

IMAGING OF JOINT REPLACEMENTS

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TORONTO
JDMI

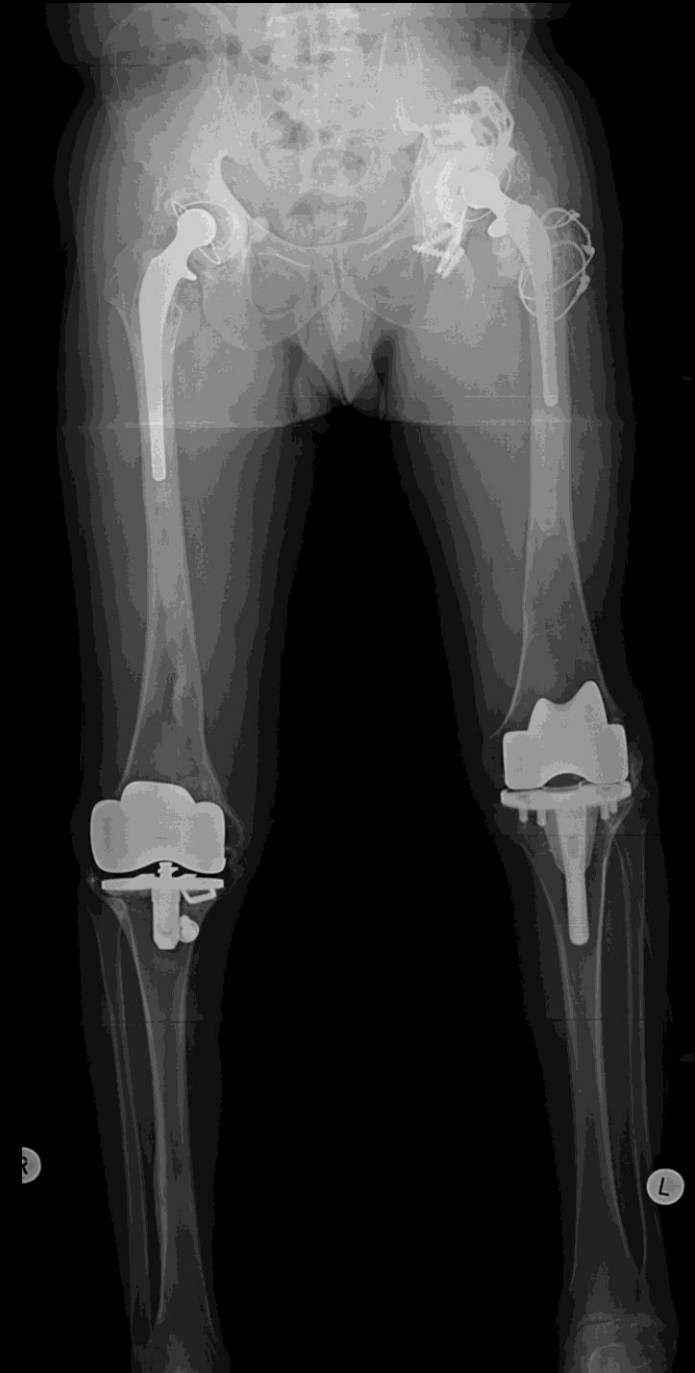


Disclosures:

- None

Outline

- Concentrate on hip arthroplasty
- Radiographic assessment
- Complications of arthroplasty
- Role of cross-section





"A HOME RUN!

A JUGGERNAUT OF AN ACTION-ADVENTURE SAGA!
A SMASHING SUCCESS. SENSATIONALLY DIRECTED AND ACTED TO STEELY PERFECTION
BY HARRISON FORD, TOMMY LEE JONES AND A FLAWLESS SUPPORTING CAST."

- Janet Maslin, NEW YORK TIMES



DELICIOUS! WONDERFULLY ACTED.
I'VE ALREADY SEEN IT TWICE. I'LL PROBABLY SEE IT AGAIN."

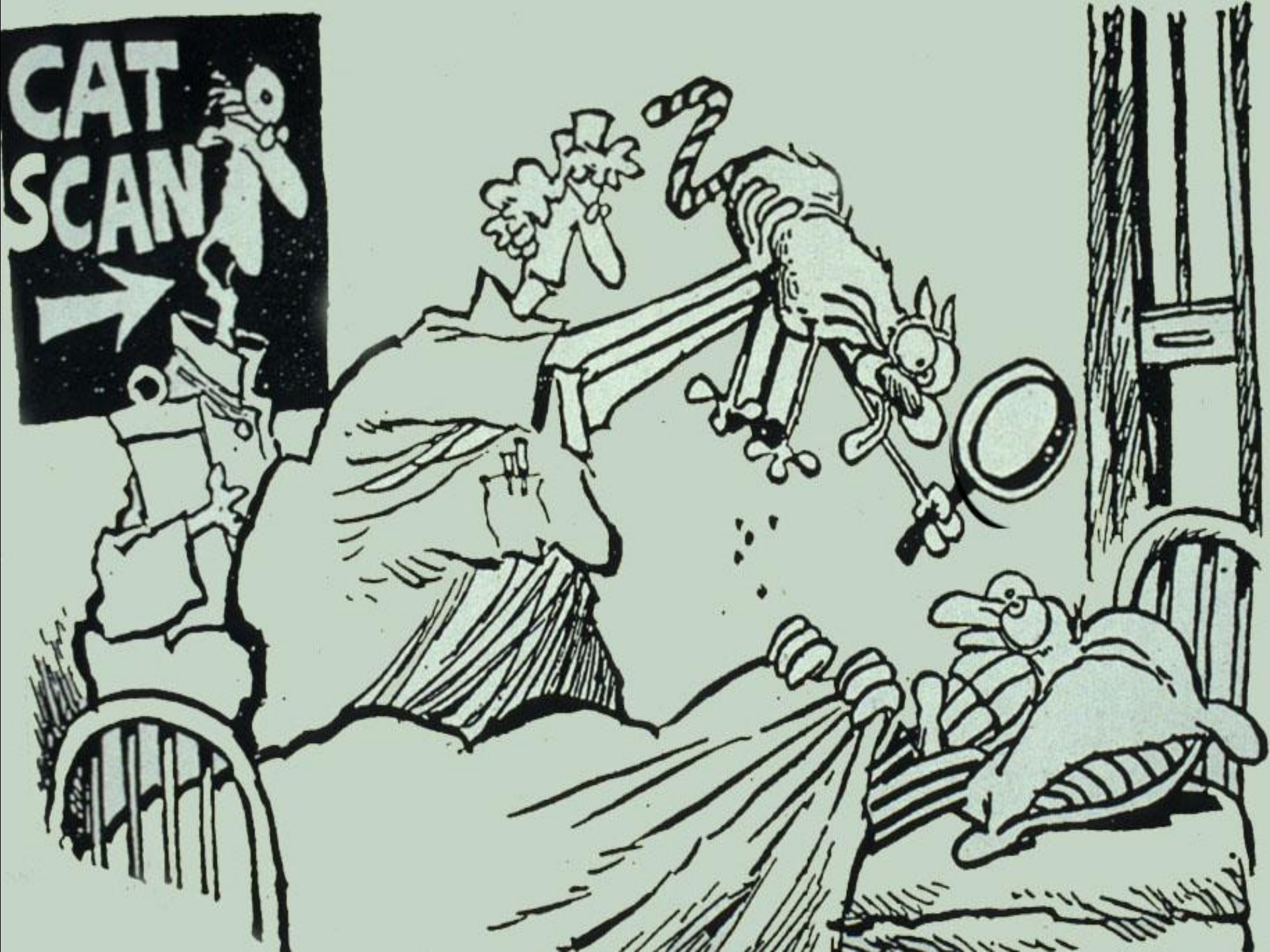
- Gene Siskel, CHICAGO TRIBUNE

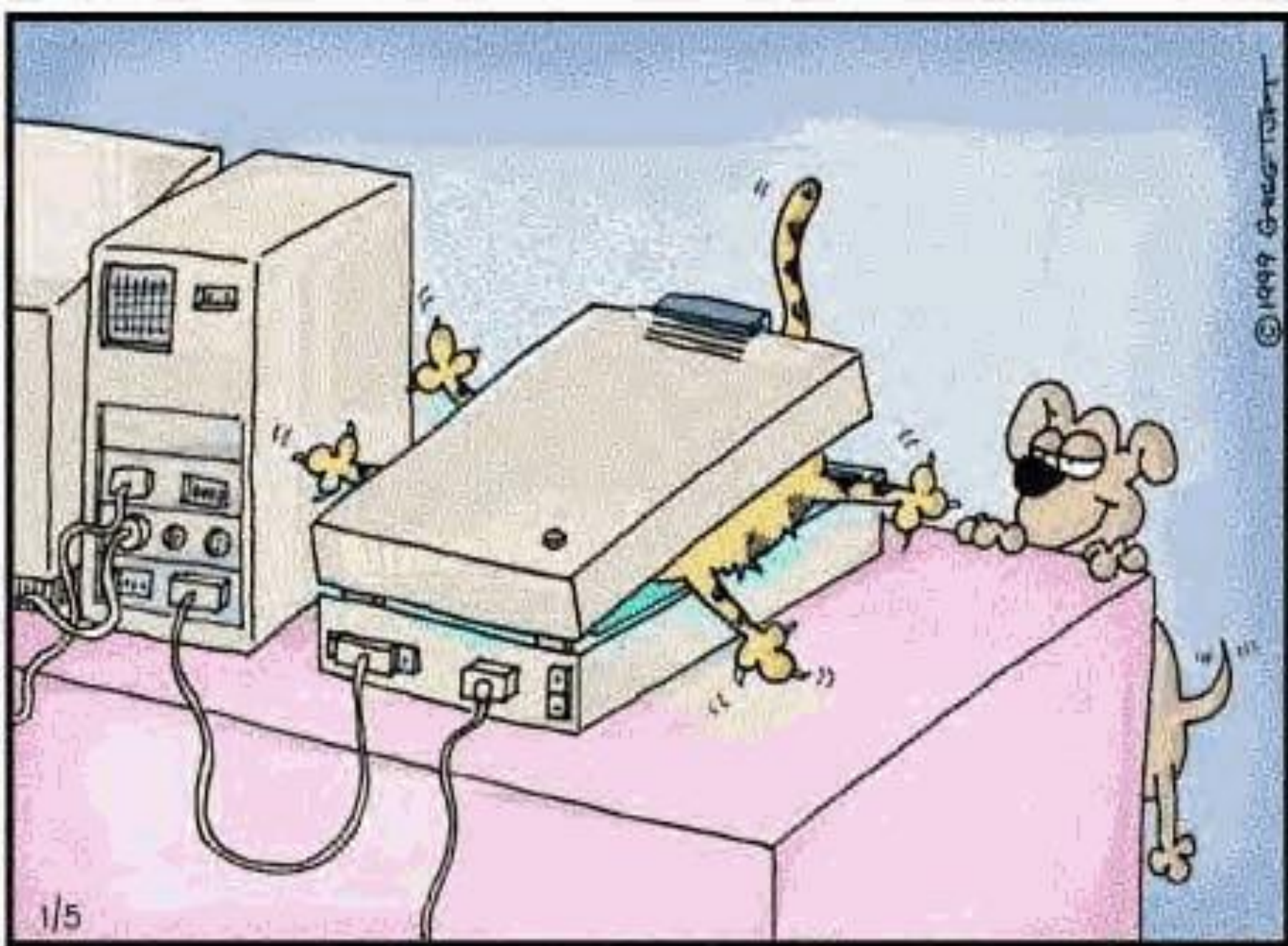
"A GRIPPING, RIPPING, BLISTERING ADVENTURE.
SCORCHINGLY PACED, FRESH AND STYLISH."

- Jim Lampley, WASHINGTON POST

HARRISON FORD
IS **THE FUGITIVE**







"Cat Scan"

Types of Hip Arthroplasty

- Metal / alloy
- Articular surfaces
- Fixation technique



Types of Hip Arthroplasty

- Metal / alloys
 - Cobalt chromium
 - Resistant to deformation
 - Stiff
 - Thigh pain
 - Titanium
 - Inert
 - High strength
 - Less artifact



Metal on Poly



Metal on Metal



Ceramic





Non-constrained



Semi-constrained



A



B



C



D



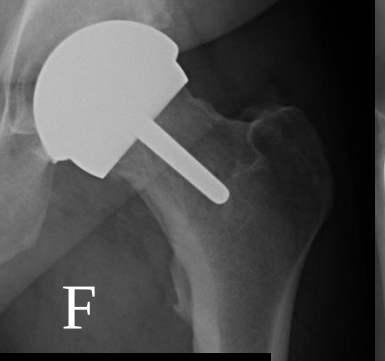
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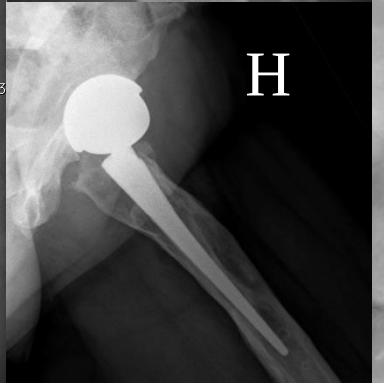
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H



I



J



K



L



4T

Fixation

- Secure fixation
 - Good function
 - Relief of pain
- Types of fixation
 - Cemented
 - Non-cemented
 - Hybrid



Fixation: Cemented

- Advantages:
 - Allows for minor incongruities in prosthesis bed
 - Early weight bearing
 - Early pain relief
- Disadvantages
 - Loss of bond with time



Cemented Total Hip Arthroplasty – Normal Appearances

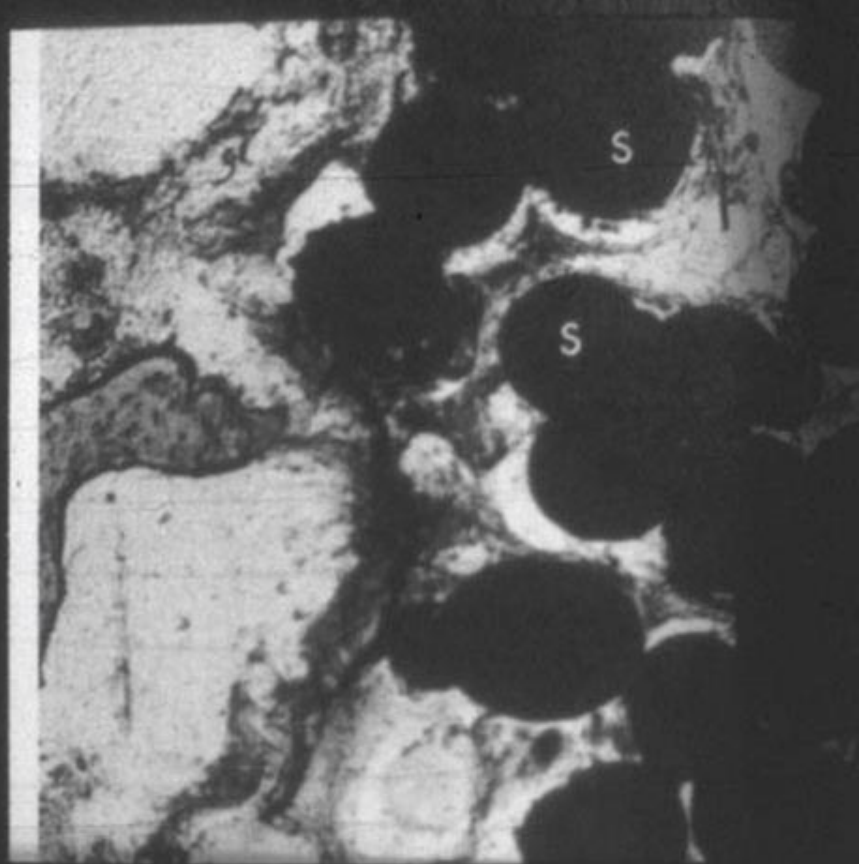
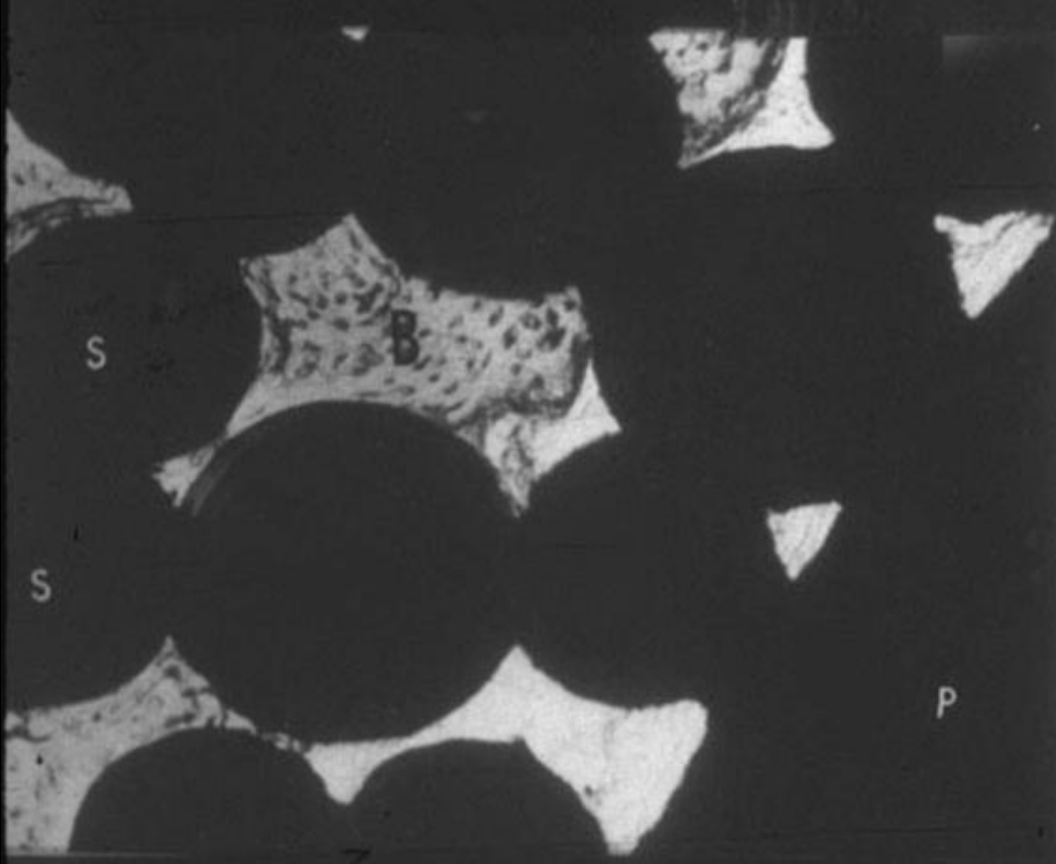
- Full coverage of prosthesis with cement
- Lucency shoulder of femoral component
- Lucency in cement:
 - Trapped air
 - Centralizer



Fixation: Non-cemented

- Press-fit / Coating
- Bone ingrowth
 - Porous coated
 - Sintered titanium balls
 - Trabecular metal
 - Greater ingrowth

