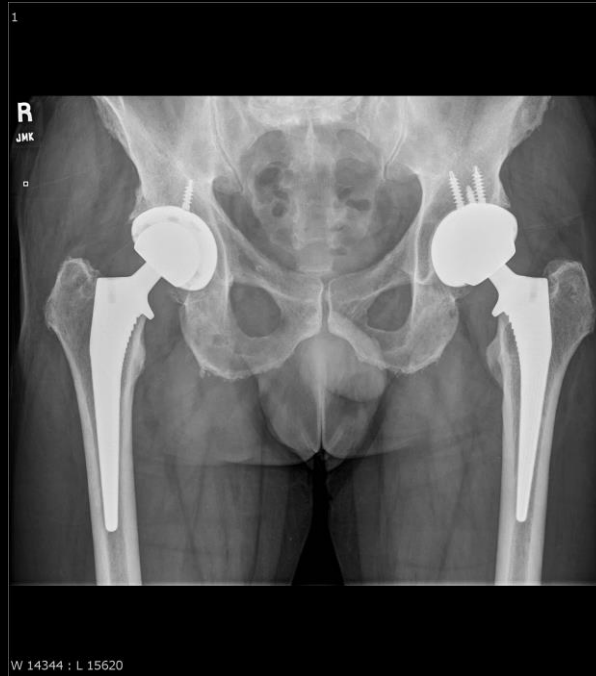
MRI



MRI



2013



2016

Patient – 2010

**2nd opinion, THA 2009 related to
femoral fracture**

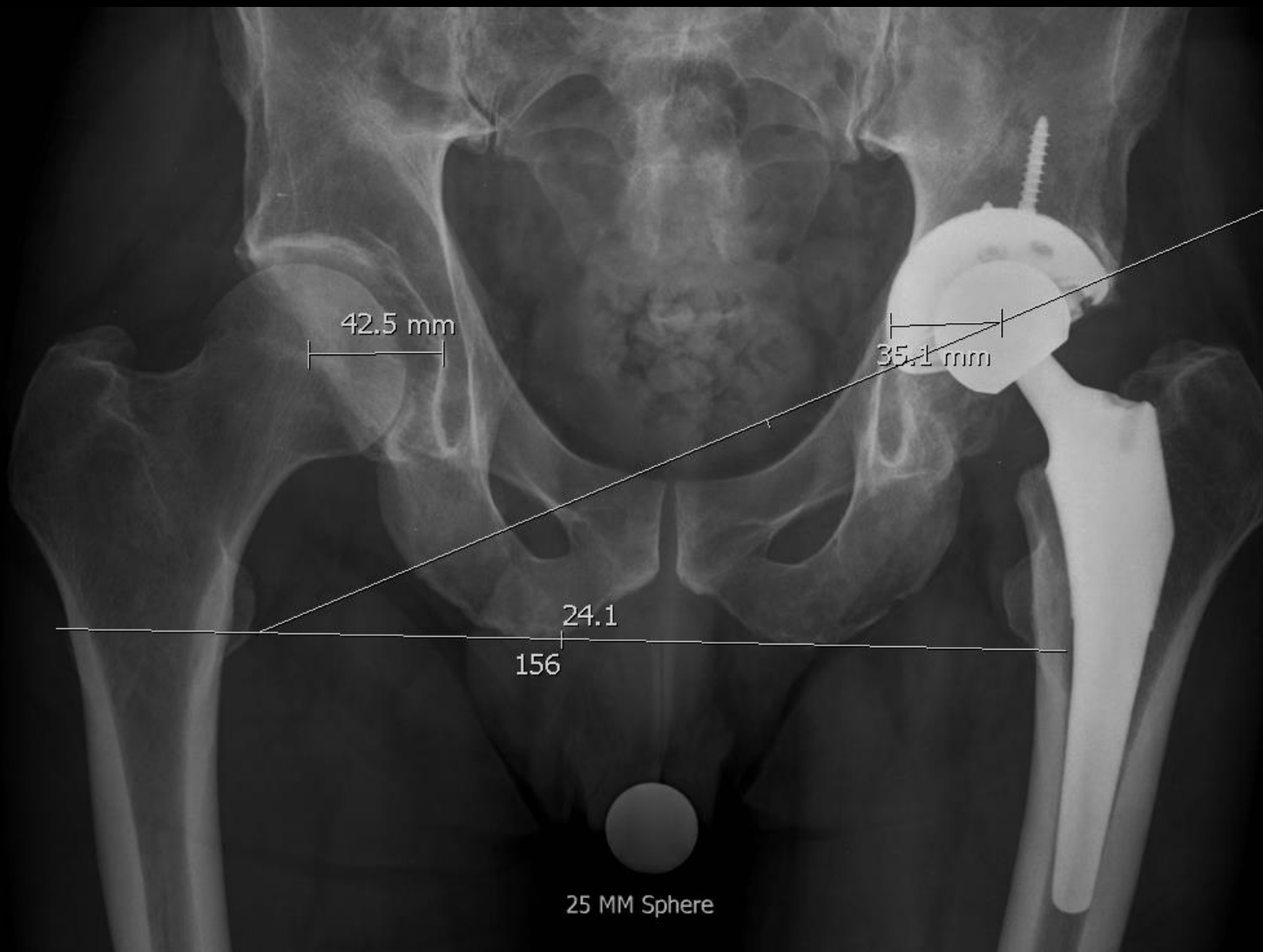
Patient – 2010

2nd opinion, THA 2009

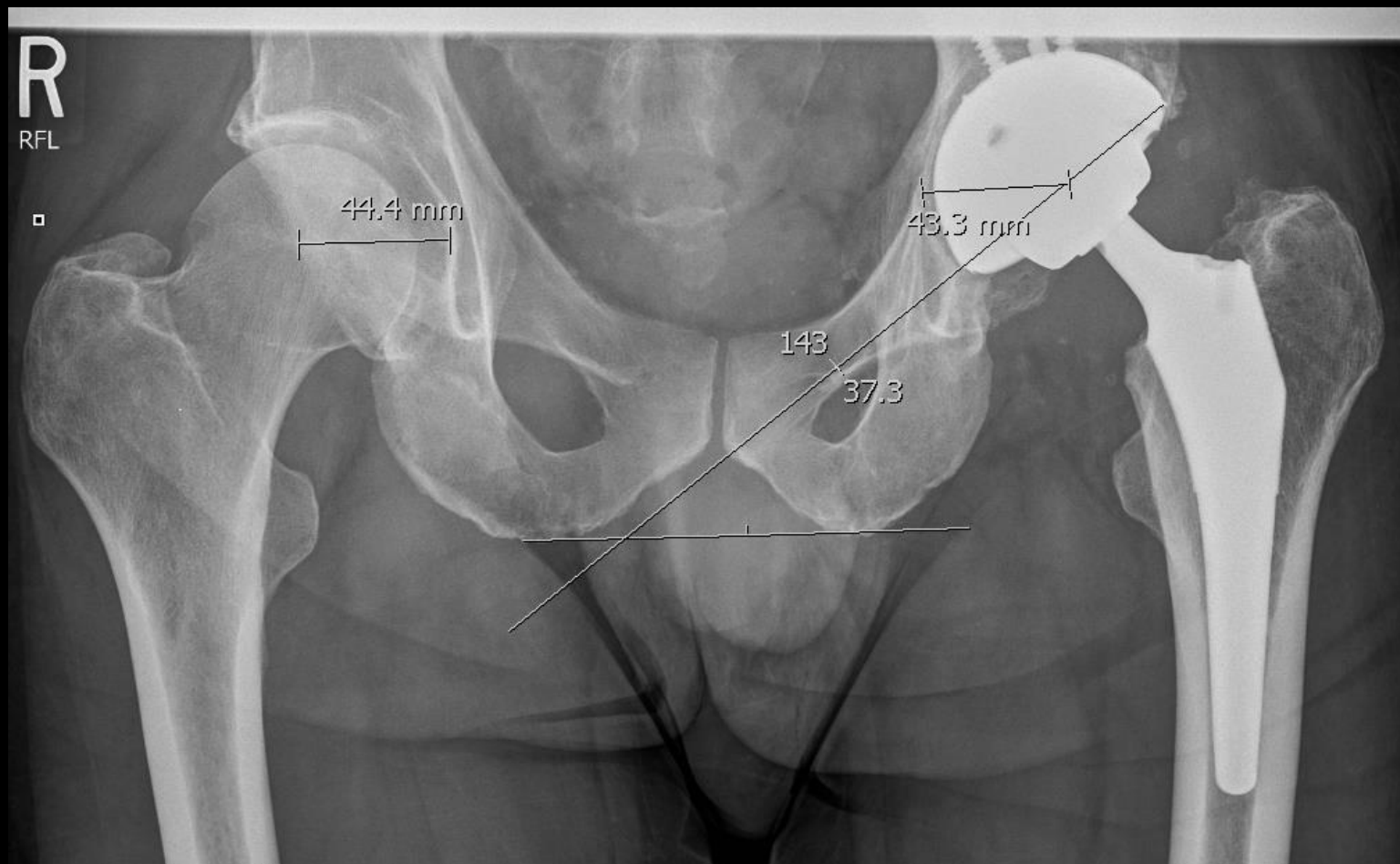


Patient – 2010

