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Radiographic Findings in Avascular Necrosis (AVN) of the Femoral Head

A Radiological and Clinical Overview

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Agenda

- Introduction to AVN
- Risk factors for AVN
- Functional Anatomy
- Clinical Presentation
- Menu of Radiologic Tests and Pertinent Findings
- Our index patient, differential diagnosis, pertinent findings
- Management of Femoral Head AVN



Introduction to Avascular Necrosis

- Known also as osteonecrosis, aseptic necrosis, ischemic necrosis, osteochondritis dissecans
- Progressive process involving compromise of bone vasculature, leading to death of bone and marrow cells and subsequently mechanical failure
- Estimated 10,000-20,000 new patients diagnosed each year, with male: female ratio as 8:1
- Cause of approximately 10% of hip replacements
- Common sites are femoral head and humeral head



Mont MA, Hungerford DS. Non-traumatic avascular necrosis of the femoral head. J Bone Joint Surg Am 1995 Mar;77(3):459-474

Picture: Avascular Necrosis | Avascular Necrosis of the Hip | Avascular Necrosis of the femoral Head | Medical Pictures Info Available at: <http://medicalpicturesinfo.com/avascular-necrosis/>. Accessed 2/18/2012, 2012.



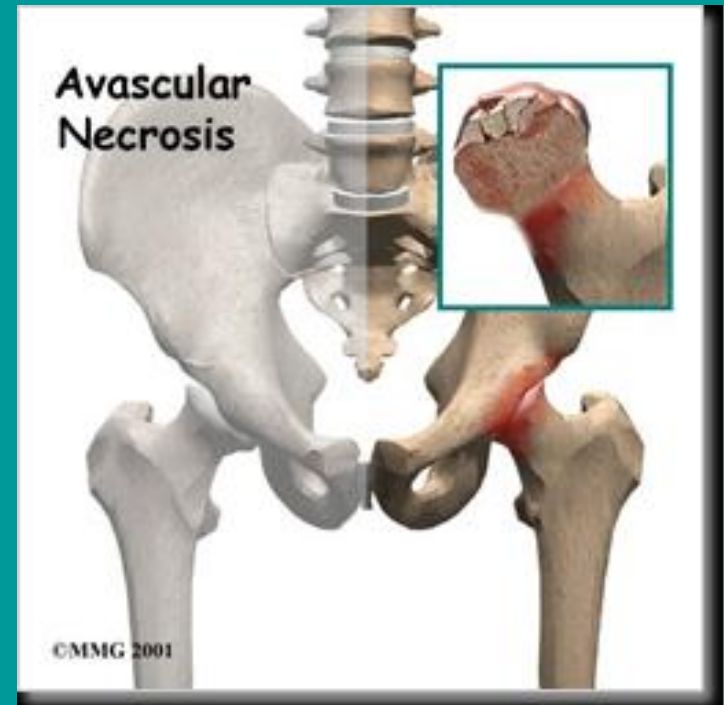
Selected Risk Factors for Femoral Head AVN

Traumatic:

- Femoral neck fracture
- Dislocation
- Minor trauma

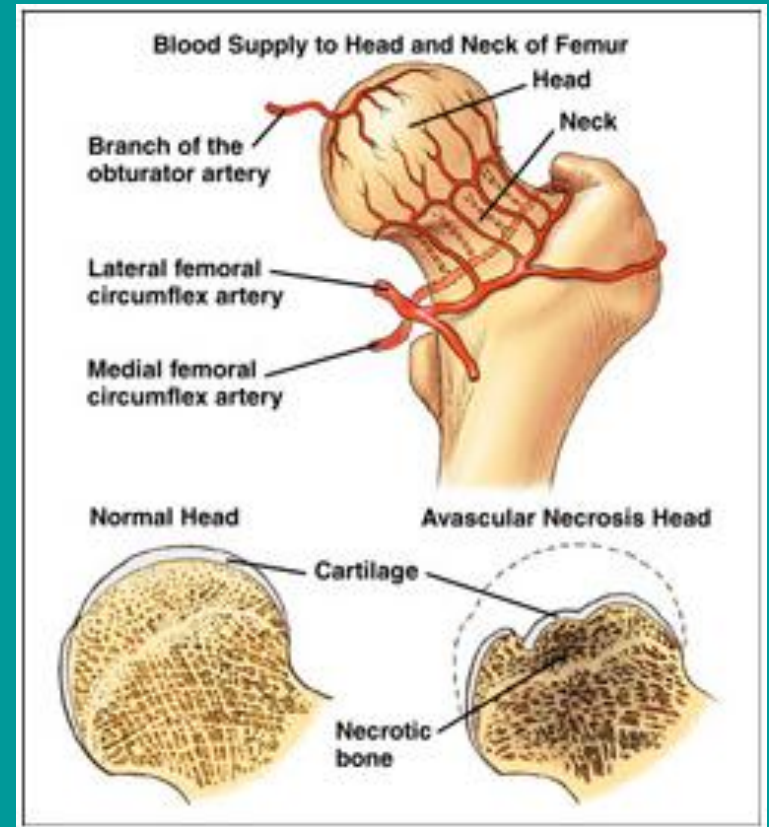
Non-Traumatic:

- Chronic corticosteroid administration
- Alcohol use/Cigarette smoking
- Hemoglobinopathies
- SLE
- Hyperlipidemia
- HIV
- Chronic Renal failure or hemodialysis
- Diabetes



Functional Anatomy and Pathophysiology of Femoral AVN

- Femoral head vasculature comprises of 1) extracapsular arterial ring at the base of the femoral neck, 2) ascending arterial branches on the femoral neck surfaces, and 3) arteries of the round ligament
- Arterial fixation to femoral neck leaves vasculature susceptible to fracture/dislocation
- Arterioles that supply femoral head also susceptible to emboli or other occlusive process





Clinical Presentation of Femoral AVN

- Most common presenting symptom is pain
- Weight bearing and motion-induced pain in most patients
- Groin pain, thigh pain, buttock pain
- Rest pain in 2/3 of patients, with pain awakening patients from sleep 1/3 of the time
- Small proportion of patients are asymptomatic
- Physical findings often non-specific



Menu of Tests

- Plain film radiography
- Magnetic Resonance Imaging
- Bone scanning
- CT



Radiologic Staging of AVN

- Stage 0: All imaging studies normal, with diagnosis made by histology only
- Stage 1: Plain radiographs and CT normal, MRI+ and biopsy +
- Stage 2: Radiographs are positive, but no evidence of collapse
- Stage 3: Early flattening of femoral head with crescent sign (subchondral lucency)
- Stage 4: Flattening of femoral head with joint space narrowing and other signs of osteoarthritis

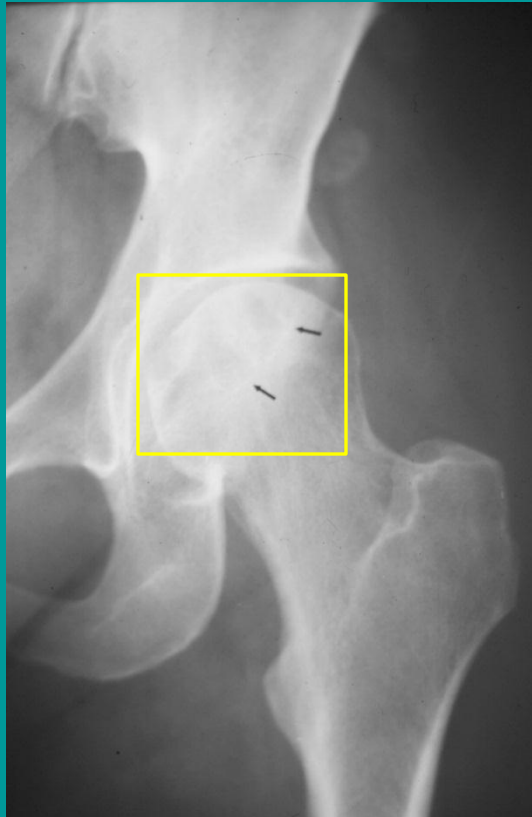
Hip AVN on Plain Film

- Suspected AVN of the femoral head should be evaluated initially by AP and lateral films
- Lateral films help to evaluate superior element of femoral head where subchondral abnormalities may be seen
- Plain films can remain normal months after AVN has begun
- Sclerosis, cysts, joint space narrowing, degenerative changes in the acetabulum



Companion Patient 1: Findings on Plain Film

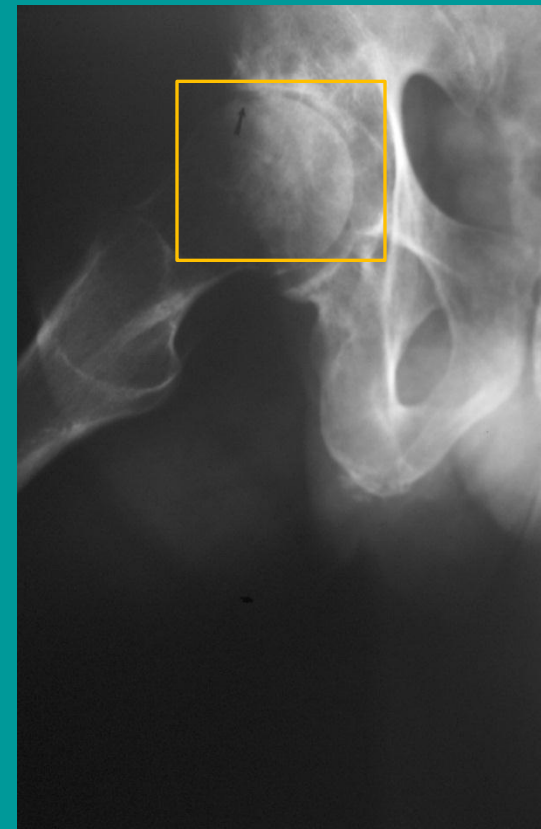
AP View of Left Hip



Subarticular radiolucency (crescent sign) due to mechanical failure of subchondral trabeculae