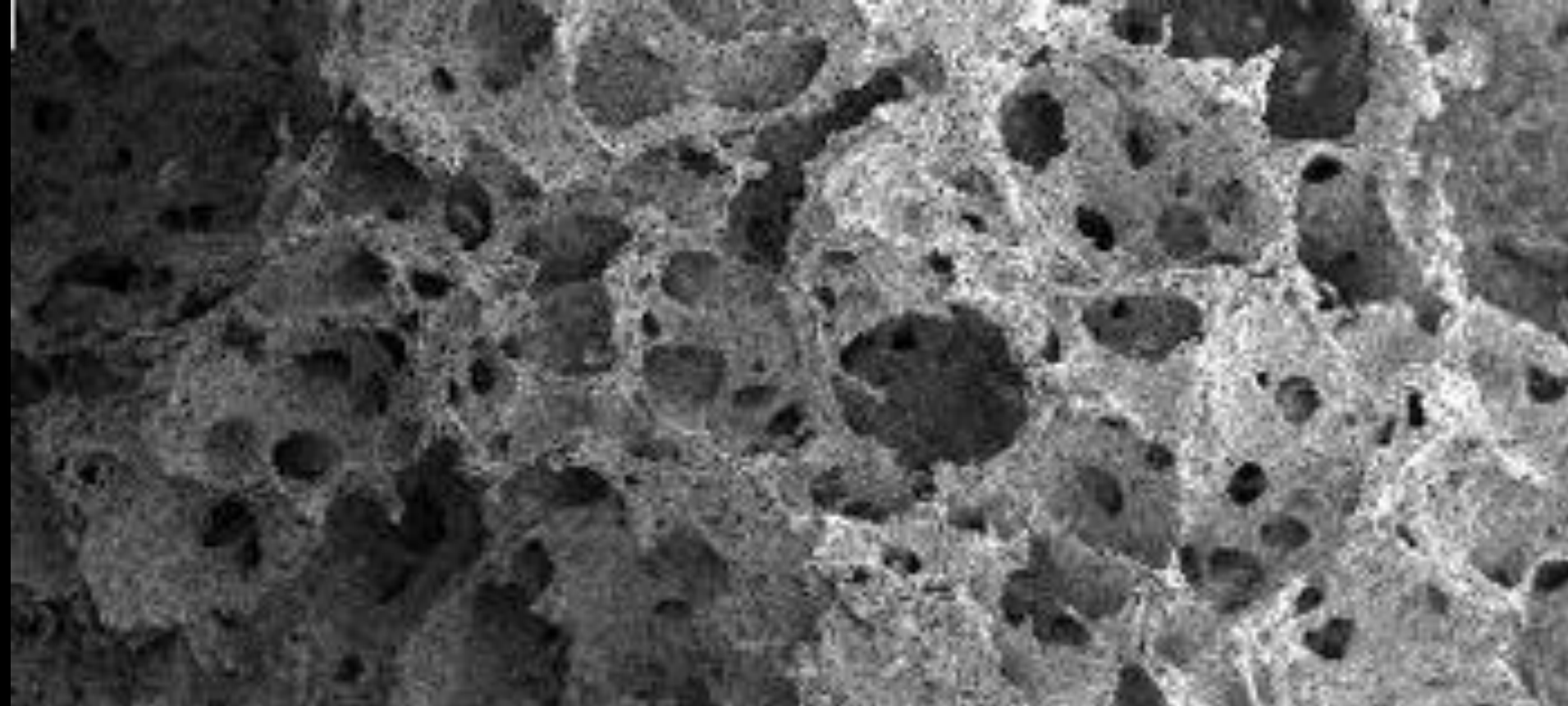


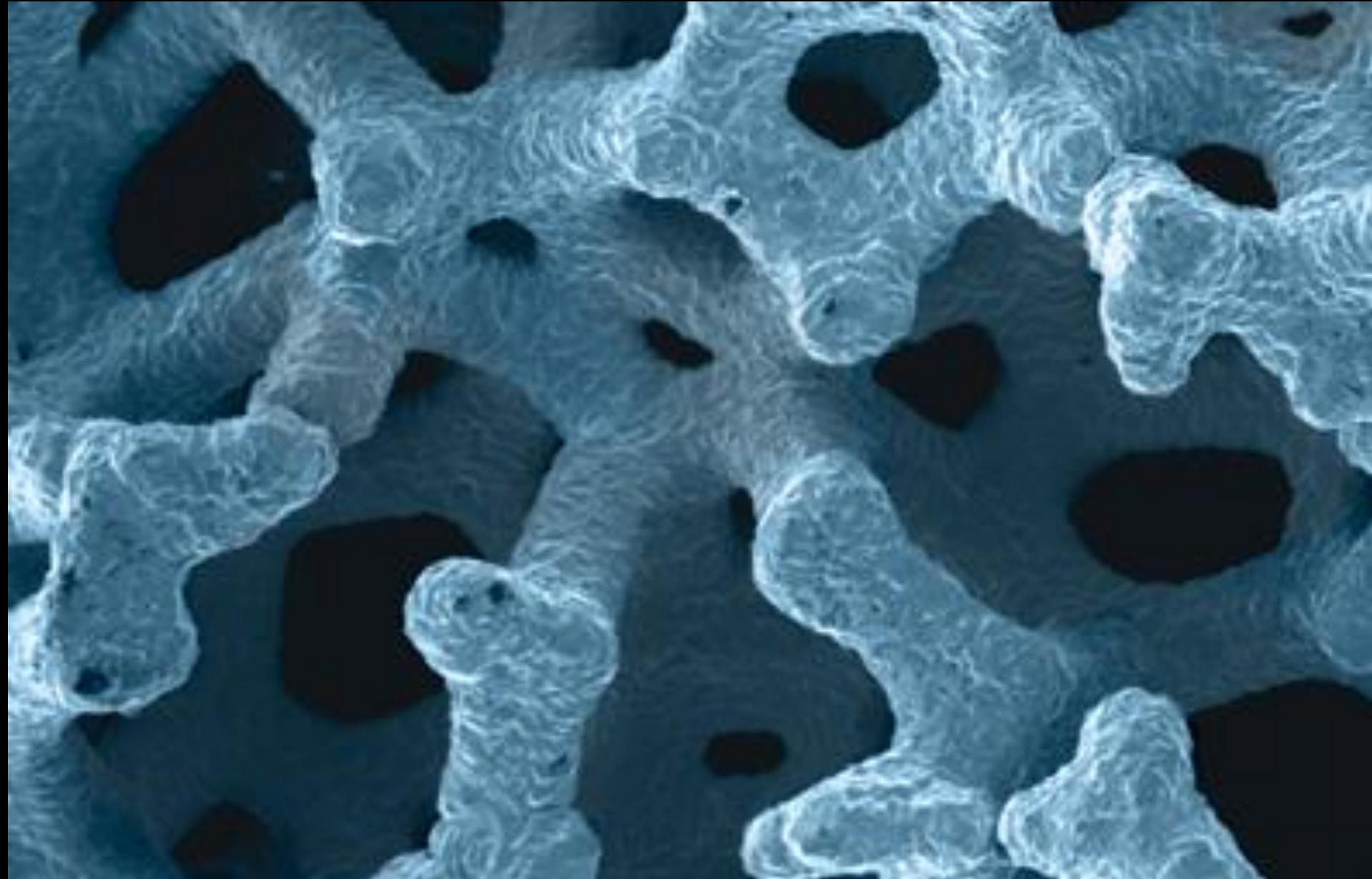


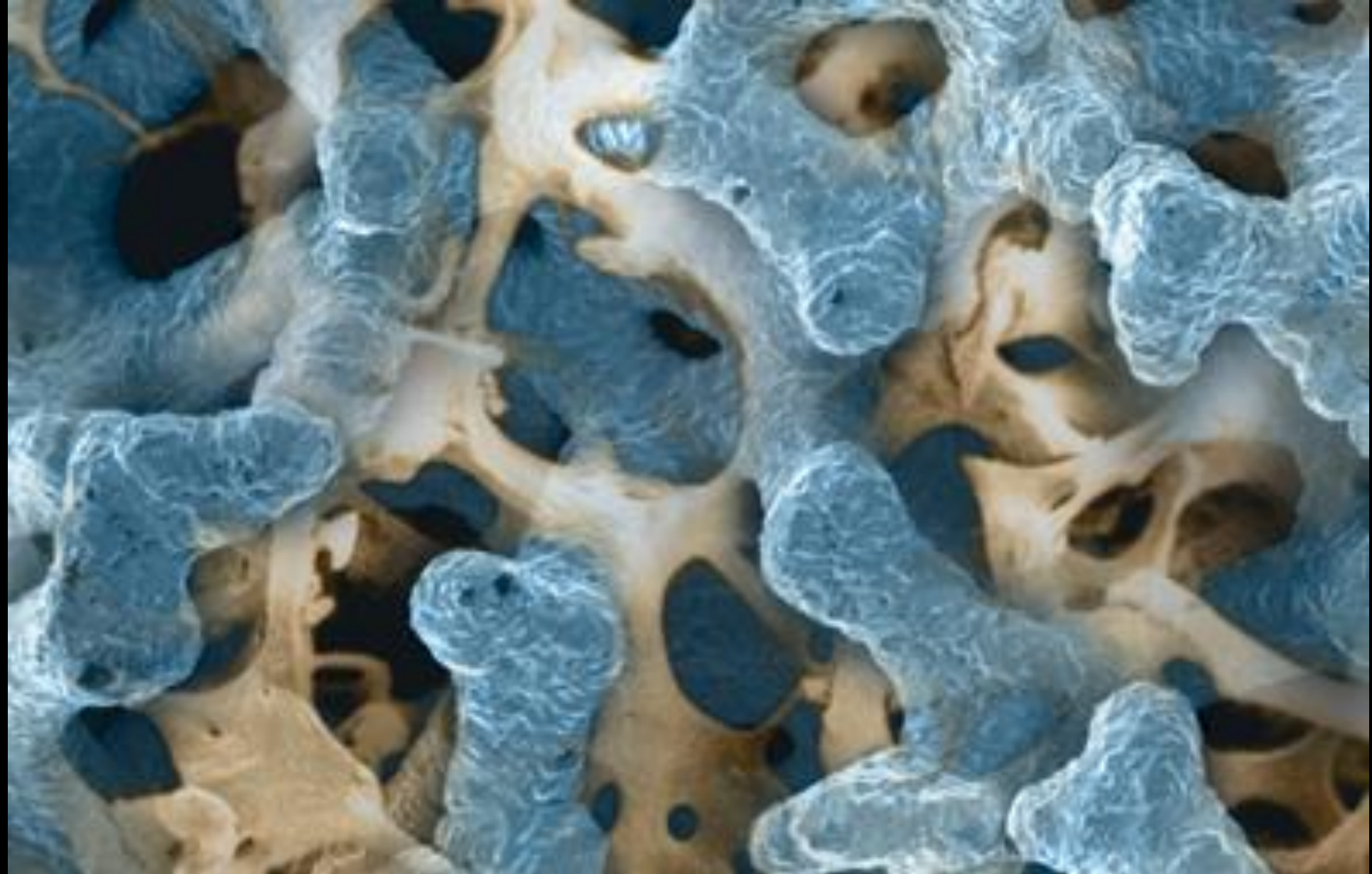
Fixation: Non-cemented

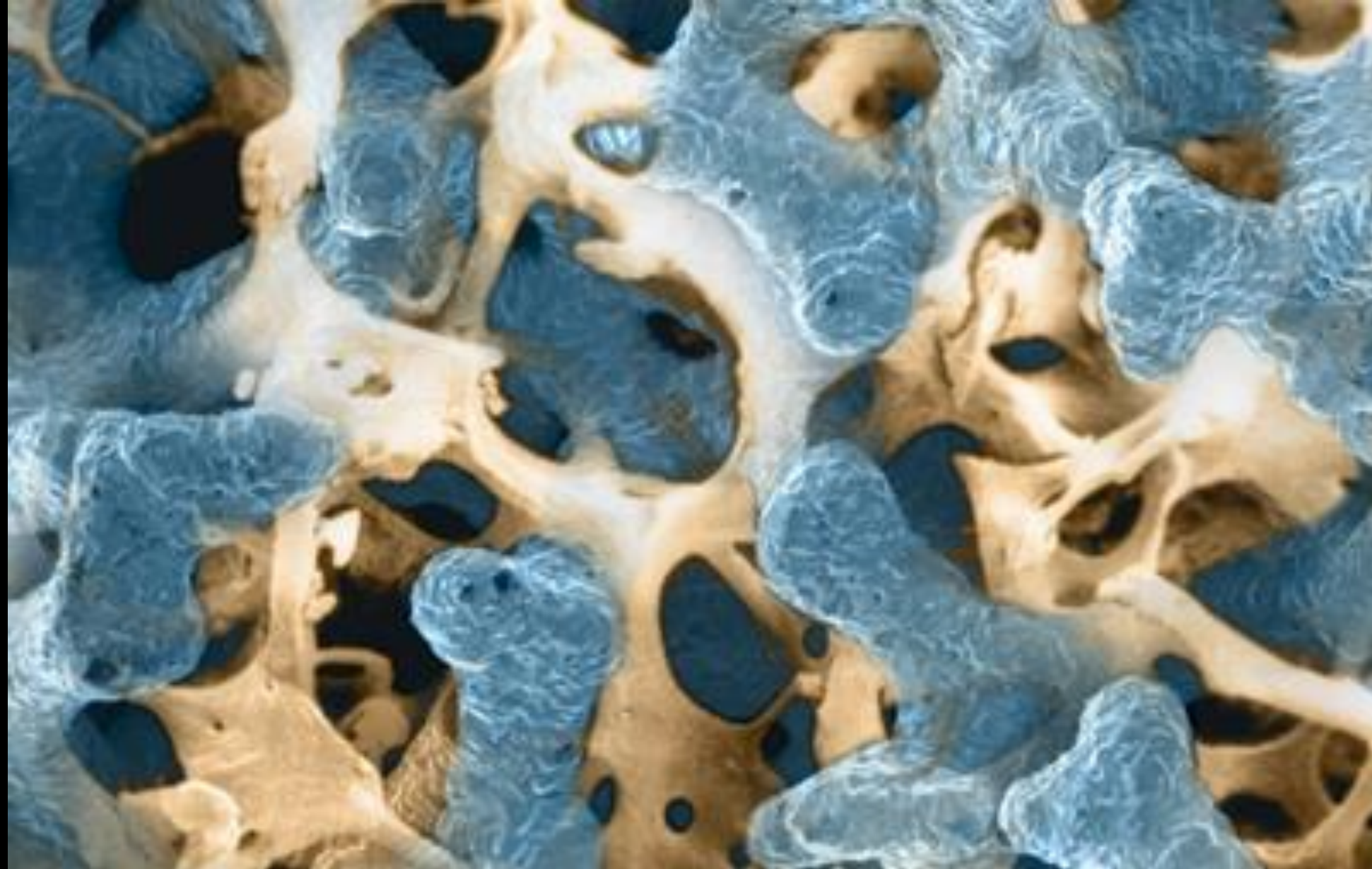
- Ingrowth:
 - Bone: Spot welds
 - Fibrous: Lucency <2mm + sclerotic rim

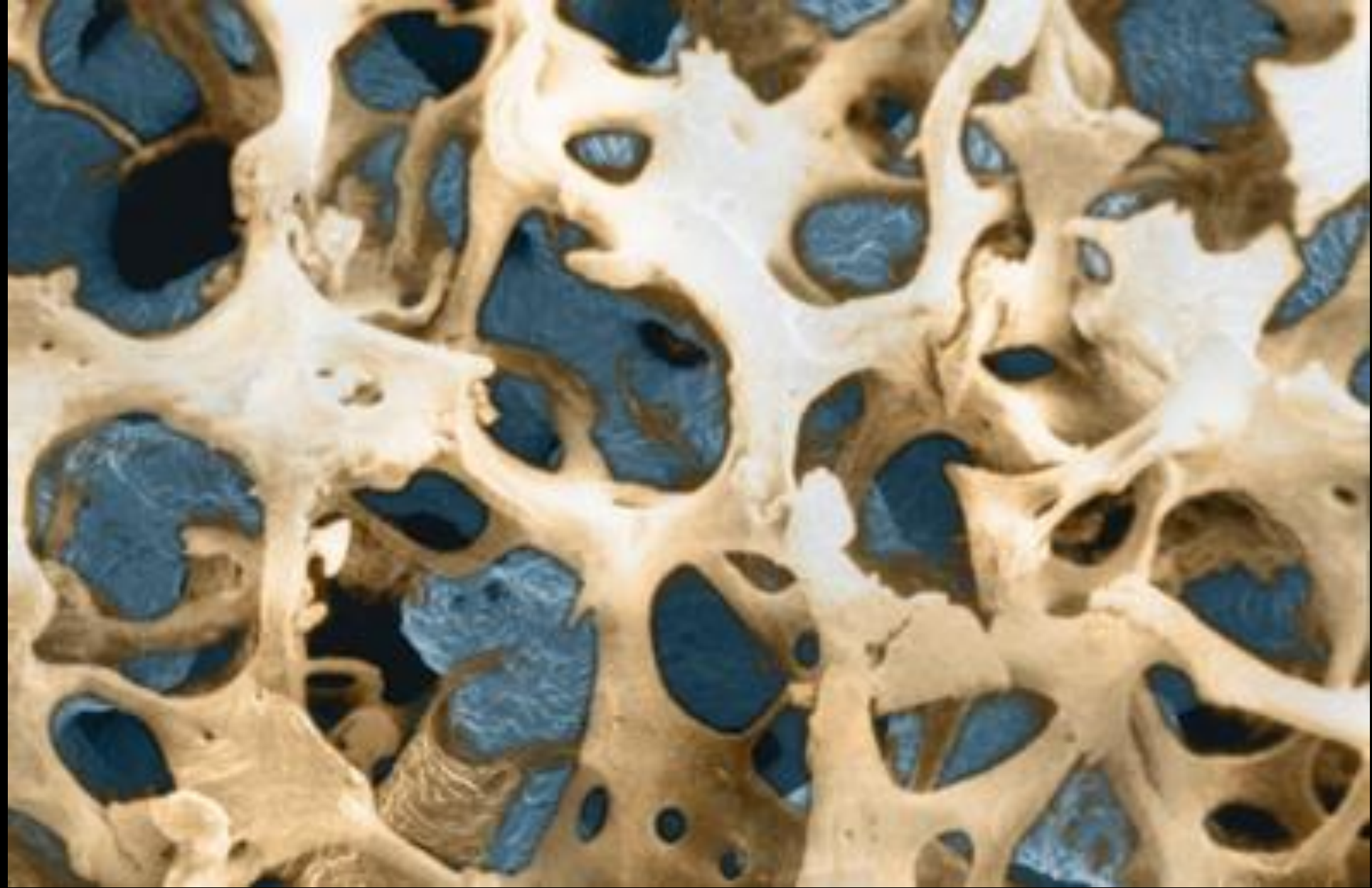








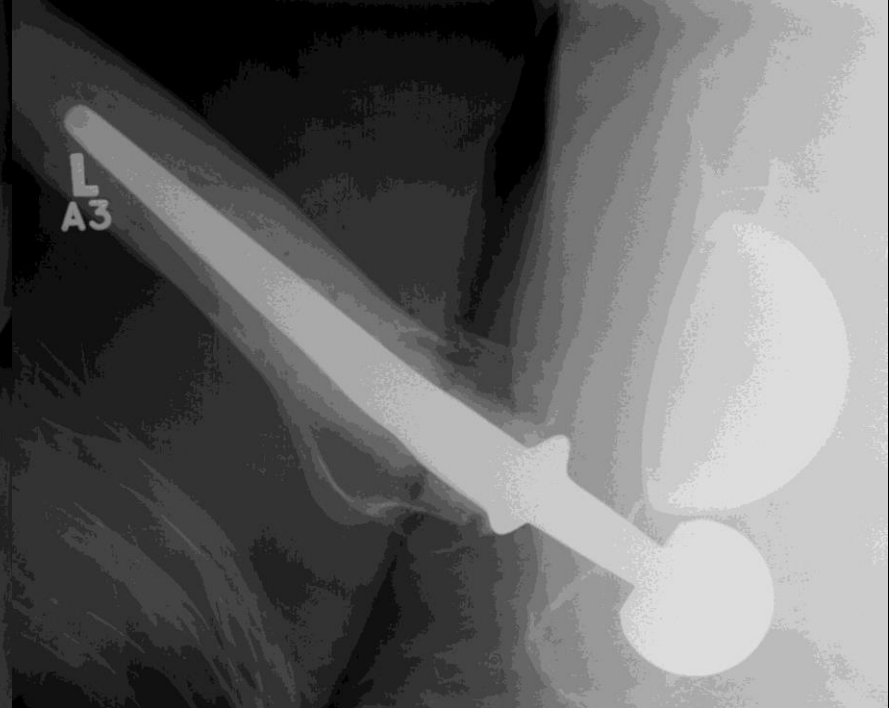




Imaging Assessment of Hip Arthroplasty

- Technique
 - Entire prosthesis
 - 2 views
 - Priors









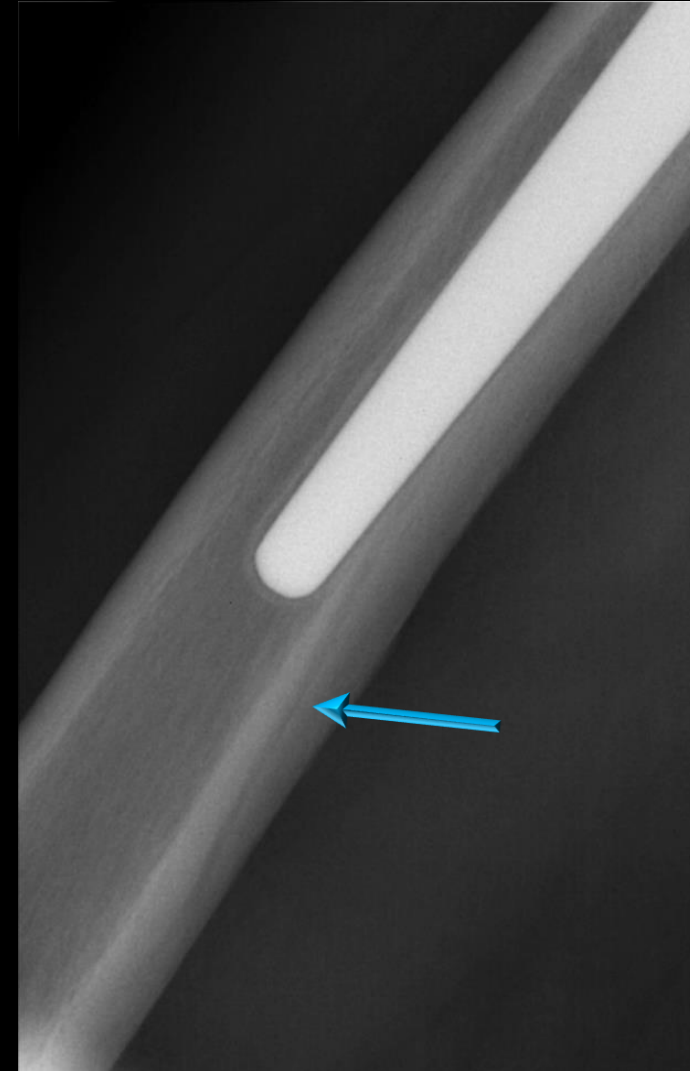
Imaging Assessment of Total Hip Arthroplasty

- Positioning
 - Central femoral component
 - Acetabular inclination
 - Acetabular version
 - Leg length discrepancy