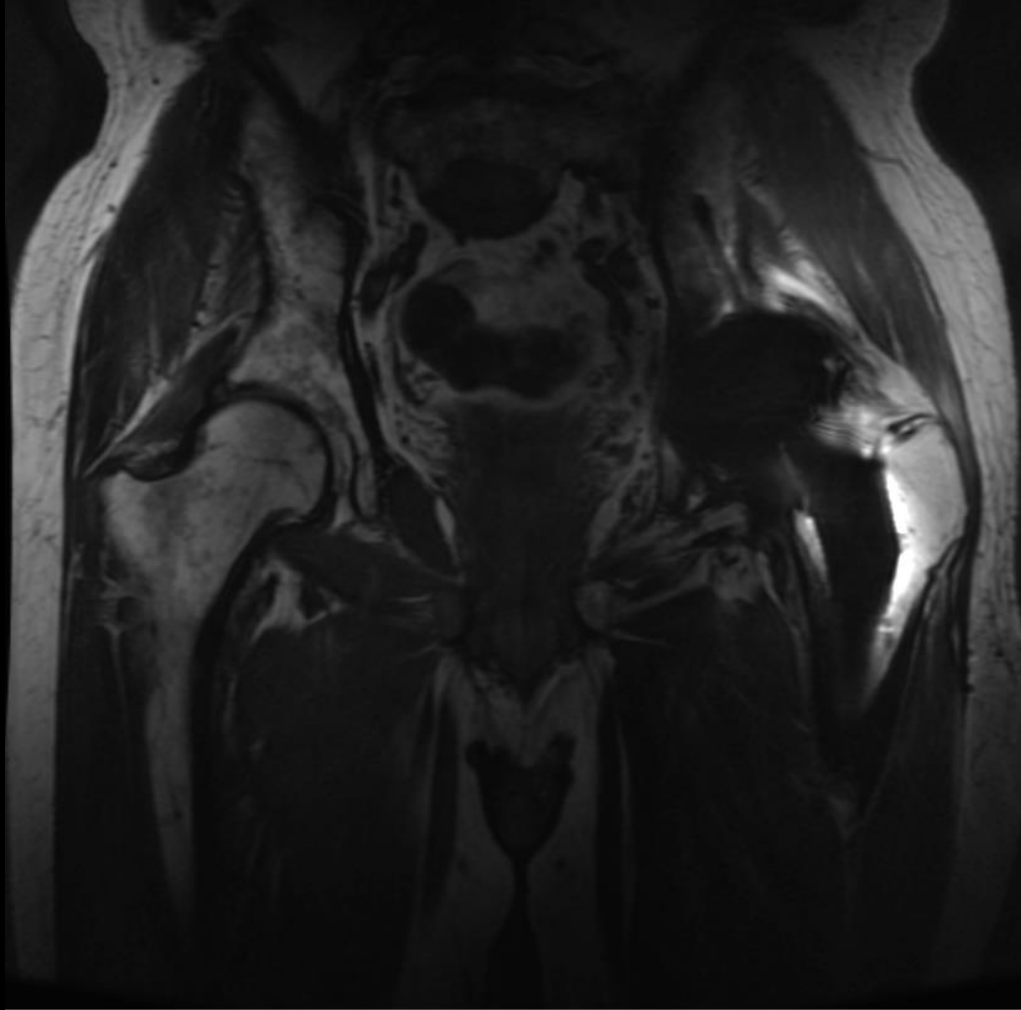
2nd opinion, THA 2009



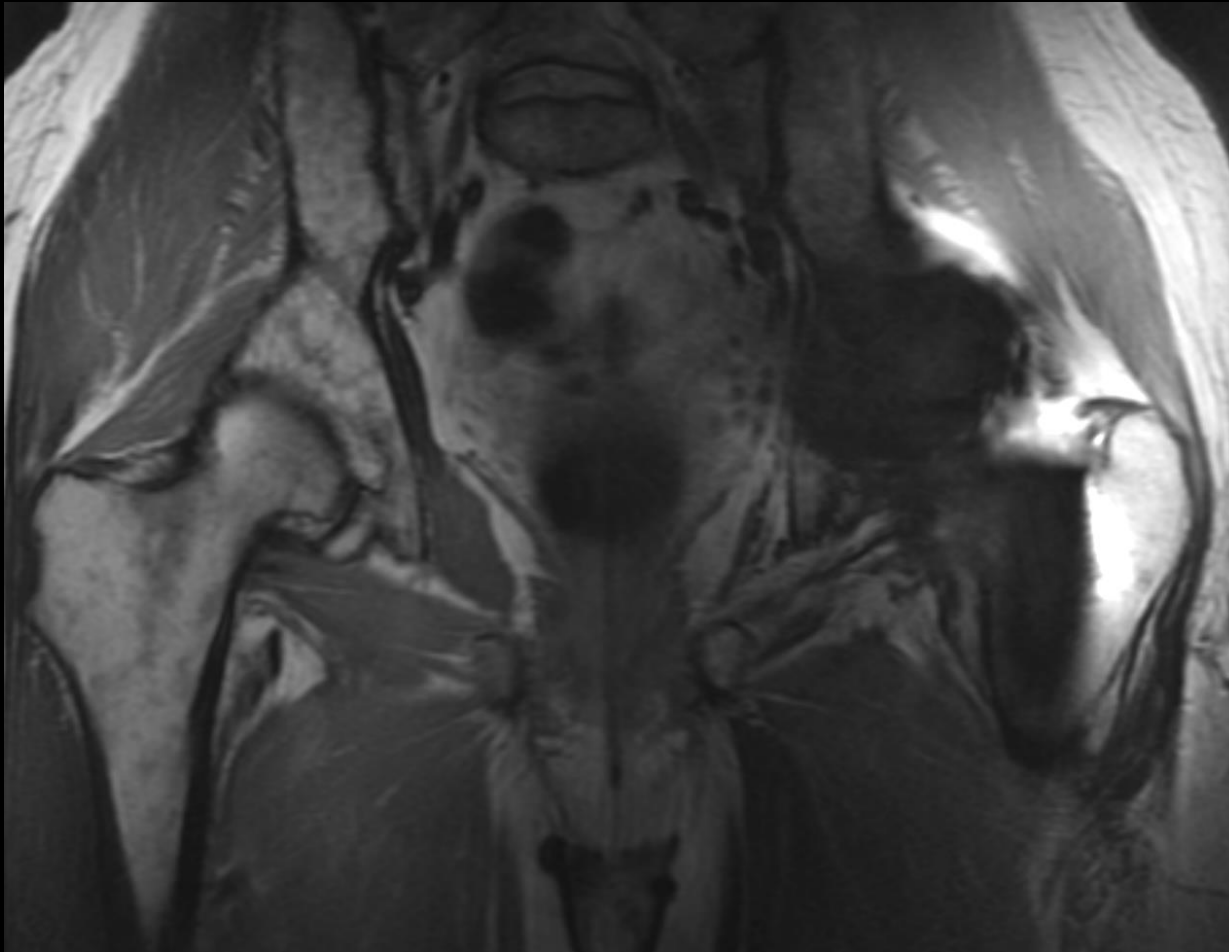
S/P Revision



MRI – years after revision



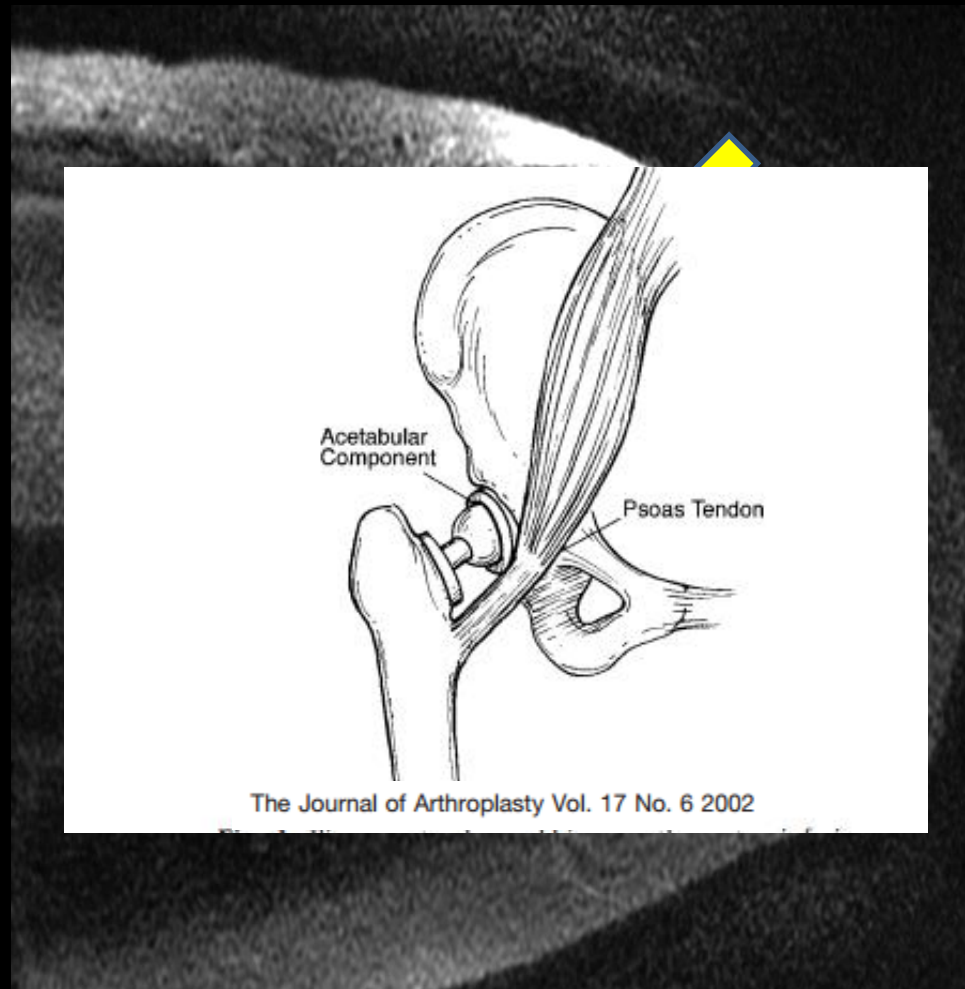
MRI



MRI



MRI



Revision

- Causes of Revision
 - Instability (22%)
 - Mechanical loosening (20%)
 - Infection (15%)
 - Implant failure (10%)
 - Osteolysis (7%)
 - Periprosthetic fracture (6%)

Revision Failure

- Infection (30%)
- Instability (25%)
- Loosening (19%)

Future Developments

- Orthopedic industry
- '95- \$6bn → '05 \$17bn

THA Market in the US



Summary

- THA is regarded as one of the most successful orthopedic procedures
 - High success rate
- A low failure rate (5%) still has a burden on the healthcare system and the patient
- Many potential candidates are still not eligible such as in the young population
- Further progress will increase clinical outcomes
- New formulations of bearing surfaces are being developed
 - The efficacy of these technologies will not be known for several years
- Future advancements in THA will rely upon improvements in:
 - Implant Design
 - Biomechanics
 - Surgical technique

End

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