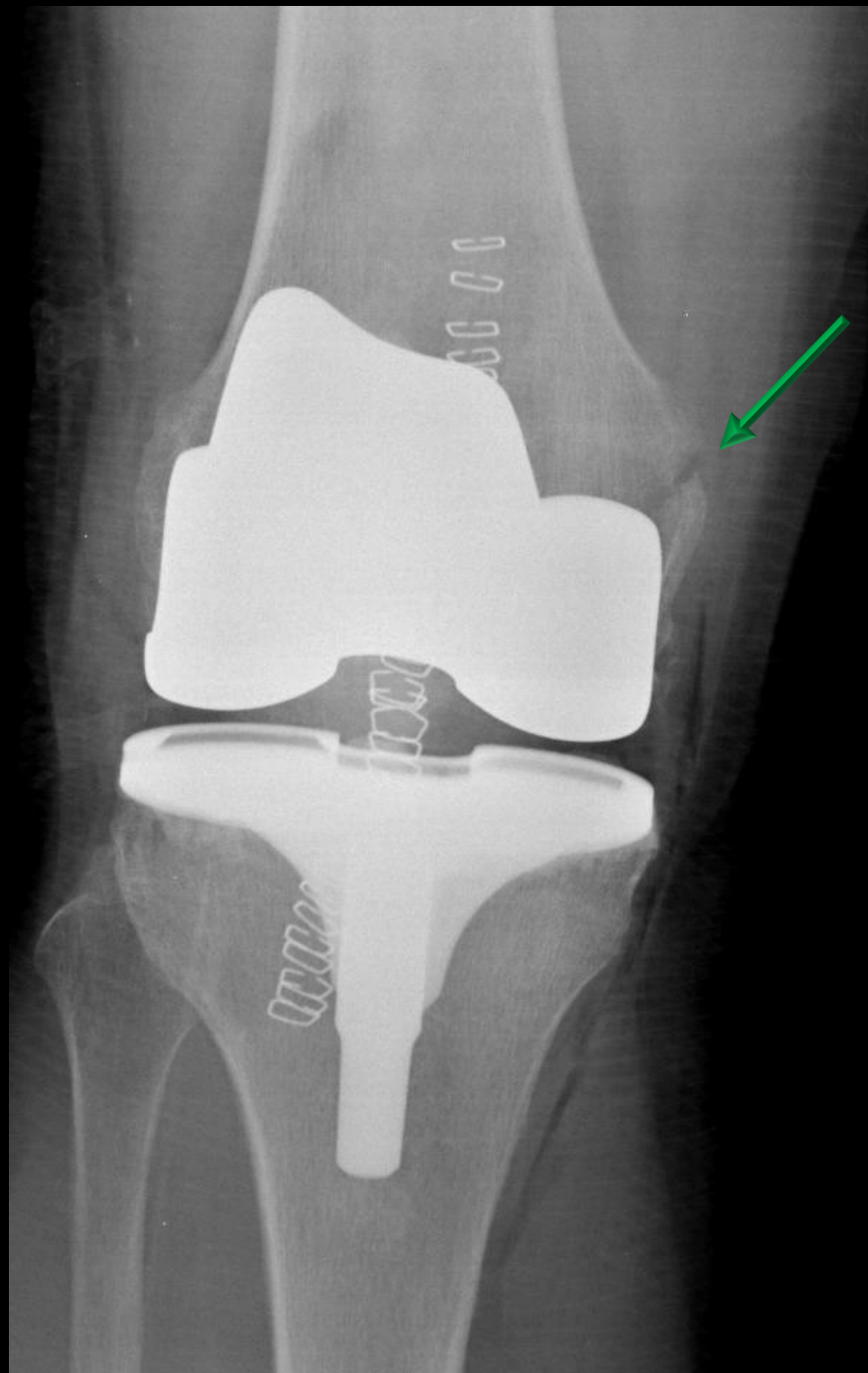


Intra-operative Fractures

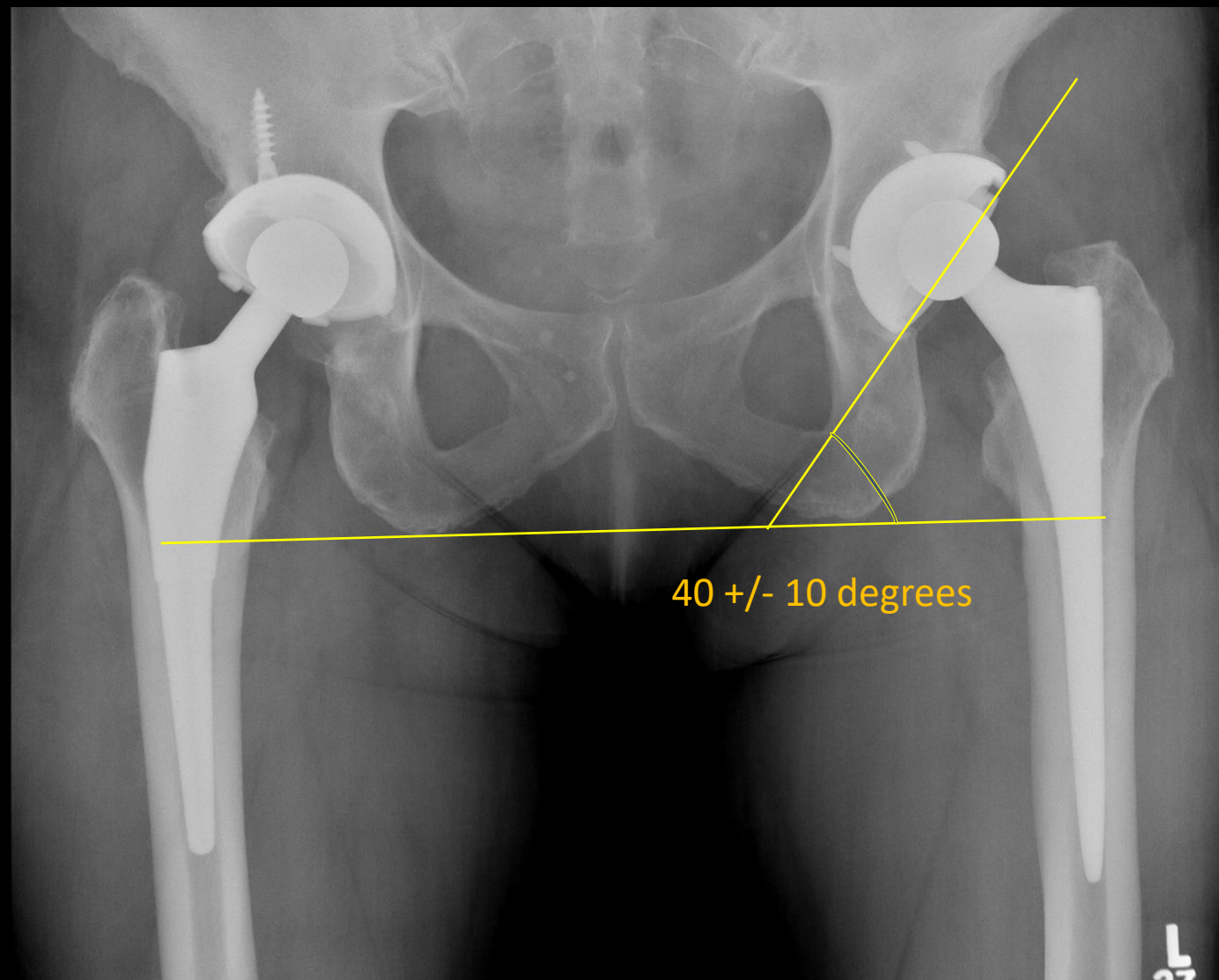
- Risk of intraoperative fractures:
 - Cemented - 1%
 - Non-cemented – 3%-7%
- Femoral fractures:
 - Tip of femoral stem tip
 - Non-displaced
 - May be confused with nutrient channels



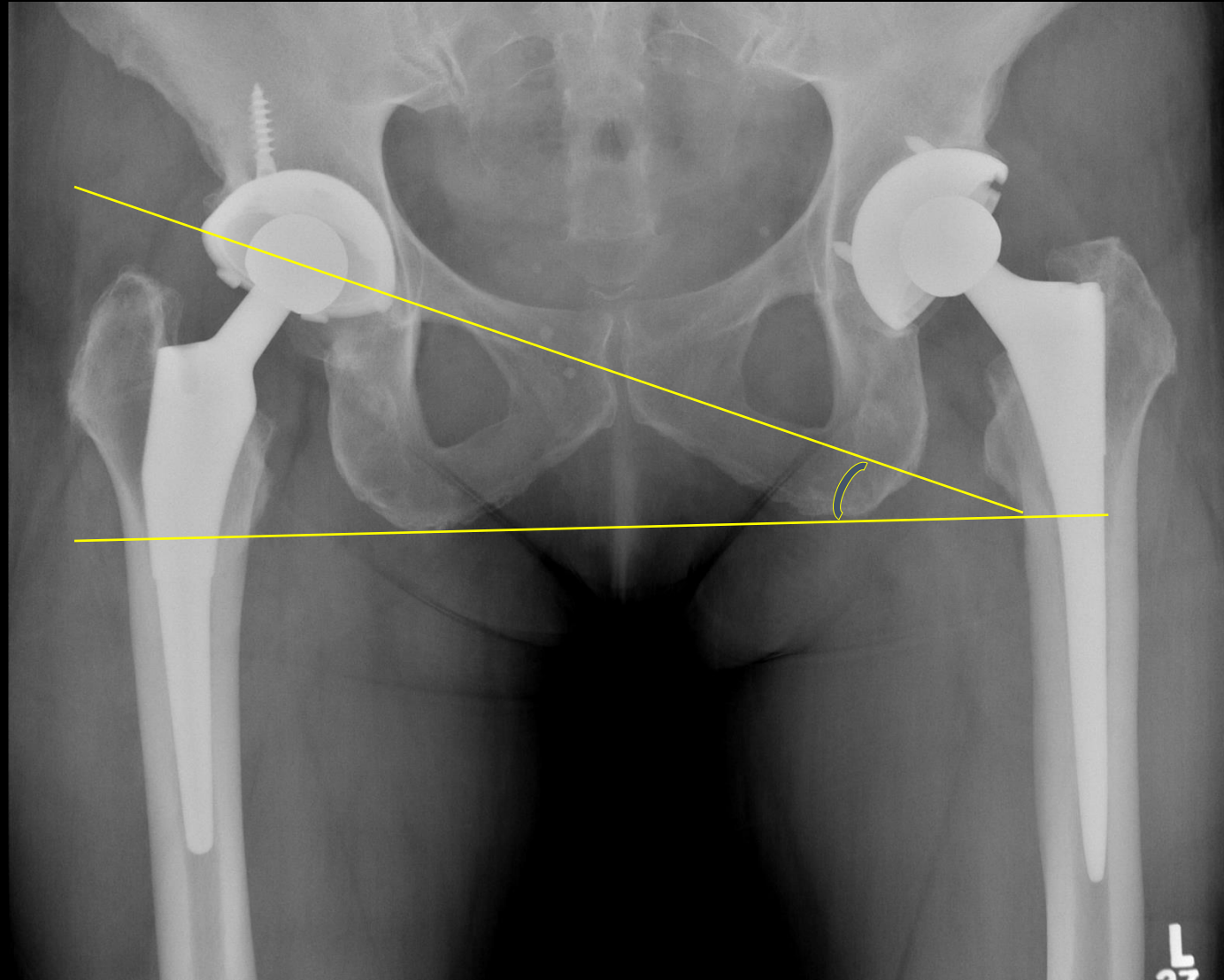




Acetabular Inclination



Acetabular Inclination





Angle $> 50^\circ$

Good ABDuction

Prone to dislocation

Prone to wear

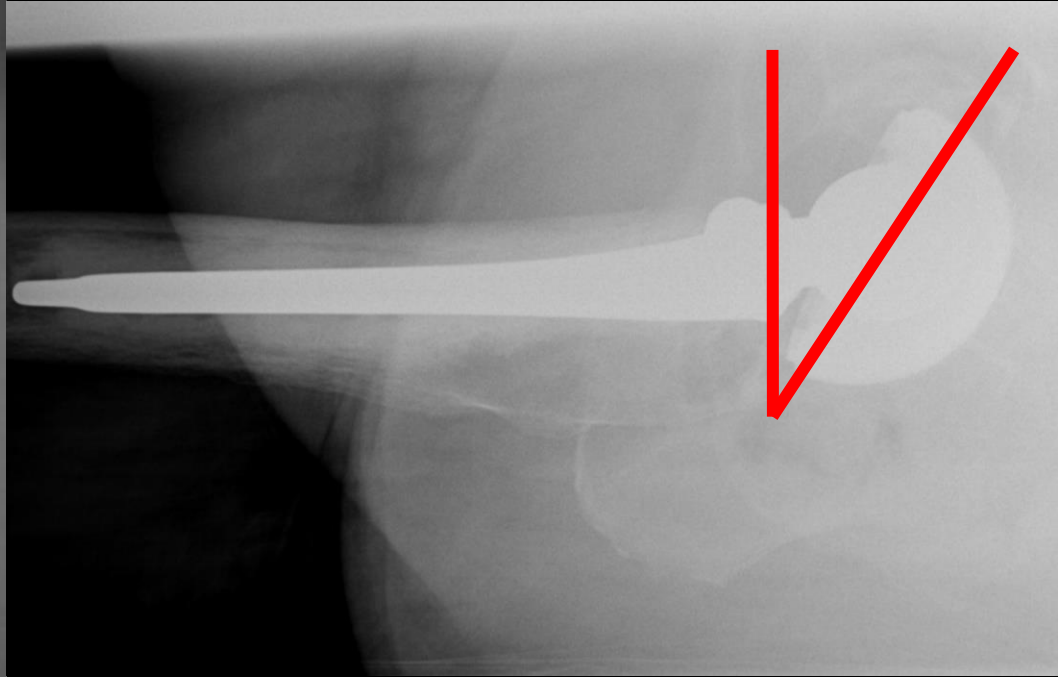
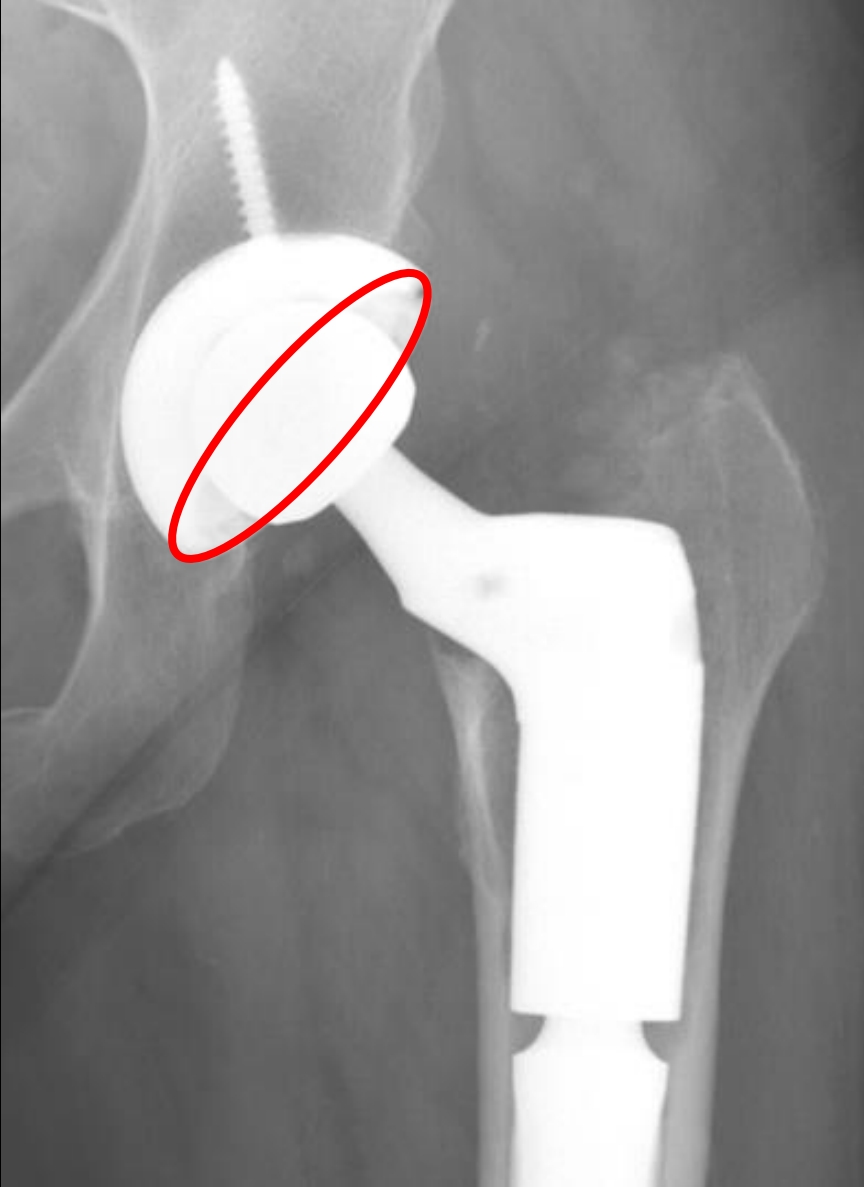


Angle $< 30^\circ$

Limited ABDuction
Stable

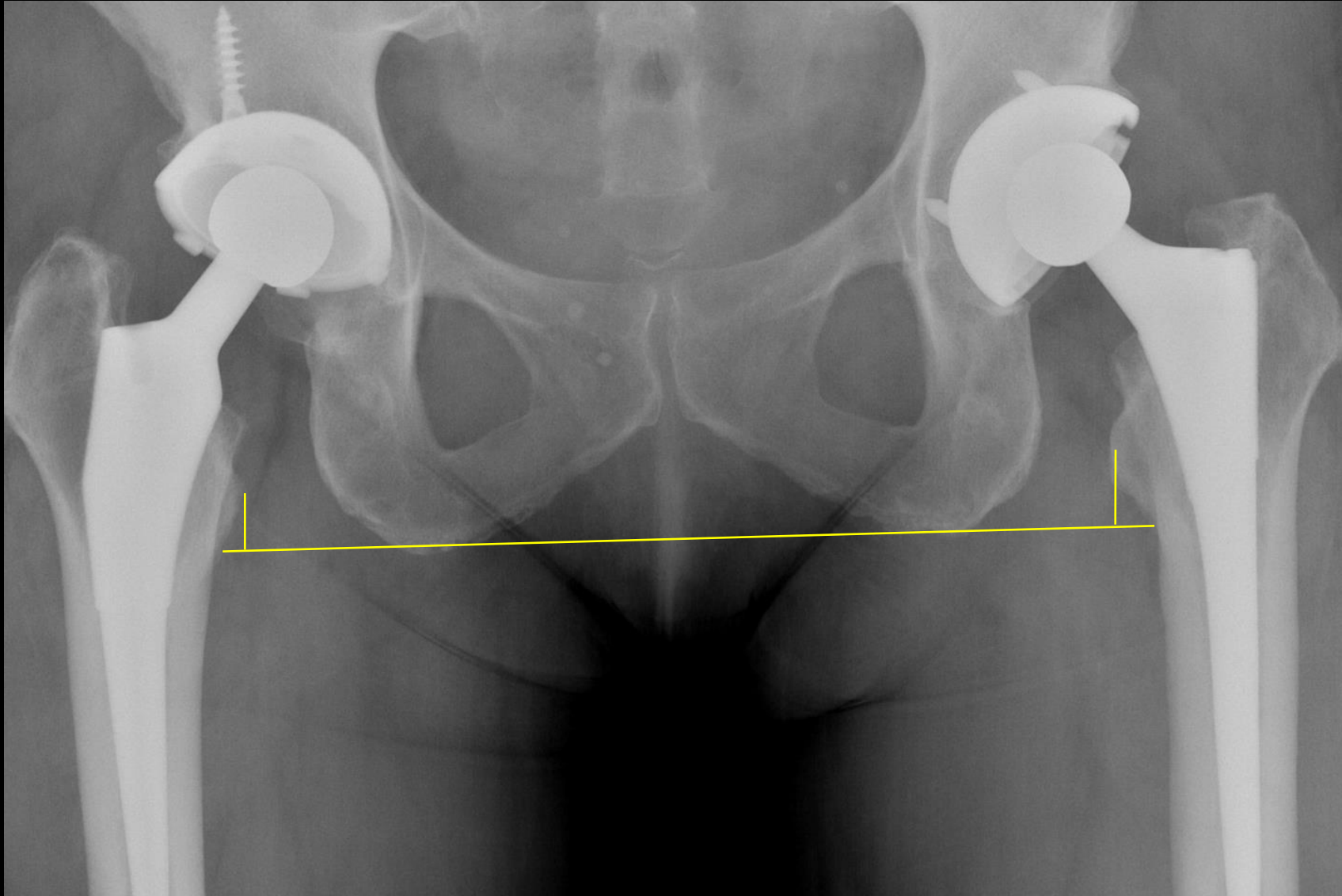


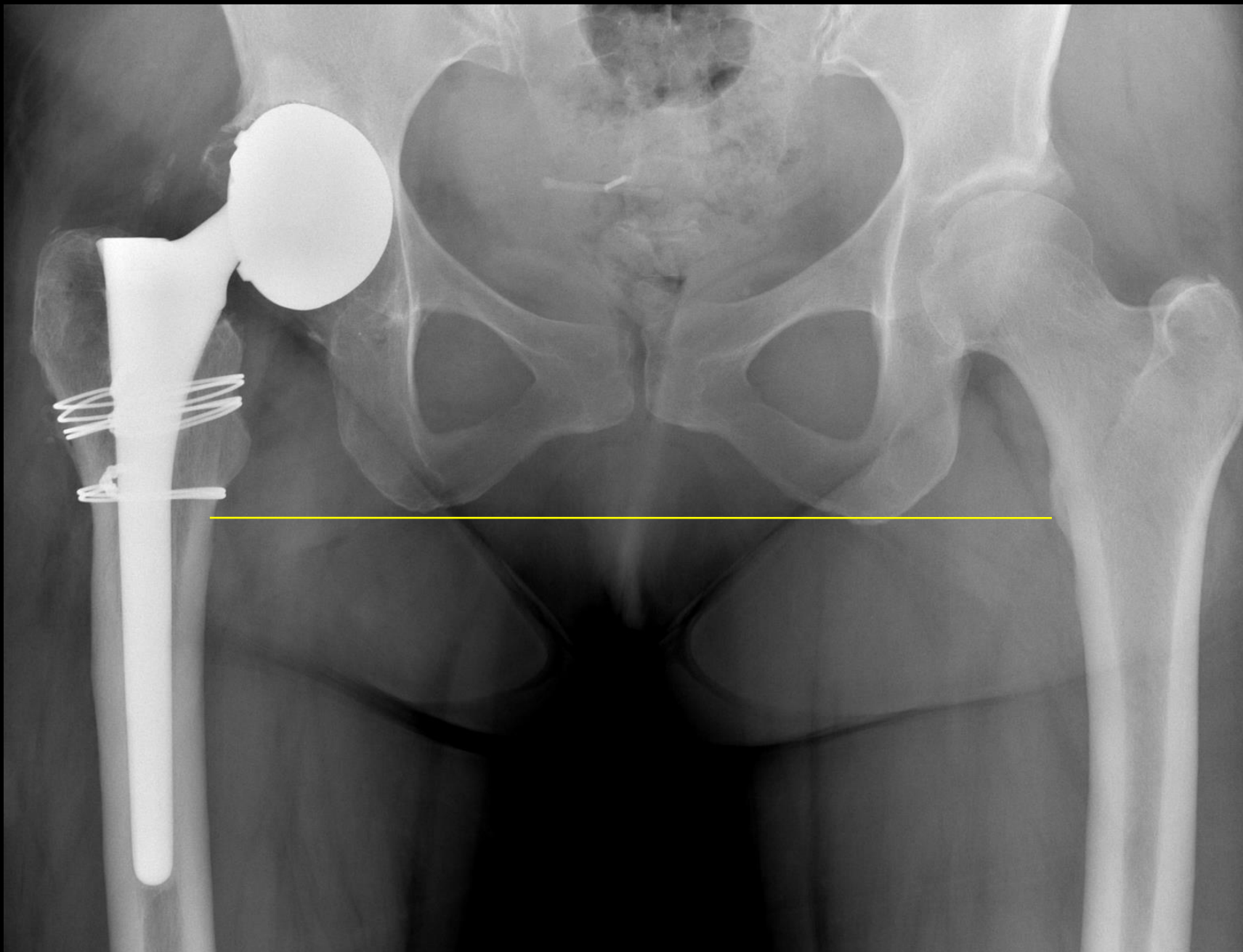
Acetabular Anteversion



Normal: 15 +/- 10 degrees

Leg Length Discrepancy





Complications of arthroplasty

- Loosening
 - Mechanical
 - Small particle disease
 - Infection
 - Dislocation
 - Periprosthetic fracture
 - Hardware Failure
 - Heterotopic ossification
- 75%
 - 8%
 - 6%
 - 5%
 - 1%
 - Technical error/other: 7%

Loosening

- Change in alignment or migration of a component
 - Reliable indicator of loosening





4 yrs post-op



6 yrs post-op

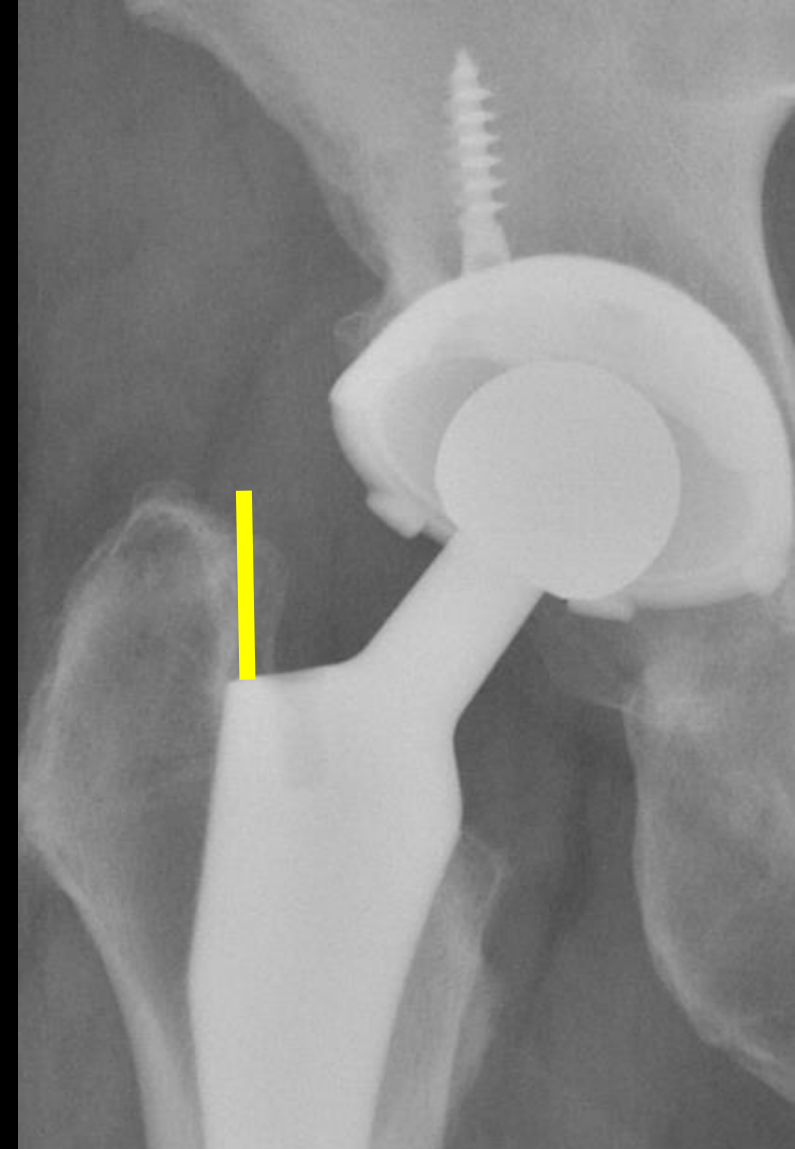


7 yrs post-op



Subsidence

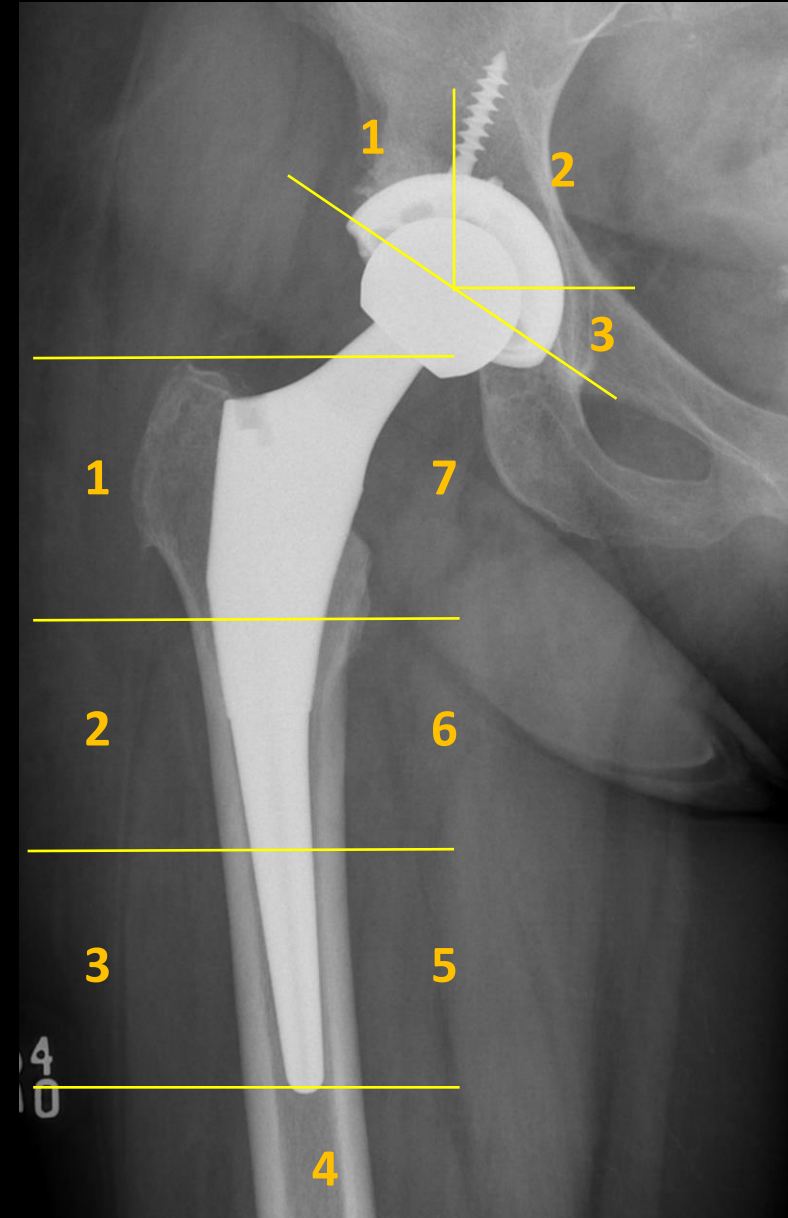
- Relationship of greater trochanter to shoulder of the arthroplasty
- >2.5 mm subsidence at 2 yrs: 5% longterm survival





Loosening

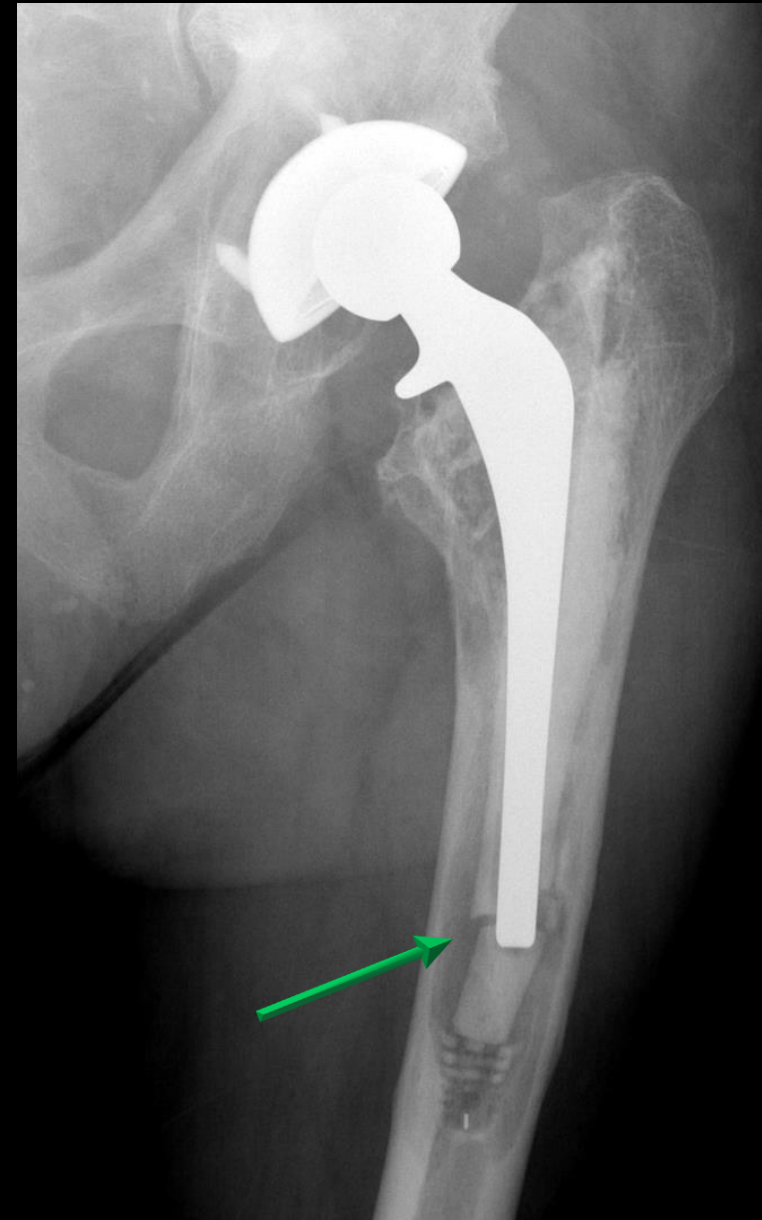
- Radiolucent zone
 - New
 - Progression >2 yrs
 - Coated segment
 - Medial acetabulum
- Localization: Zones
 - Femoral (Gruen)
 - Acetabular (Charnley)





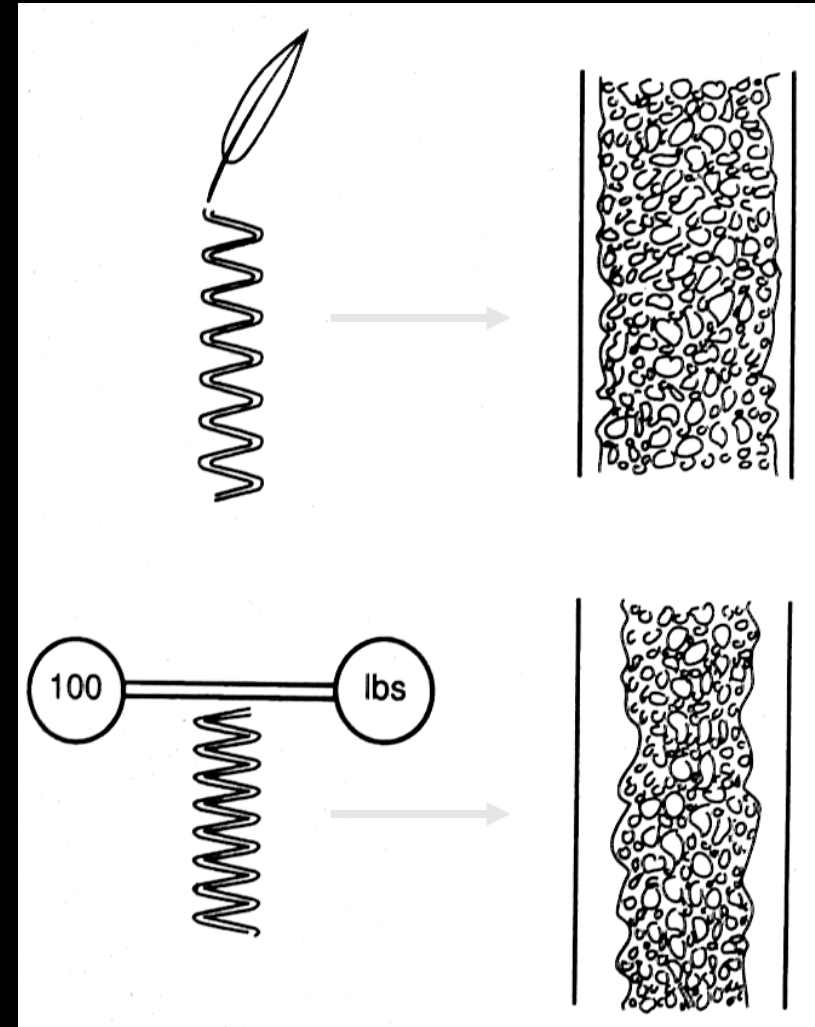
Loosening

- Fractured cement mantle
 - Often associated with other findings
 - May be asymptomatic



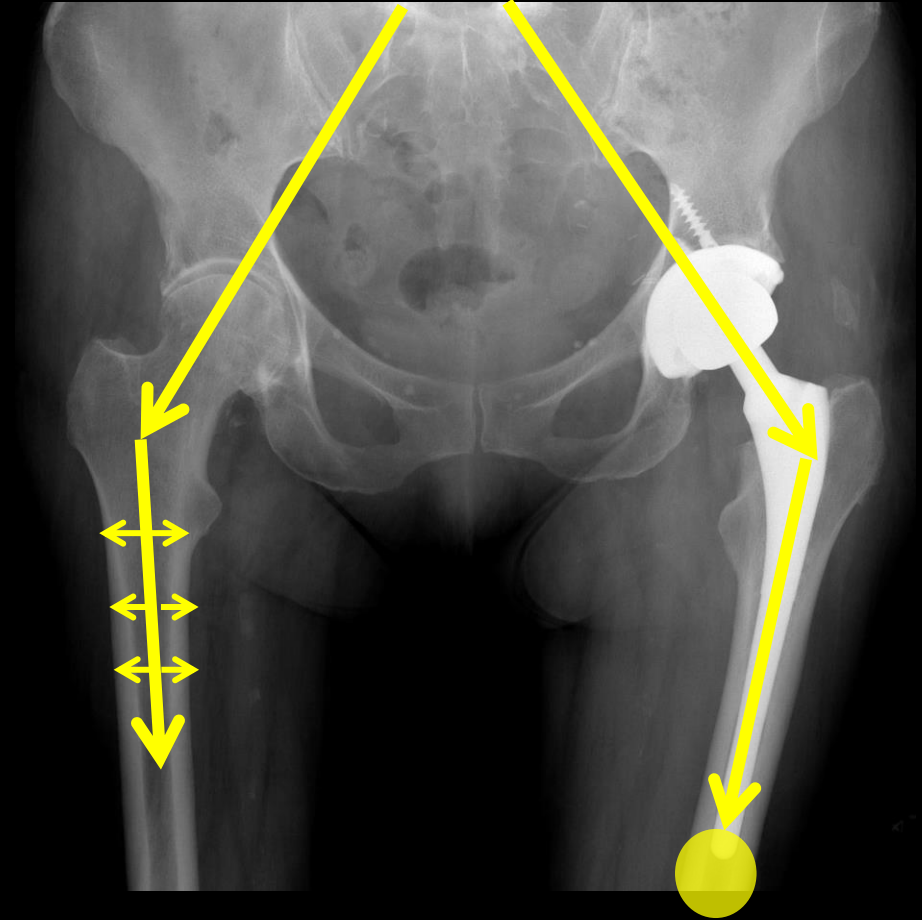
Stress Shielding

- Wolff's Law
 - Bone is deposited and resorbed in accordance with the stresses placed upon it
- Bone exposed $\uparrow$ stress
 - Hypertrophy
- Bone exposed $\downarrow$ stress
 - Demineralization/atrophy



Stress Shielding

- 25% of stems at 2 yrs
- Risk factors:
 - Non-cemented stems
 - Stiff stems:
 - Thick stem
 - Cobalt chromium



Stress Shielding

- Features:
 - Proximal osteopenia
 - Gruen zones 1 and 7
 - Acetabulum: medially
 - Atrophy proximal cortex
 - Cortical hypertrophy distal stem
 - Little clinical significance



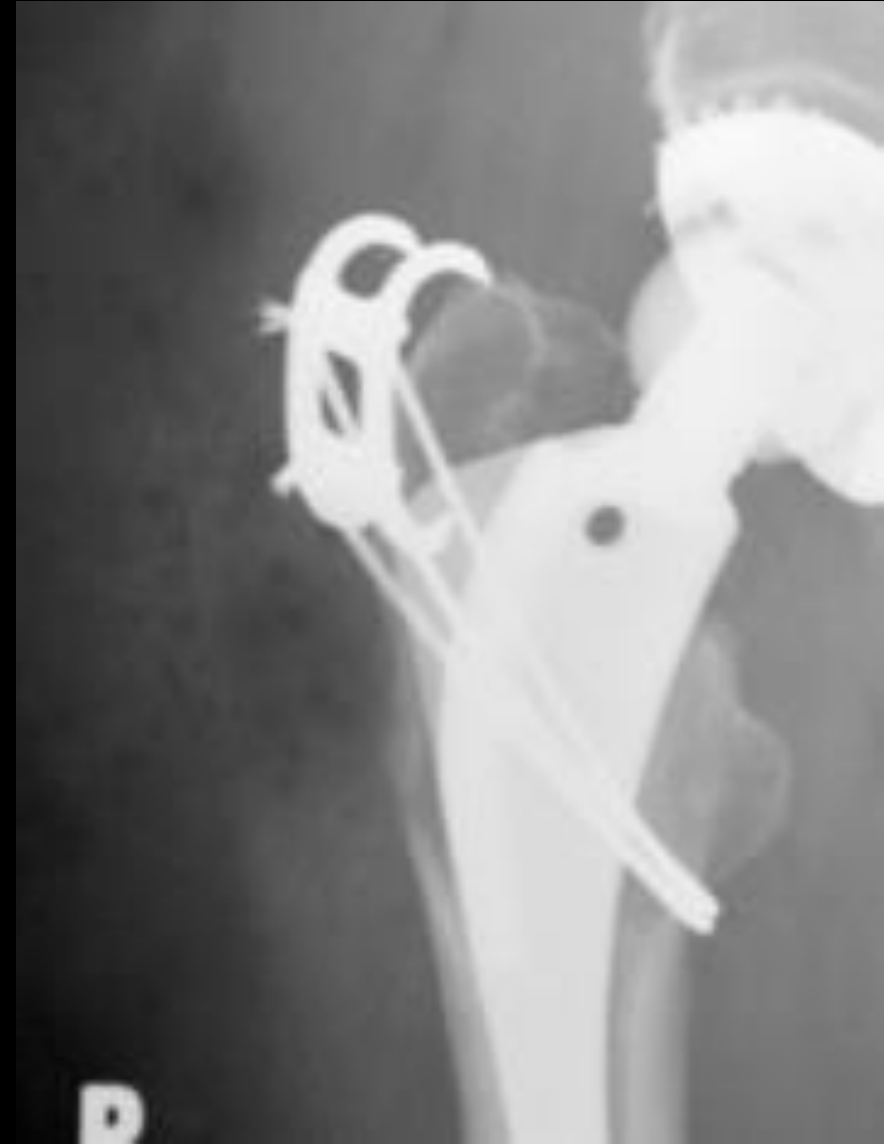
Infection

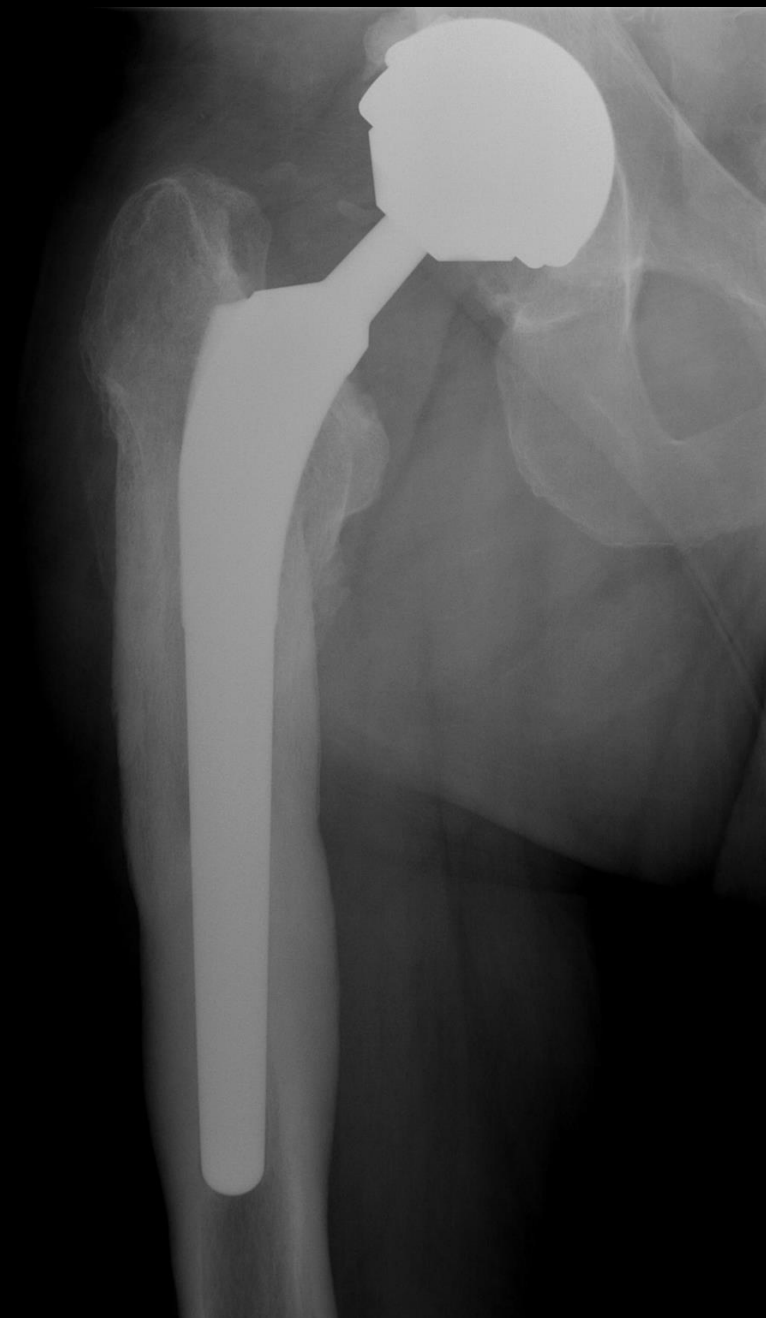
- Perioperative
 - Innoculation / Hematogenous
- Late
 - Distant hematogenous seeding
- Conventional radiographs
 - Usually normal
- Abnormalities non specific
 - Mimic loosening or osteolysis



Infection

- Adjacent soft tissue collection
- Bone destruction
- Periostitis (1%-2%)
- Rapid time course

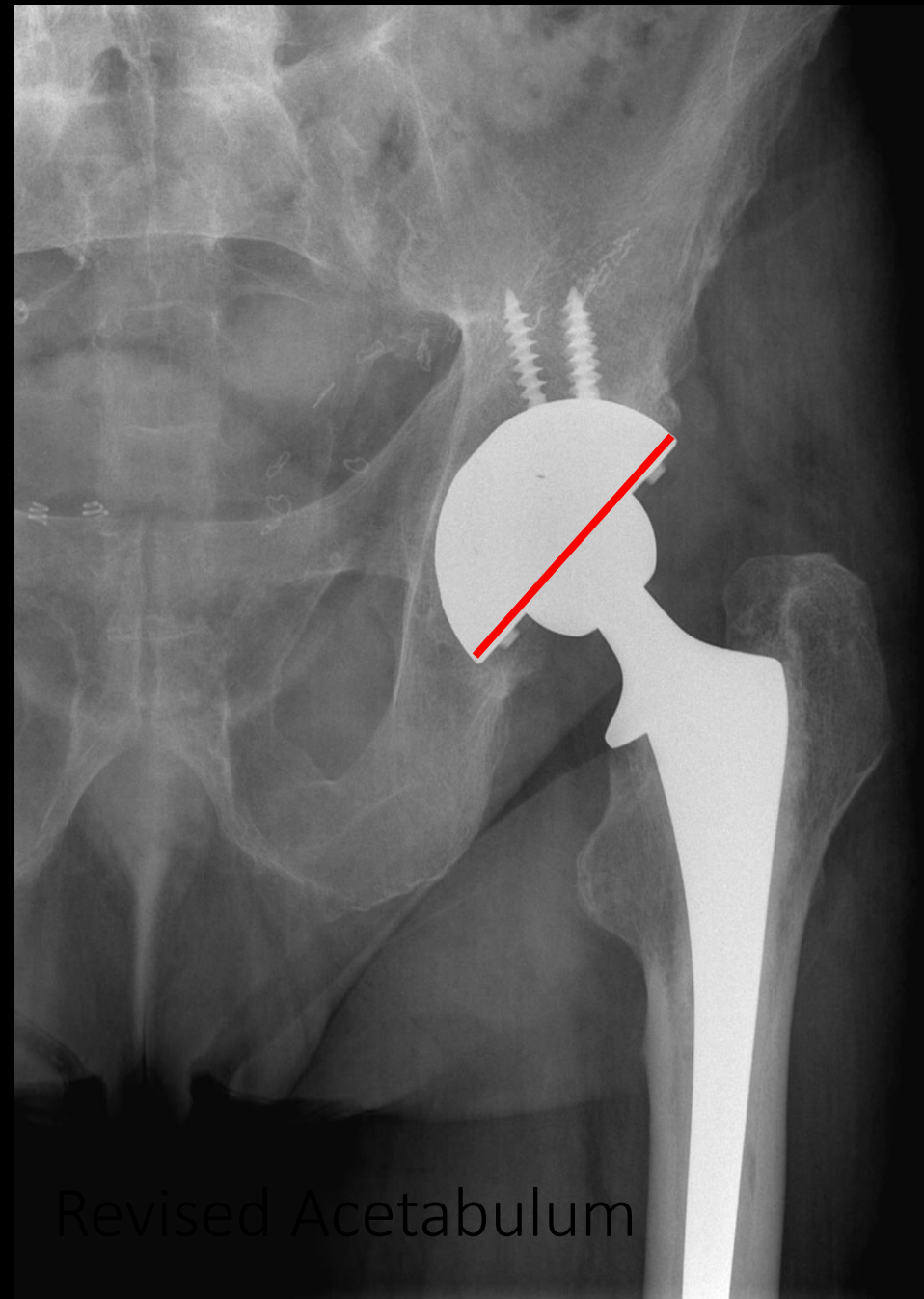
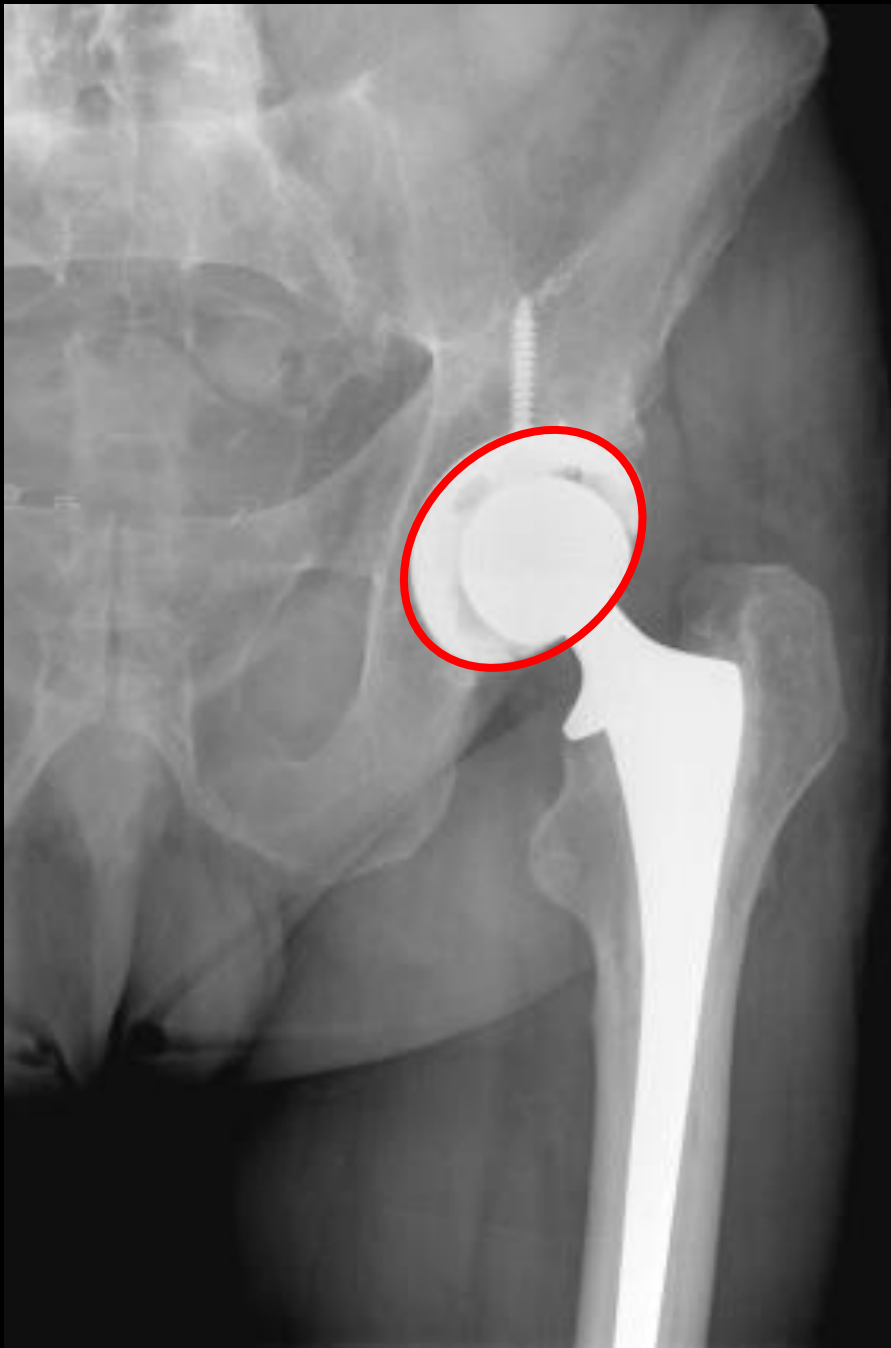




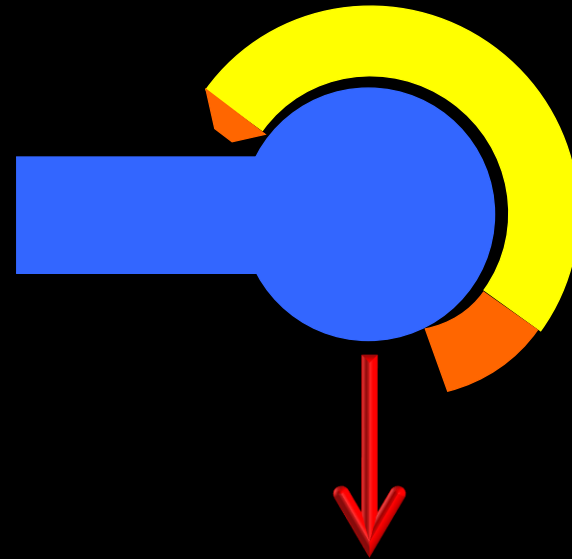
Dislocation

- Incidence: 5% primary, 15% revision
- Early vs late
- **Posterior > anterior**
- Risk factors:
 - **Increased inclination or anteversion**
 - Soft tissue laxity
 - Abductor insufficiency
 - Small femoral head size



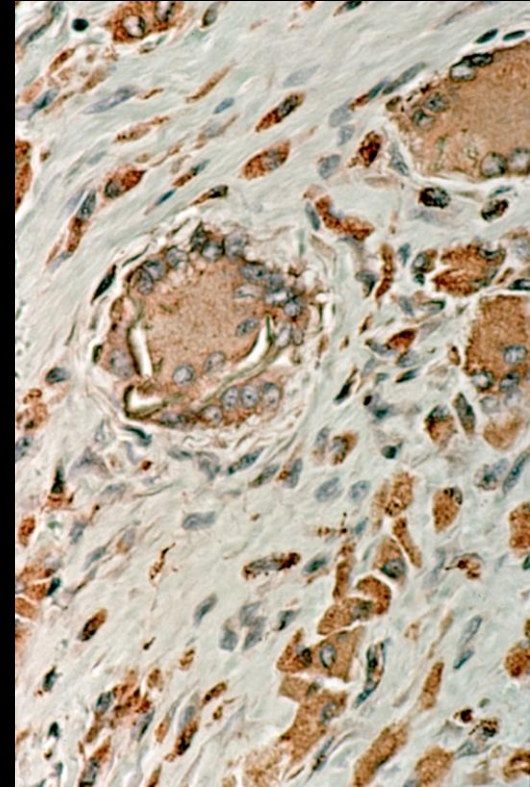


Constrained Acetabular Linear



Small Particle Disease / Granulomatosis / Granulomatous Pseudotumor / Osteolysis

- Particulate debris
 - macrophages, multinucleated giant cells
- Cause: Polyethylene
- Rare < 2-3 years postop
- 12% of non-cemented stems at 5 yrs
- May be asymptomatic



Small Particle Disease

- Lobulated lucencies



Small Particle Disease



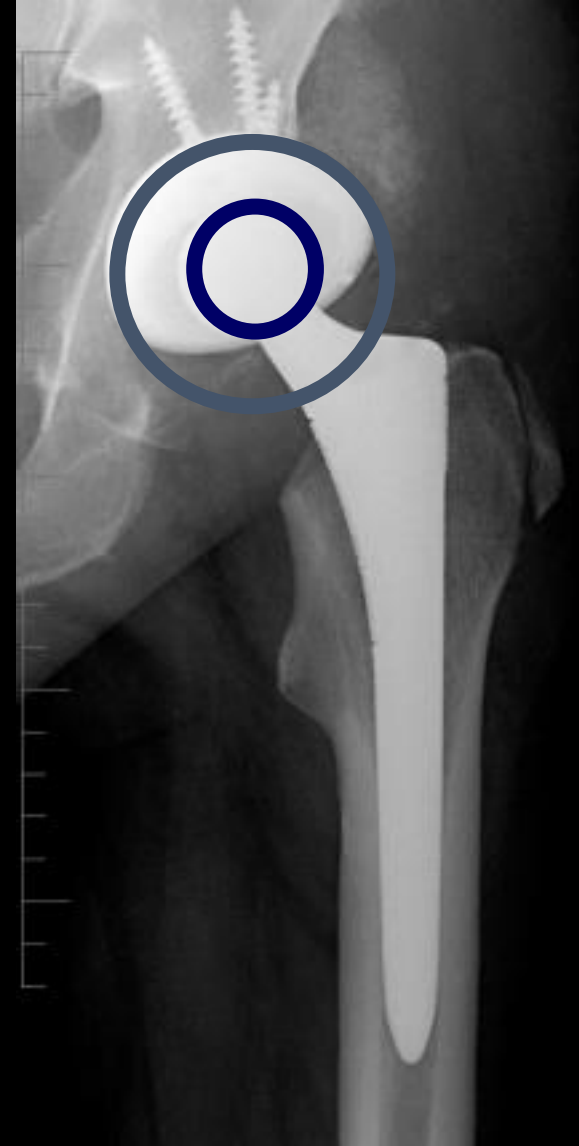
Small Particle Disease

- Asymmetric polyethylene wear



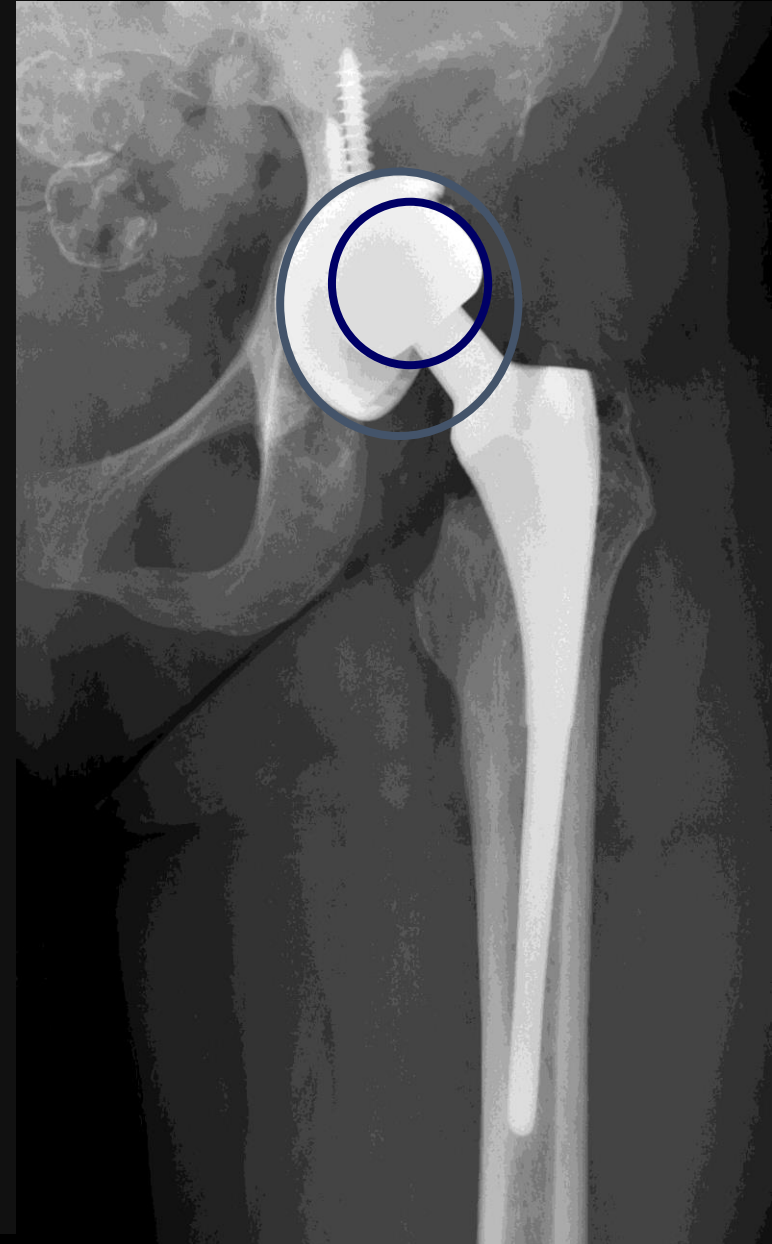
Small Particle Disease

- Asymmetric polyethylene wear



Small Particle Disease

- Asymmetric polyethylene wear





8 years post-op



9 years post-op

Small Particle Disease

- Periprosthetic fractures



R
K80

R

MR Imaging of Arthroplasties:

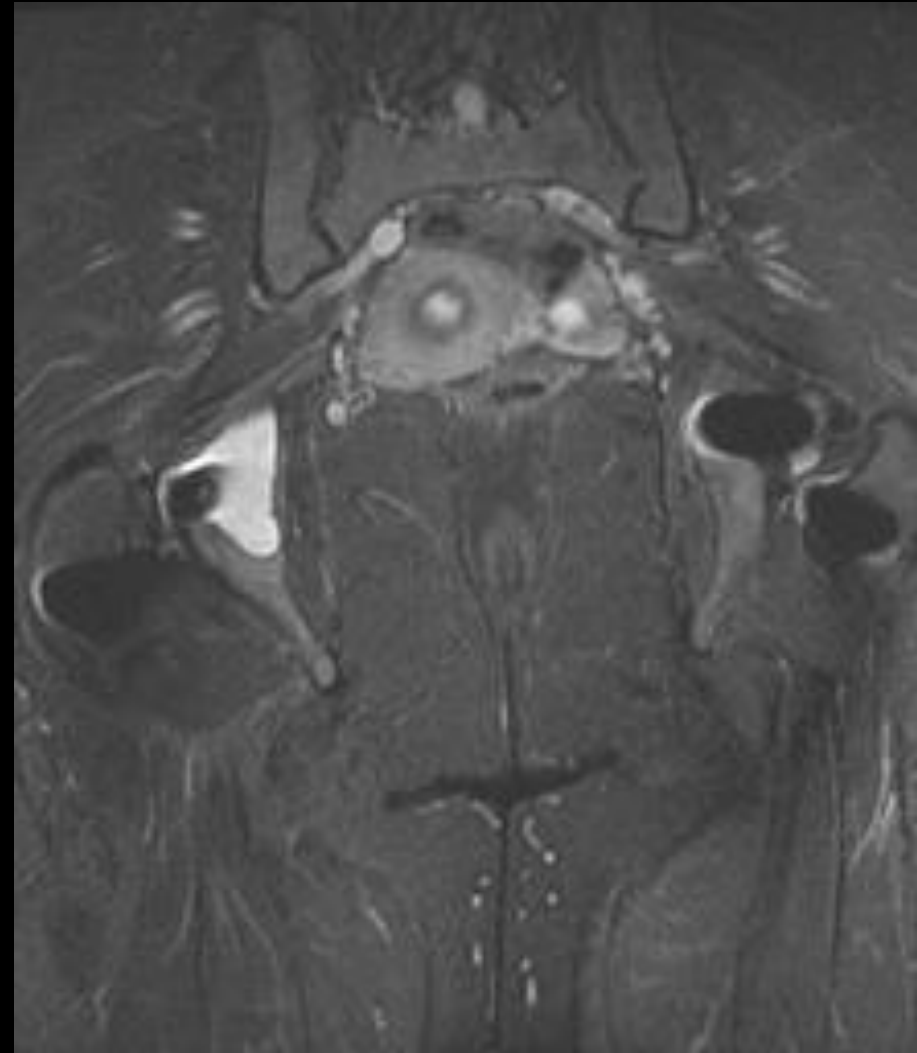
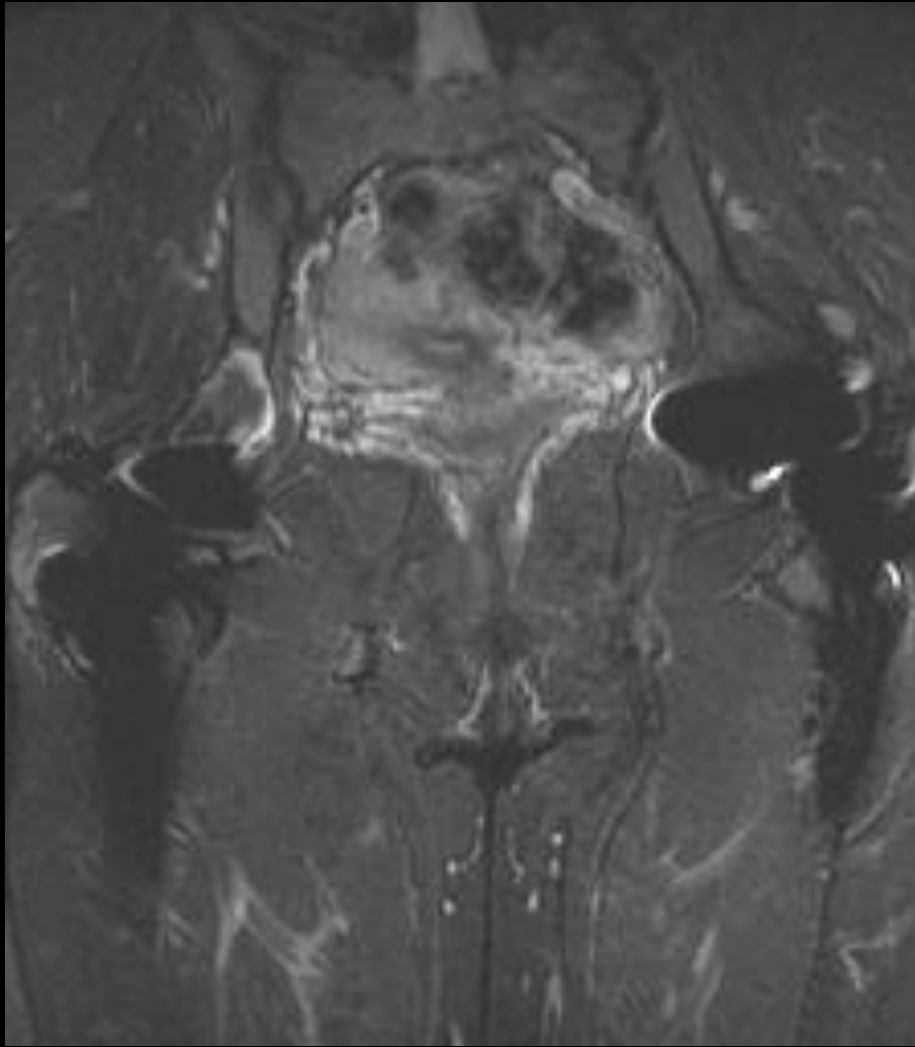
- MR Artifacts
- Metal Suppression Techniques
- Abductor Tears
- Metal on Metal Arthroplasties
 - Terminology
 - Complications
 - MR Findings

Artifact

- Intravoxel dephasing
- Misregistration
- Signal loss
- Slice thickness variation
- Poor fat-suppression

Pulse sequence Modification

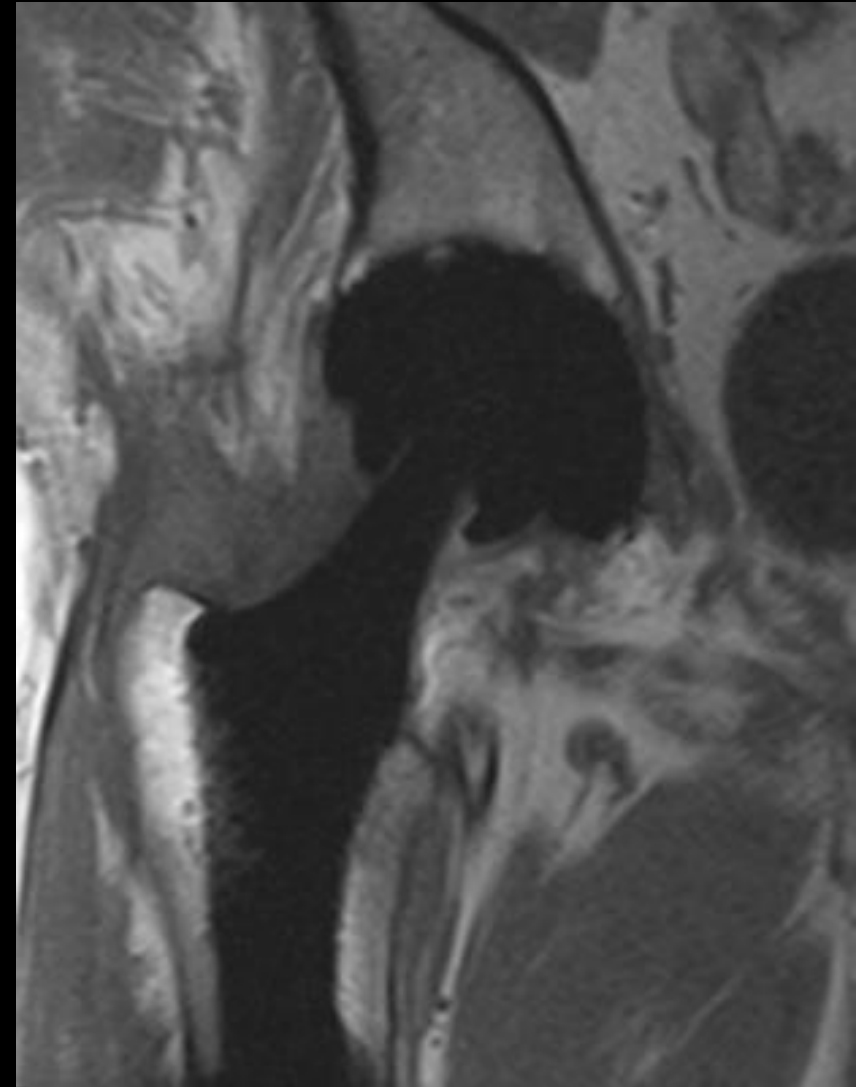
- FSE pulse sequences
- Broaden bandwidth
Frequency along long axis
Long axis along B^0
- FSE with short TE
Reduce interecho spacing
- Reduce slice thickness
Increase matrix
- STIR or three-point Dixon

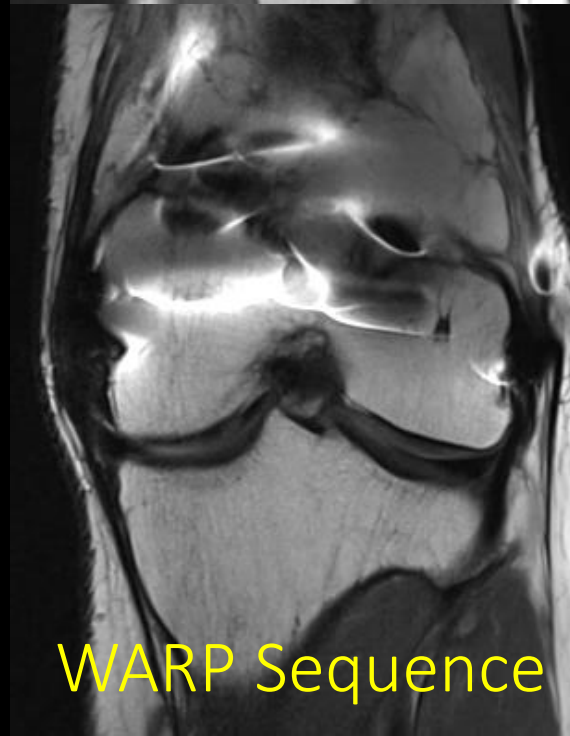
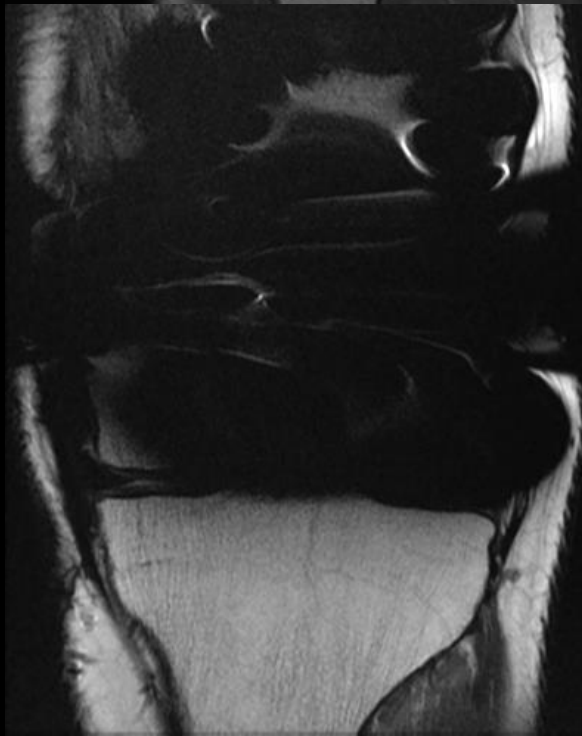
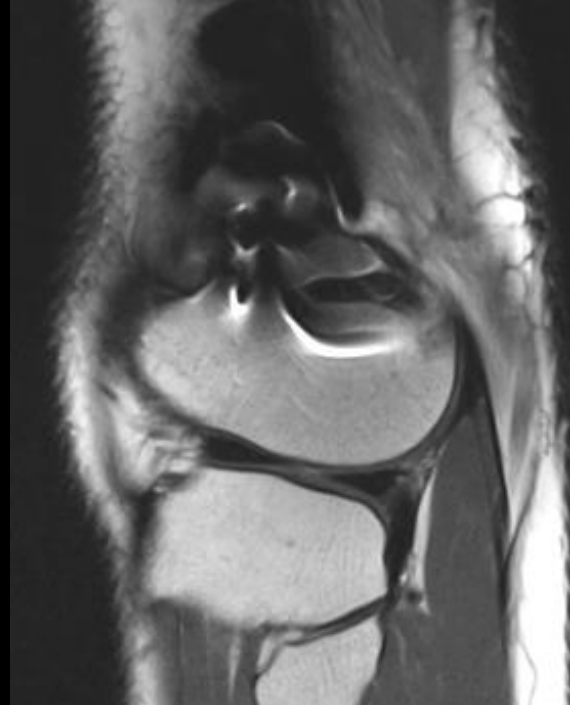
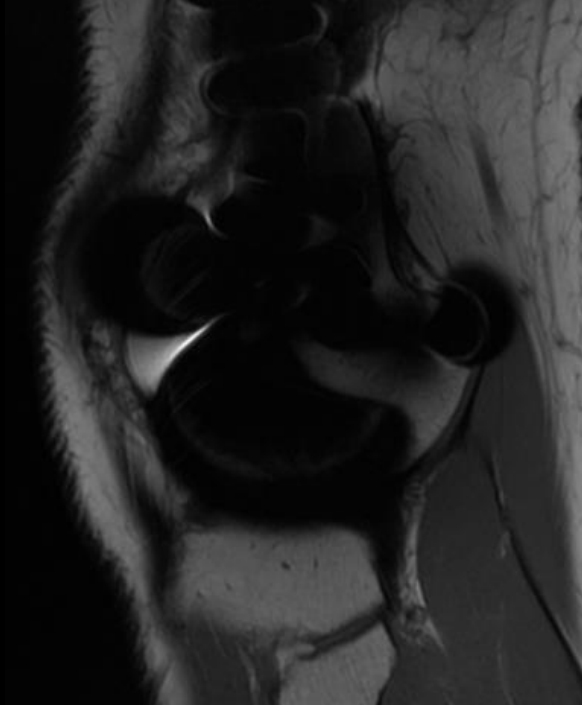


FSE IR 5000/36, TI 150ms, 4thk/0, 256x256
BW 64 kHz, Freq encoding L→R

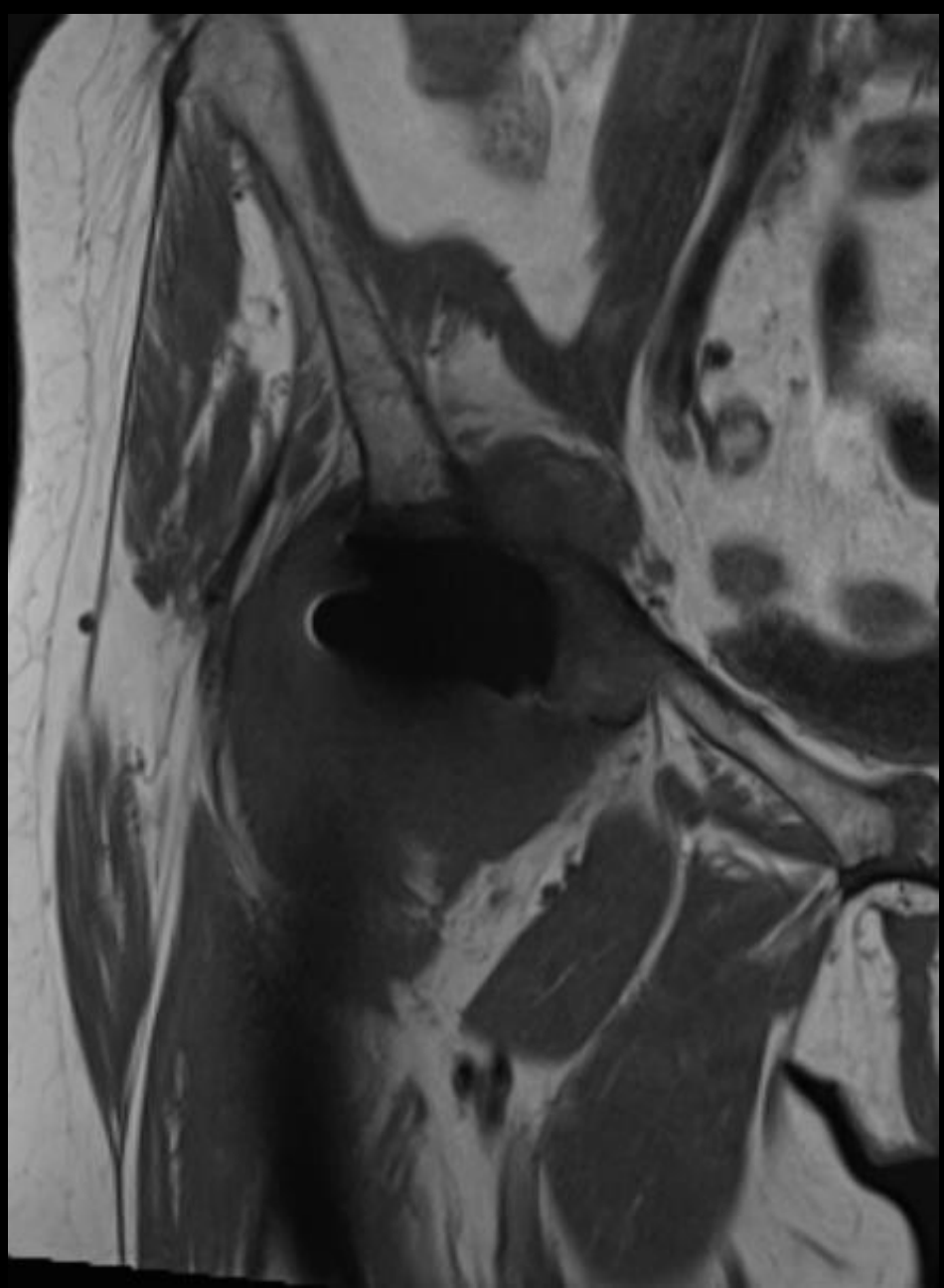
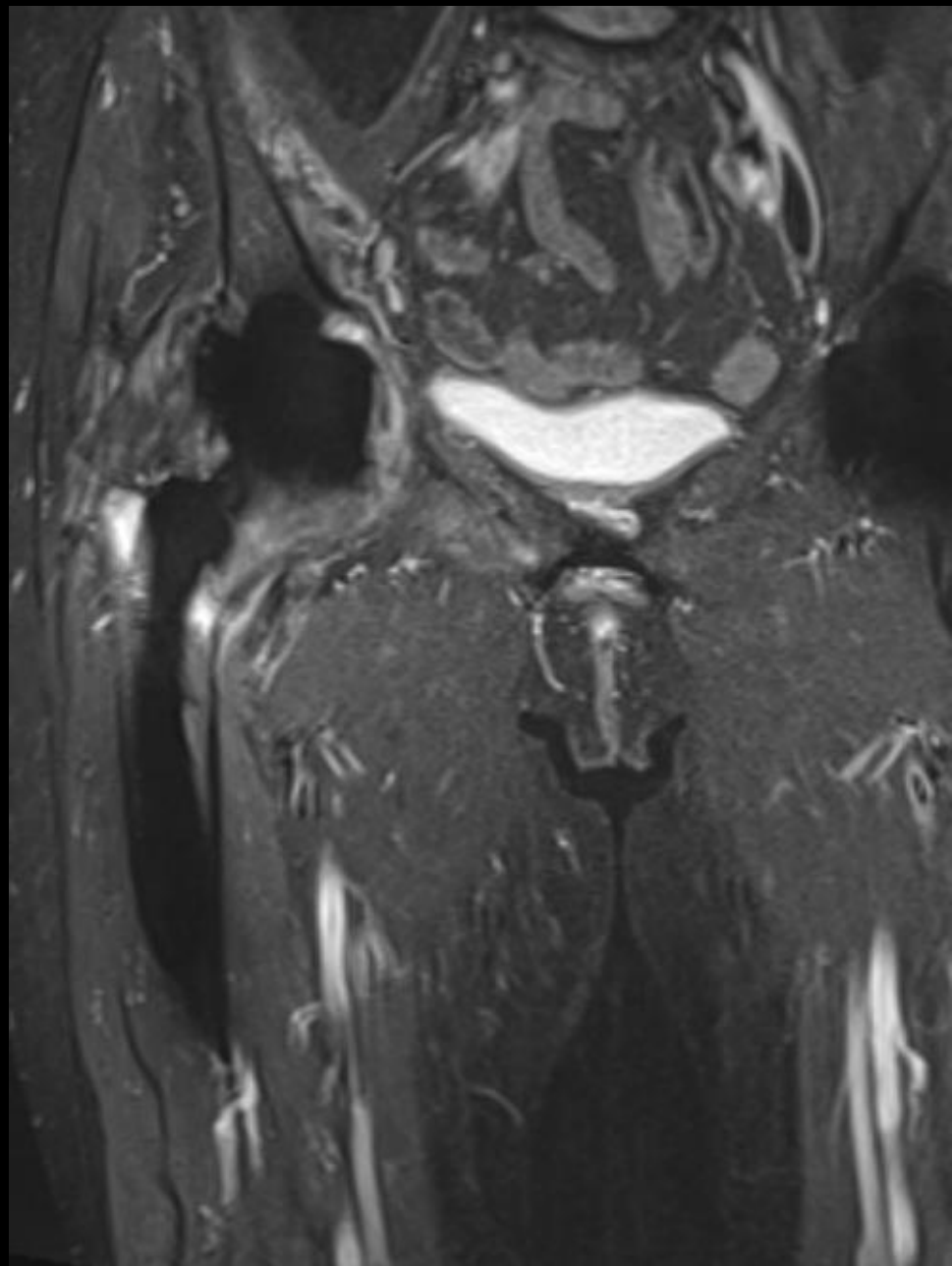
Newer Metal Suppression Techniques

- View angle tilting (VAT)
- MAVRIC
(Multiacquisition variable-resonance image combination)
- SEMAC
(Slice-encoding metal artifact reduction)
- WARP



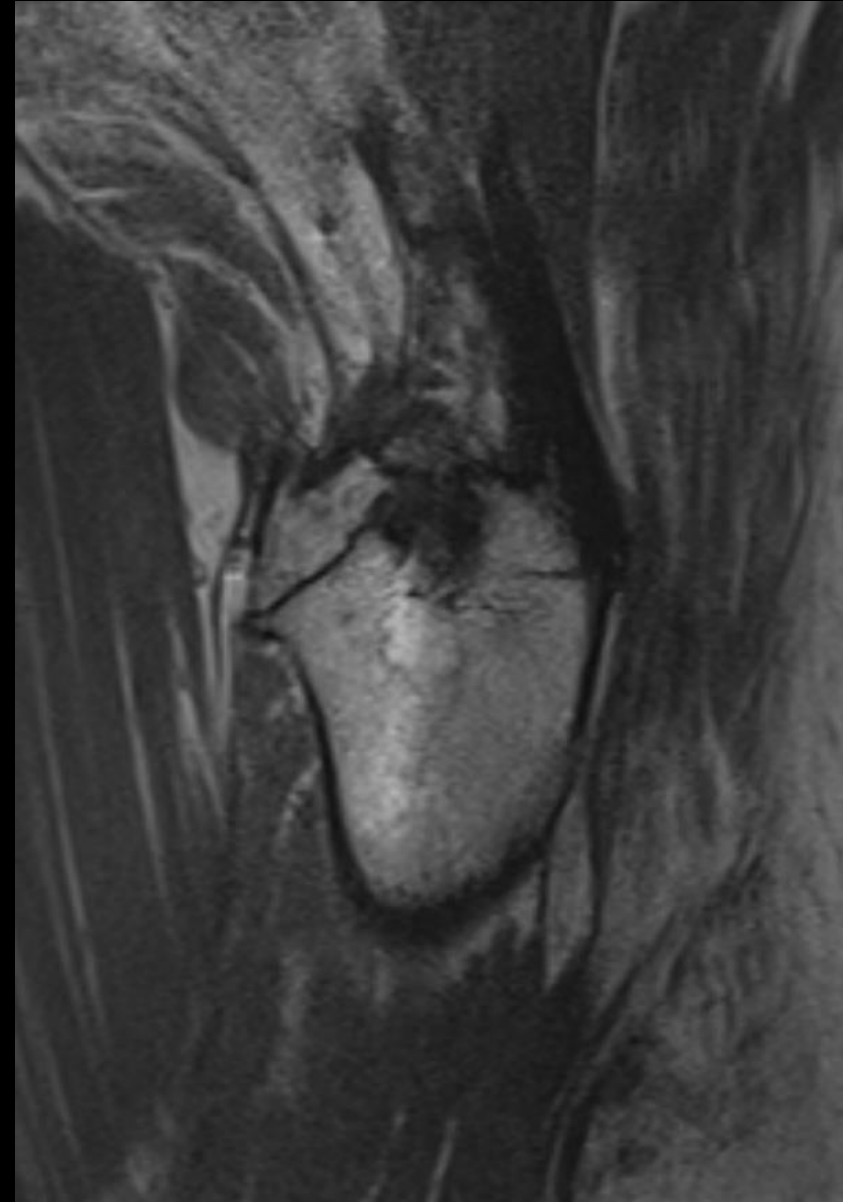


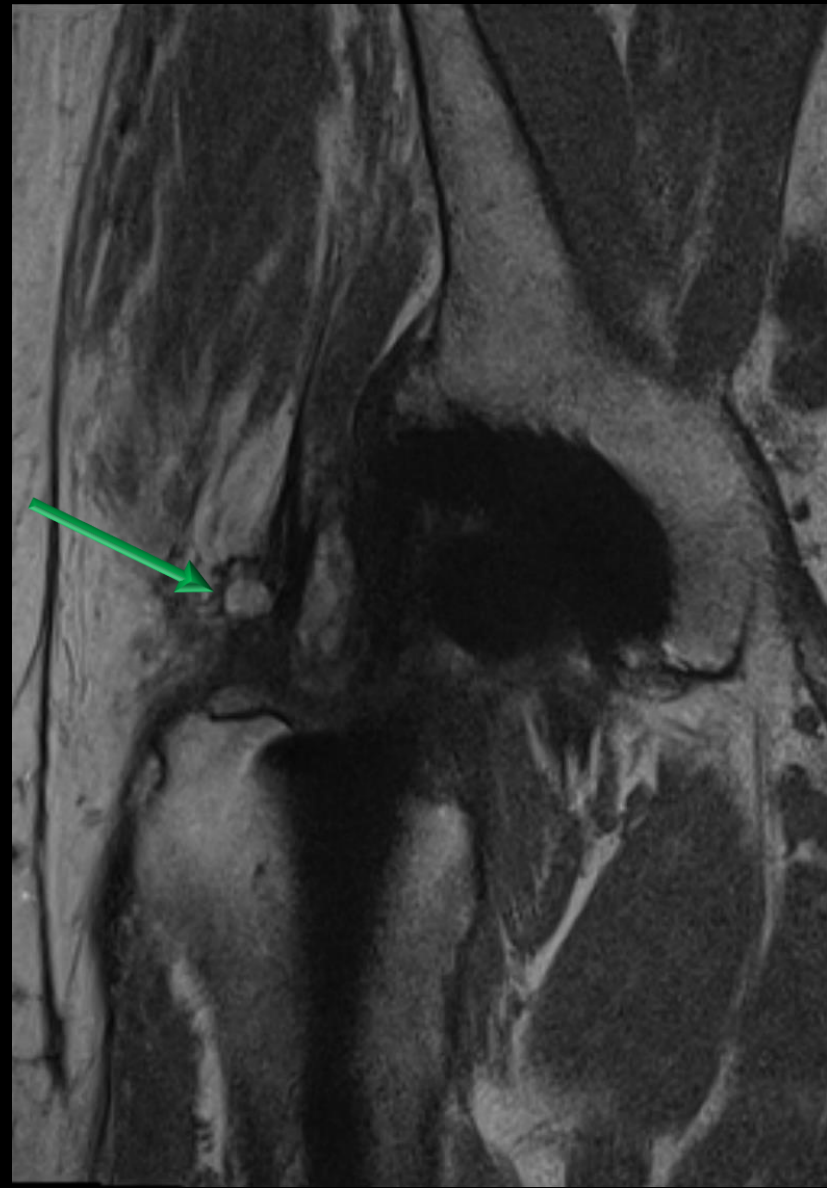
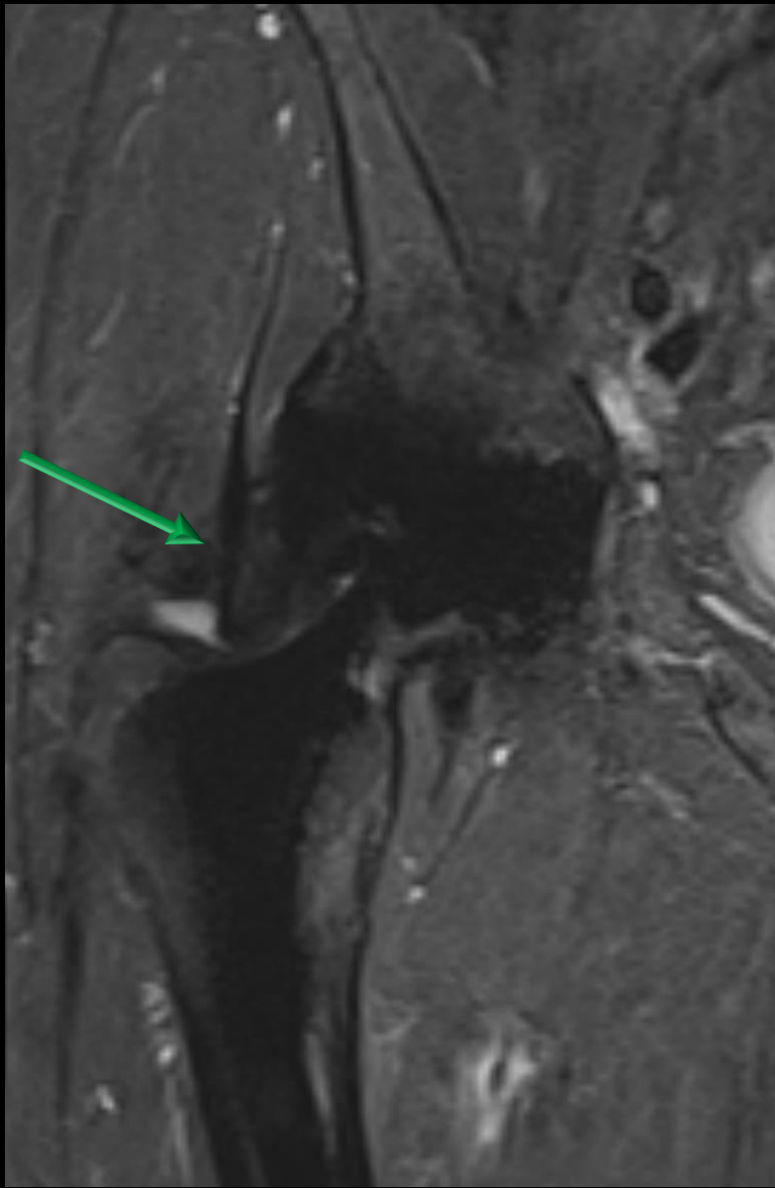
WARP Sequence



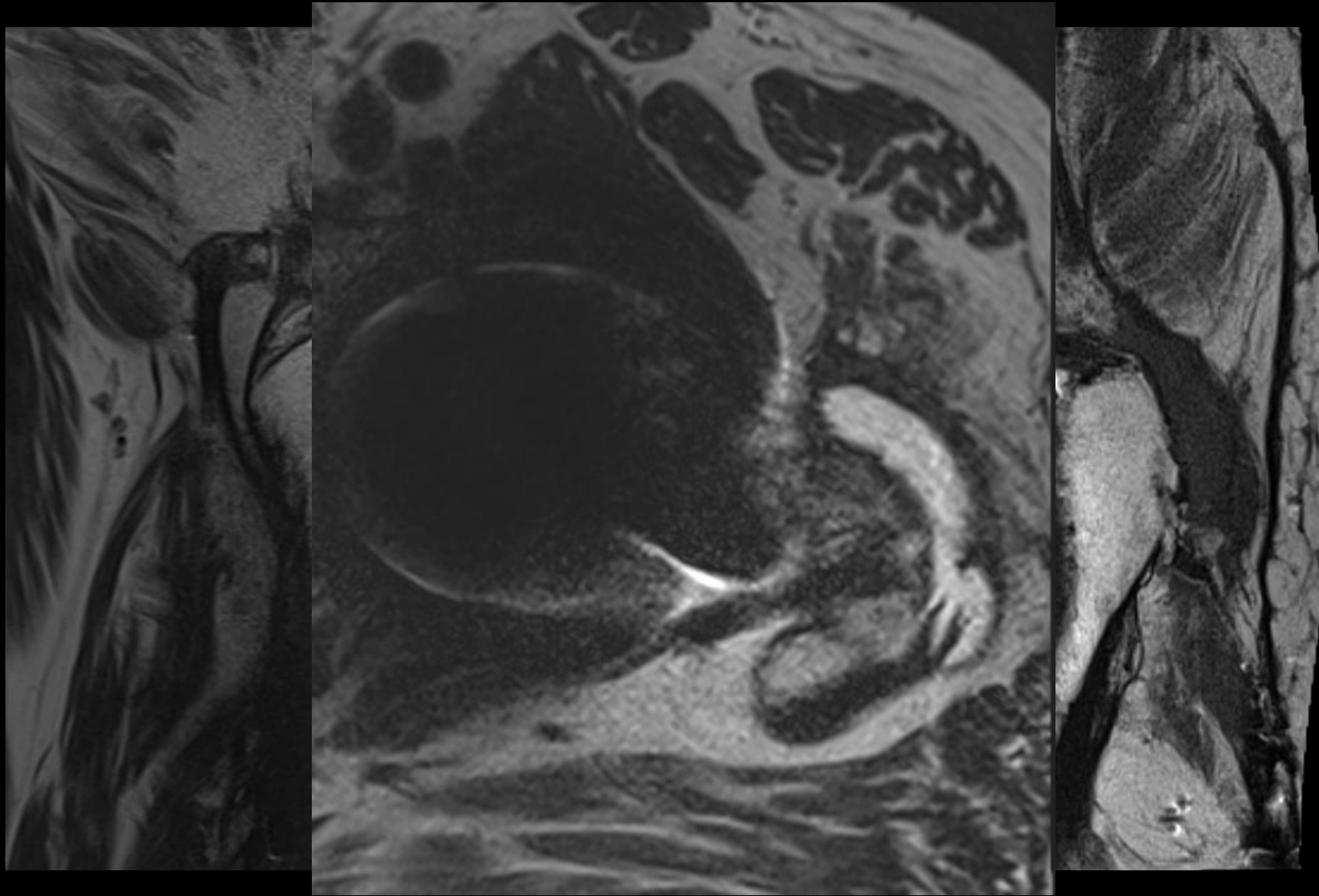
Abductor Tears

- Tears common with lateral approach
- Gluteus minimus or medius
- Fatty atrophy of anterior gluteus minimus common in asymptomatics
- Gluteus medius atrophy typically symptomatic





Gluteus minimus tear



Gluteus minimus & medius tear

Metal on Metal Arthroplasty



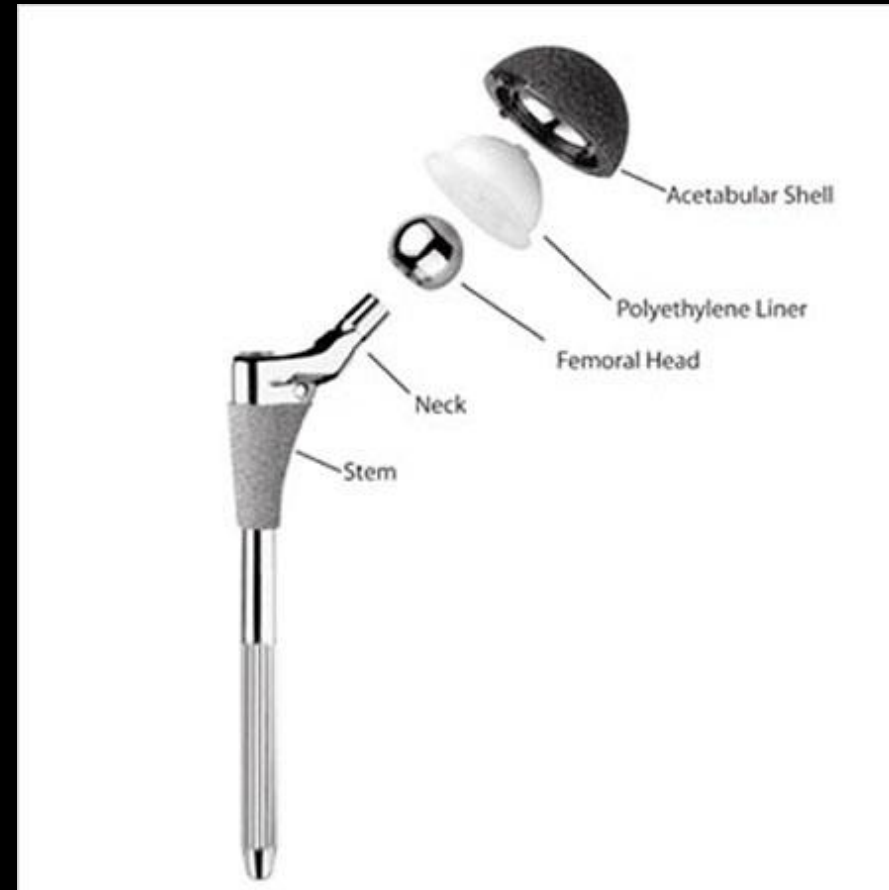
Metal on Metal Arthroplasty

- Trunnion
 - from Old French "*trognon*", trunk
 - cylindrical protrusion used as a mounting or pivoting point
 - first associated with cannons



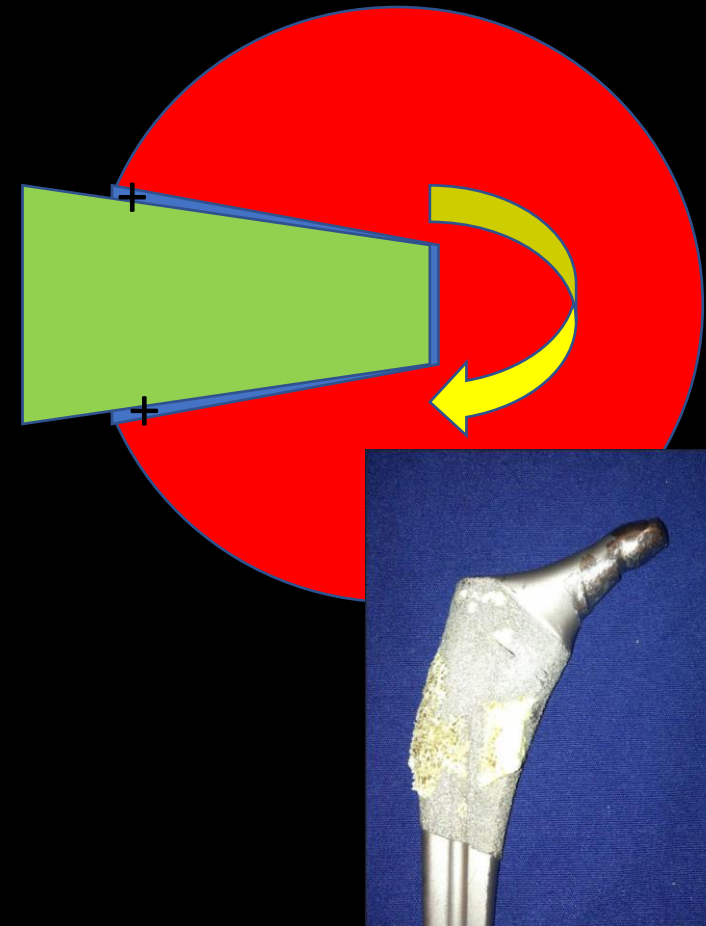
Metal on Metal Arthroplasty

- Trunnion
 - from Old French "*trognon*", trunk
 - cylindrical protrusion used as a mounting or pivoting point
 - first associated with cannons



Metal on Metal Arthroplasty

- Trunnion
 - Larger femoral head increases torque at the trunnion
 - → micromotion
 - → erodes the trunnion
 - → metal ions released



Metal on Metal Hip Resurfacing

- Younger active individuals
- Advantages:
 - Low wear rates
 - Preservation of bone stock
 - Larger head:
 - Enhanced stability due to larger head
 - Greater range of motion
- Disadvantage: Release of metal ions

Metal on Metal Hip Resurfacing

- Complications:
 - Notching
 - Stem lucency and migration
 - Femoral neck fractures
 - Avascular necrosis



Metal on Metal Hip Resurfacing

- No consensus on terminology
 - Hypersensitivity response
 - Metallosis
 - Aseptic lymphocyte-dominated vasculitis-associated lesions (ALVAL)
 - Pseudotumors

An advertisement for a hip implant recall lawsuit. It features a blue header with the text "Hip Implant Recall Lawsuit". Below the header is a photograph of two elderly people walking on a beach at sunset. To the right of the photograph is a list of symptoms: "Problems Walking", "Pain Or Swelling", "Implant Loosened Or Dislocated", and "Metal In Blood". At the bottom is a red banner with the text "You may be entitled to compensation!".

Hip Implant Recall Lawsuit

- Problems Walking
- Pain Or Swelling
- Implant Loosened Or Dislocated
- Metal In Blood

You may be entitled to compensation!

Terminology

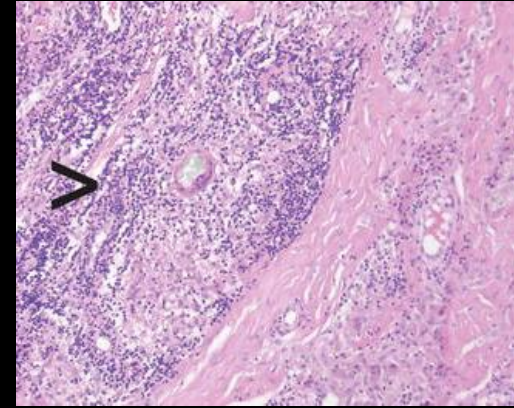
- No consensus on terminology
- ALTR (Adverse Local Tissue Reaction) and ARMD (Adverse Reaction to Metal Debris)
 - synonymously used
 - comprise immunological host reactions to metal products
 - metal ions
 - metal corrosion
 - frank metal particles
 - Not every host is equally susceptible
- Particle disease
 - traditionally assigned to synovitis induced by polyethylene wear particles
 - macrophage-mediated synovitis
 - Metallosis and polymeric particle disease have a similar cellular response

Terminology

- Pseudotumor:
 - Originally Solid granulomatous masses in metal on poly THA
 - Currently Primarily metal-on-metal masses or destructive cystic lesions
 - ALTR or ARMD seem now preferred terms
- ALVAL
 - Histological diagnosis with type IV hypersensitivity
 - Used for clinical appearance of necrosis and abnormal joint fluid
- Metallosis
 - Aseptic fibrosis, necrosis, metal staining due to metallic corrosion and particle release

Terminology

- ALVAL
 - Histopathologic descriptions
 - similar to those of failed arthroplasty soft tissues in general
 - Findings associated with inflammatory arthritis
 - synovial inflammation and hyperplasia
 - Single **unique histologic feature** associated with ALVAL
 - **dense perivascular infiltrate**
 - specifically referred to in the name of the syndrome (“vasculitis-associated lesion”)



Terminology

- spectrum of ALTRs
 - spans from lymphocyte-mediated (ALVAL) to macrophage-mediated (Metallosis) reactions
- more solid components on MRI, the more aggressive an allergic ALTR seems to be ¹

Symptoms

- Swelling
- Pressure effects
- Elevated metal ions
- Systemic reactions

Type of Synovitis	Joint Fluid Volume	Synovial Wall Lining	Fluid Signal Characteristics	Periprosthetic Soft Tissues	Osteolysis
Nonspecific synovitis	Small volume	Low signal intensity, thin	Uniform high signal intensity	Intact	Absent
Polyethylene wear-induced synovitis	Usually at least some degree of capsular distention but ranges from moderate to large volumes of fluid	Low to intermediate signal intensity, mildly thickened	Low- to intermediate-signal-intensity debris, similar to muscle, can appear partially solid	Capsular dehiscence often seen, decompression of debris into surrounding bursae and soft tissue, usually no necrosis	Commonly seen, geographic, often contains dense intermediate-signal-intensity debris
Metal hypersensitivity	Capsular distention usually seen, volume of fluid does not correlate with histologic ALVAL score	Hyperintense, thickened	Uniform high signal intensity; or mixed fluid and solid; or "solid" appearance caused by extensive synovial debris	Capsular dehiscence, hyperintense with loss of tissue planes indicating necrosis, abductor tears, perisynovial edema, lymphadenopathy	May be seen but not a dominant feature, typically caused by expanded pseudocapsule eroding into proximal femur or acetabulum
Metallosis	Moderate to large volume of fluid but variable	Hypointense with susceptibility artifacts, mildly thickened	Hypointense with susceptibility artifacts, may coexist with metal hypersensitivity or polyethylene wear-induced synovitis	Capsular dehiscence often seen, decompression of hypointense debris into bursae	May be seen, geographic, typically hypointense with susceptibility artifact
Infection	Variable fluid volume	Hyperintense, thickened, lamellated	Debris typically seen	Soft-tissue edema, sinus tracts, abscess formation	Seen if aggressive pattern of bone loss

Findings — Polyethylene Wear-induced synovitis

- Joint Fluid Volumes
 - Some degree of capsular distention
- Synovial Wall Lining
 - Low to intermediate, mildly thickened
- Fluid Signal Characteristics
 - Low to intermediate, can appear partially solid
- Periprosthetic Soft Tissues
 - Capsular dehiscence, decompress into soft tissues no necrosis
- Osteolysis
 - Commonly seen

Findings – Metal Hypersensitivity

- Joint Fluid Volumes
 - Usually higher
- Synovial Wall Lining
 - Hyperintense, thickened
- Fluid Signal Characteristics
 - Uniform ↑ signal, or mixed fluid and solid
- Periprosthetic Soft Tissues
 - Capsular dehiscence, abductor tears, lymphadenopathy
- Osteolysis
 - May be seen, not a dominate feature

Findings – Metallosis

- Joint Fluid Volumes
 - Moderate to large
- Synovial Wall Lining
 - Hypointense with metal susceptibility, mildly thickened
- Fluid Signal Characteristics
 - Hypointense with metal susceptibility
- Periprosthetic Soft Tissues
 - Capsular dehiscence, decompress into soft tissues
- Osteolysis
 - May be seen

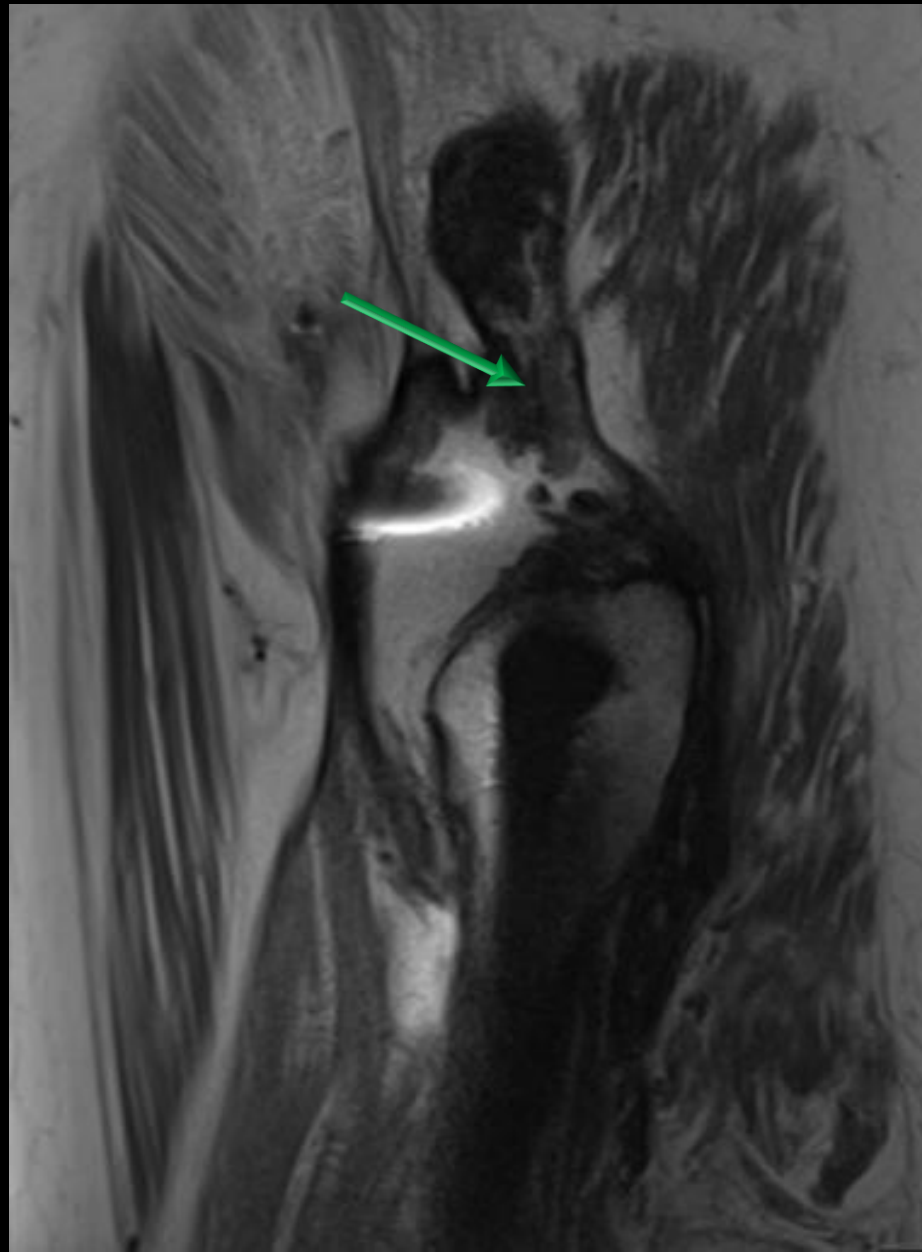
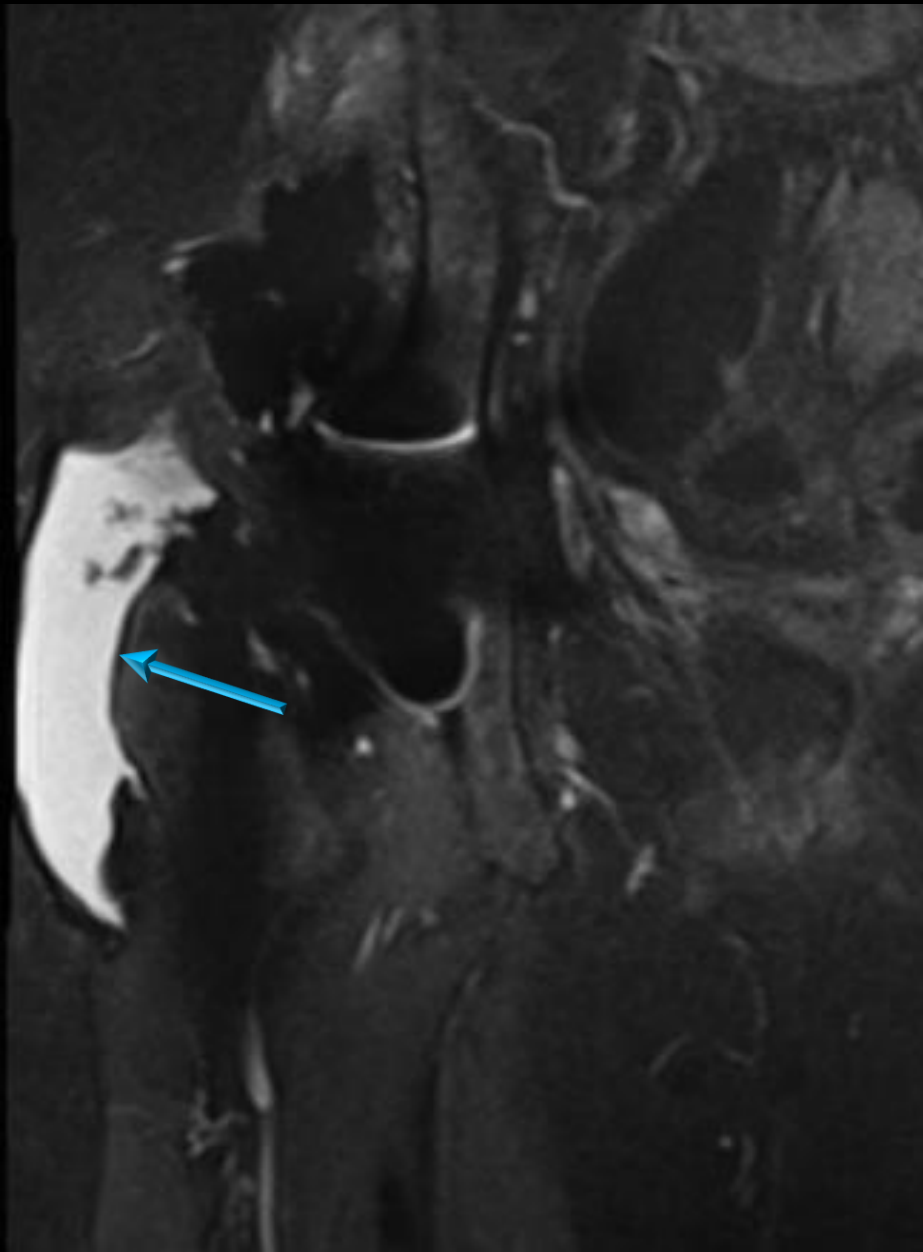
Findings of Metal on Metal (MoM)

- MRI findings
 - Mixed masses/collections
 - Increased synovial thickness
 - Higher synovial volumes
 - Low signal deposits
 - Decompression outside joint
 - Abductor disruption
 - Soft Tissue Necrosis

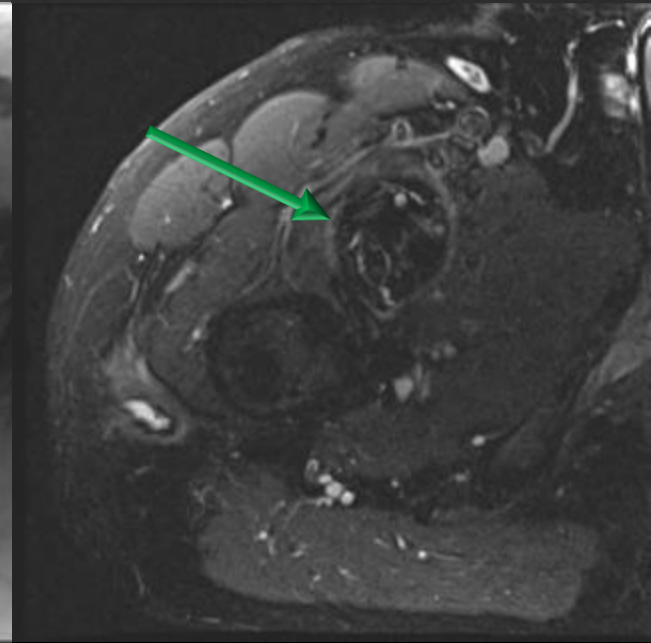
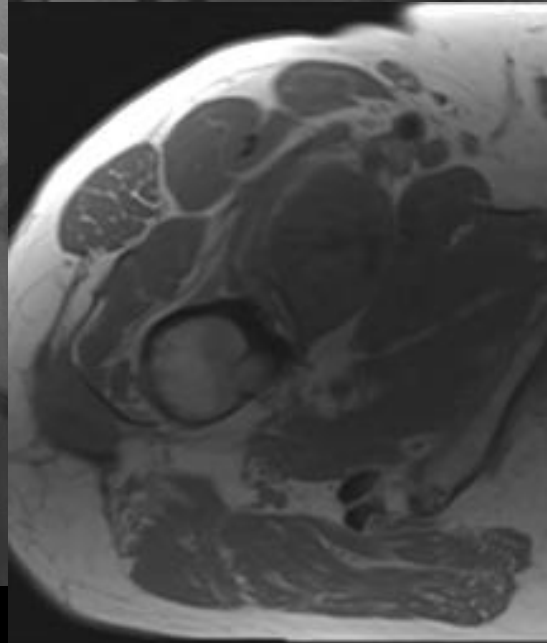
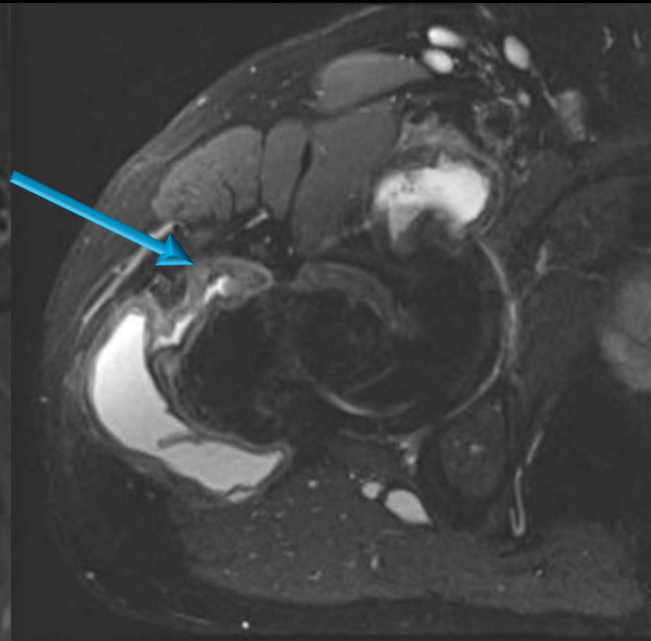
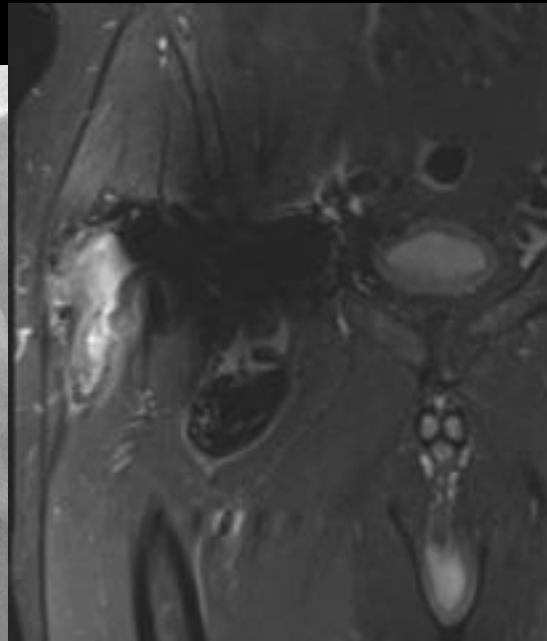
How to Approach a Case:

- Helpful to know
 - Type of prosthesis
- Describe the MRI findings
- I prefer using in MoM
 - ALTR (Adverse Local Tissue Reaction)
 - ARMD (Adverse Reaction to Metal Debris)

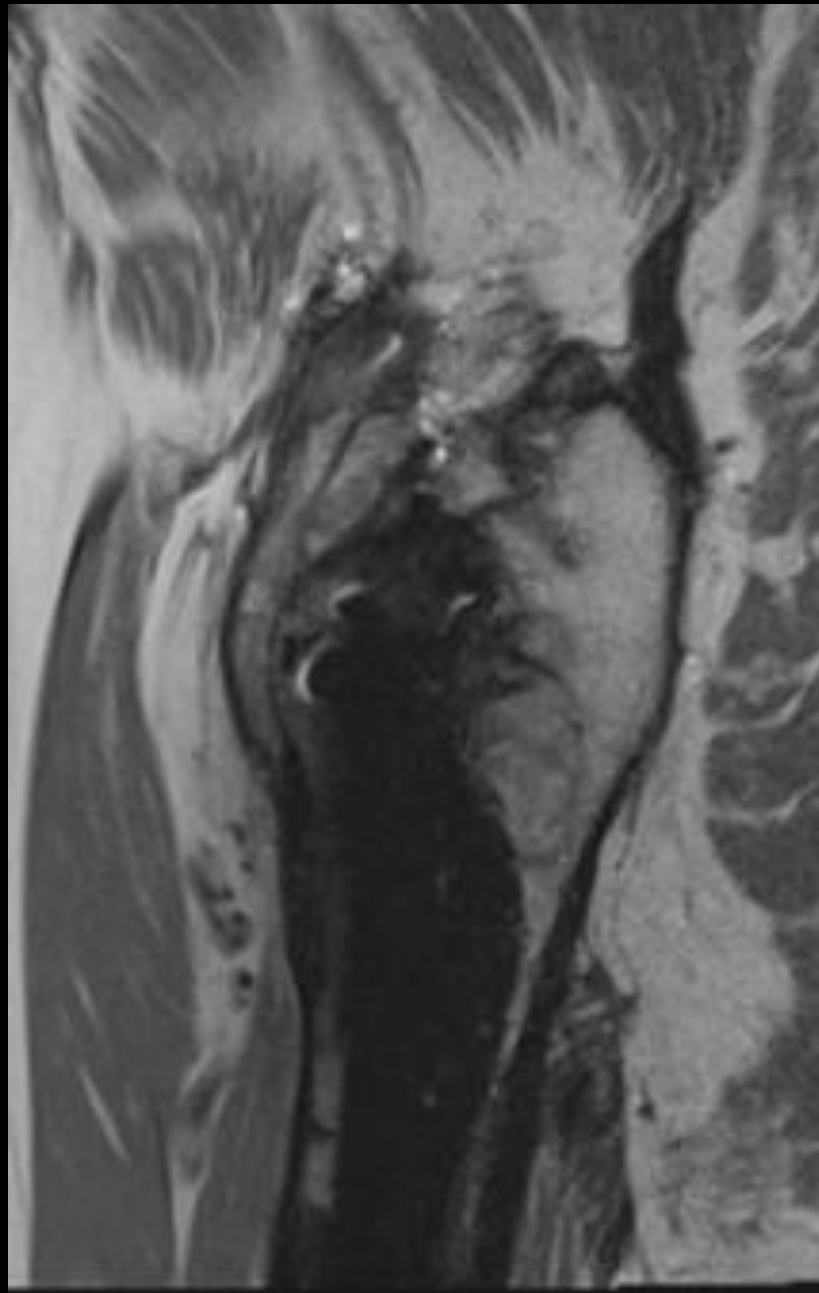
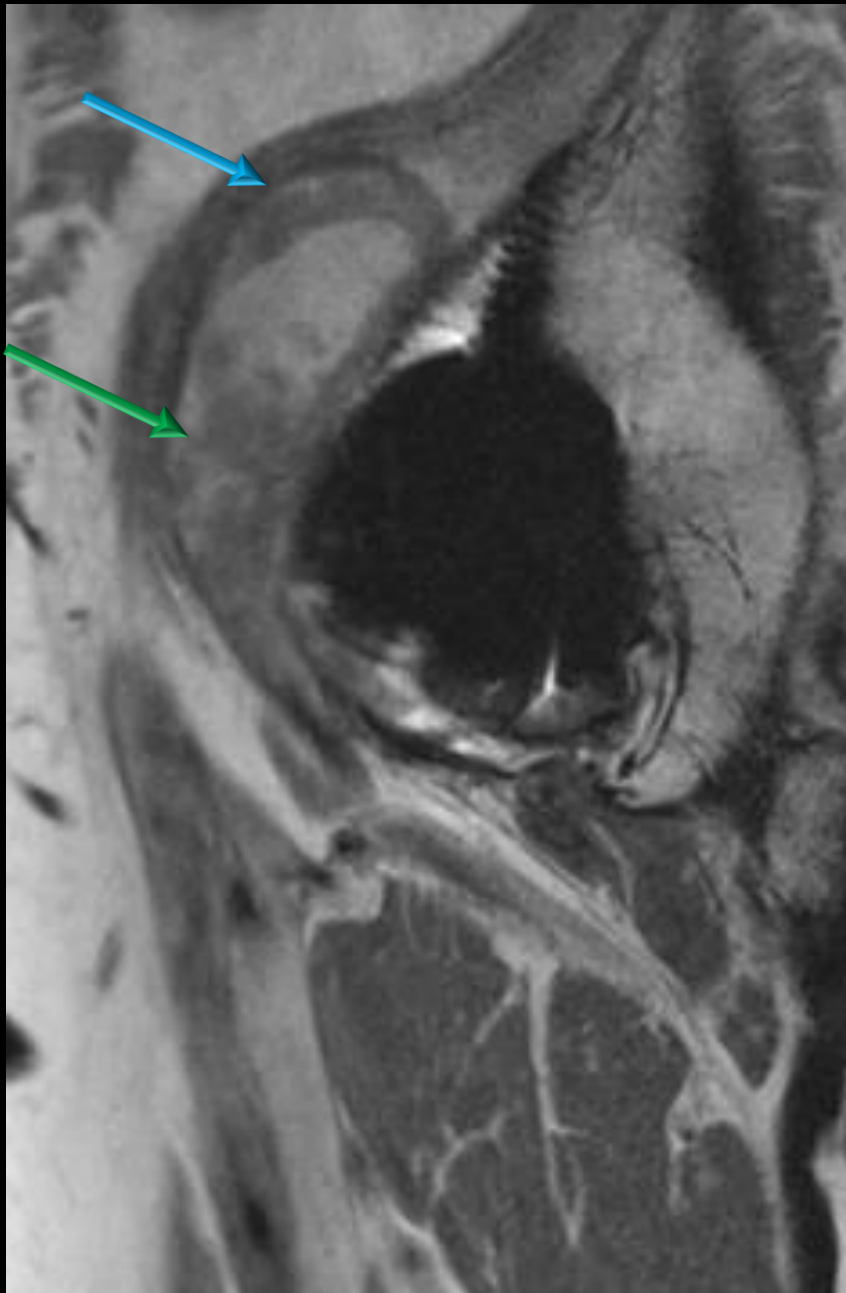




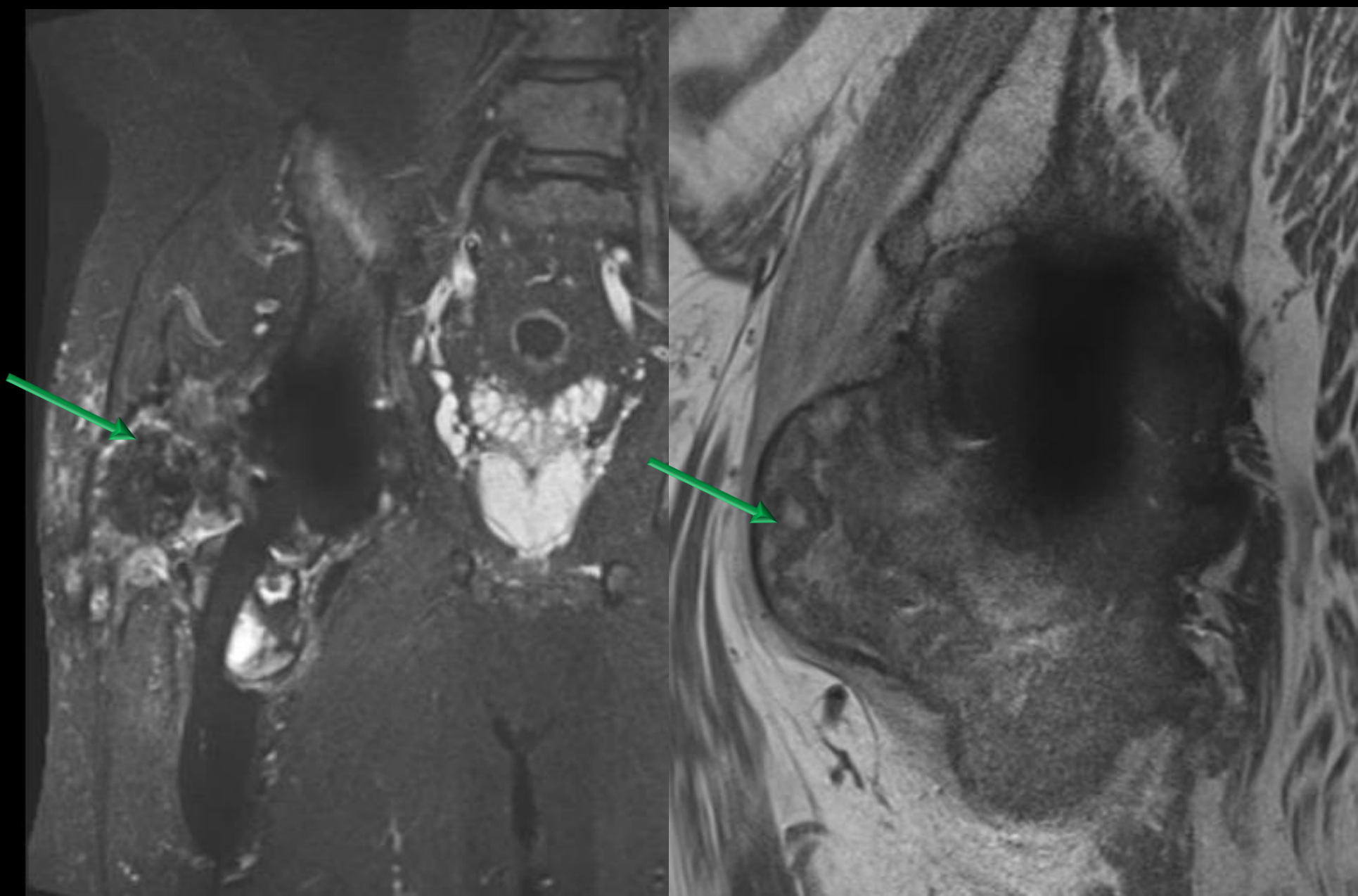
Extra-art. fluid coll., thin wall, minimal solid



Extra-art. fluid coll., thicker wall, mild-mod solid –hypointense



Extra-art. fluid coll., thicker wall, moderate solid



Extra-art. fluid coll., marker solid –hypointense

Conclusion

- Types of hip arthroplasty
- Complications of hip arthroplasty
 - Loosening
 - Small particle disease
 - Periprosthetic fractures
 - Dislocations
 - Infection
- Metal on metal arthroplasty