Joint space narrowing. Alternating regions of sclerosis and lucency on superior aspect of femoral head. Sclerosis indicates areas of new bone on dead trabeculae. Lucency indicates resorption of dead marrow and trabecular meshwork

Frog-leg lateral view of right hip





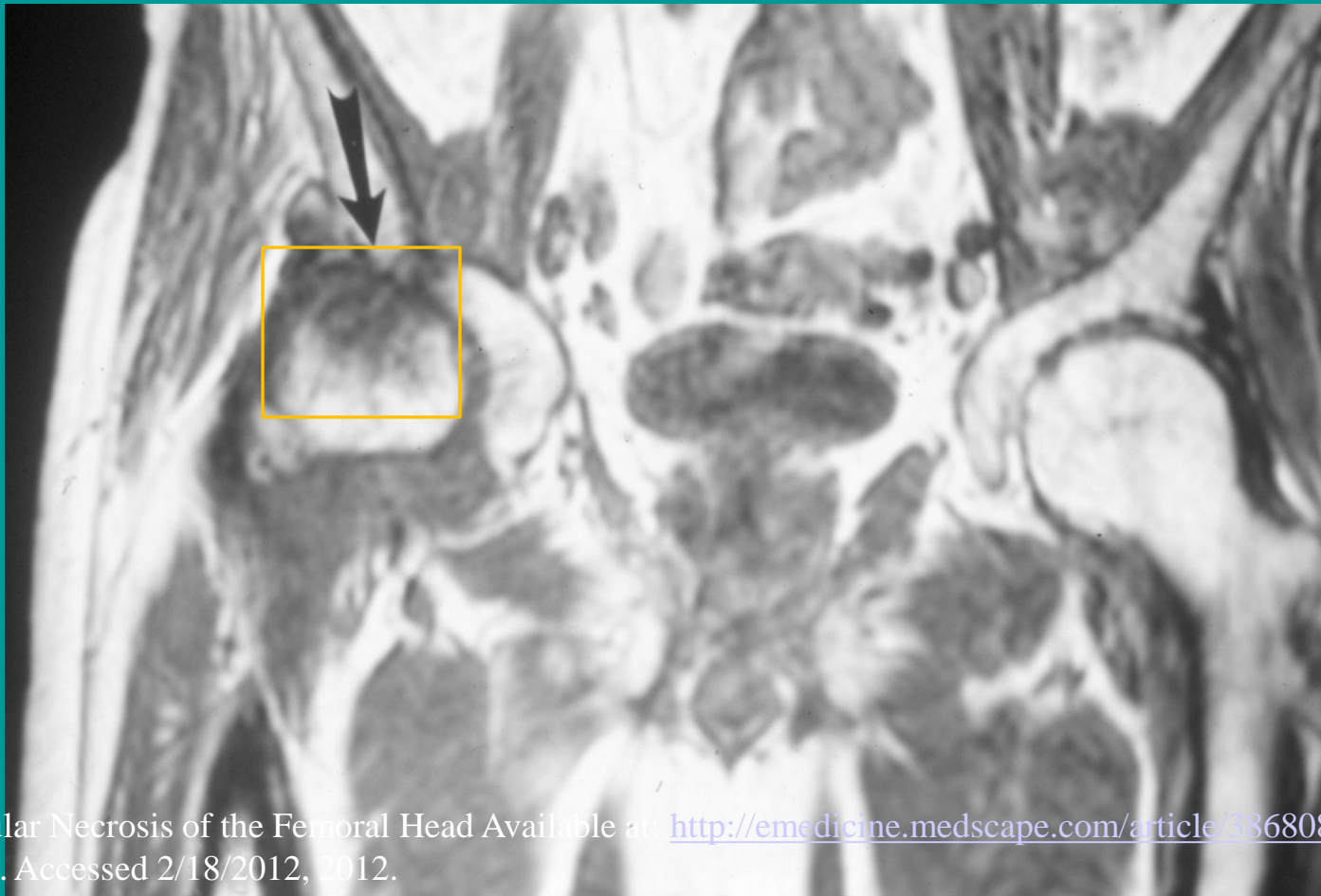
Hip AVN on T1 MRI

- Reported sensitivity of 91%, higher than plain radiographs or bone scanning
- Changes can be seen early in the course of disease when other imaging studies are still negative
- Focal lesions well demonstrated on T1, with single density line between normal and ischemic bone as first indication



Companion Patient 2: Findings on T1 MRI

Decreased signal within the femoral head representing edema. Areas of higher intensity in the area may represent blood. These subchondral lesions may also represent fracture



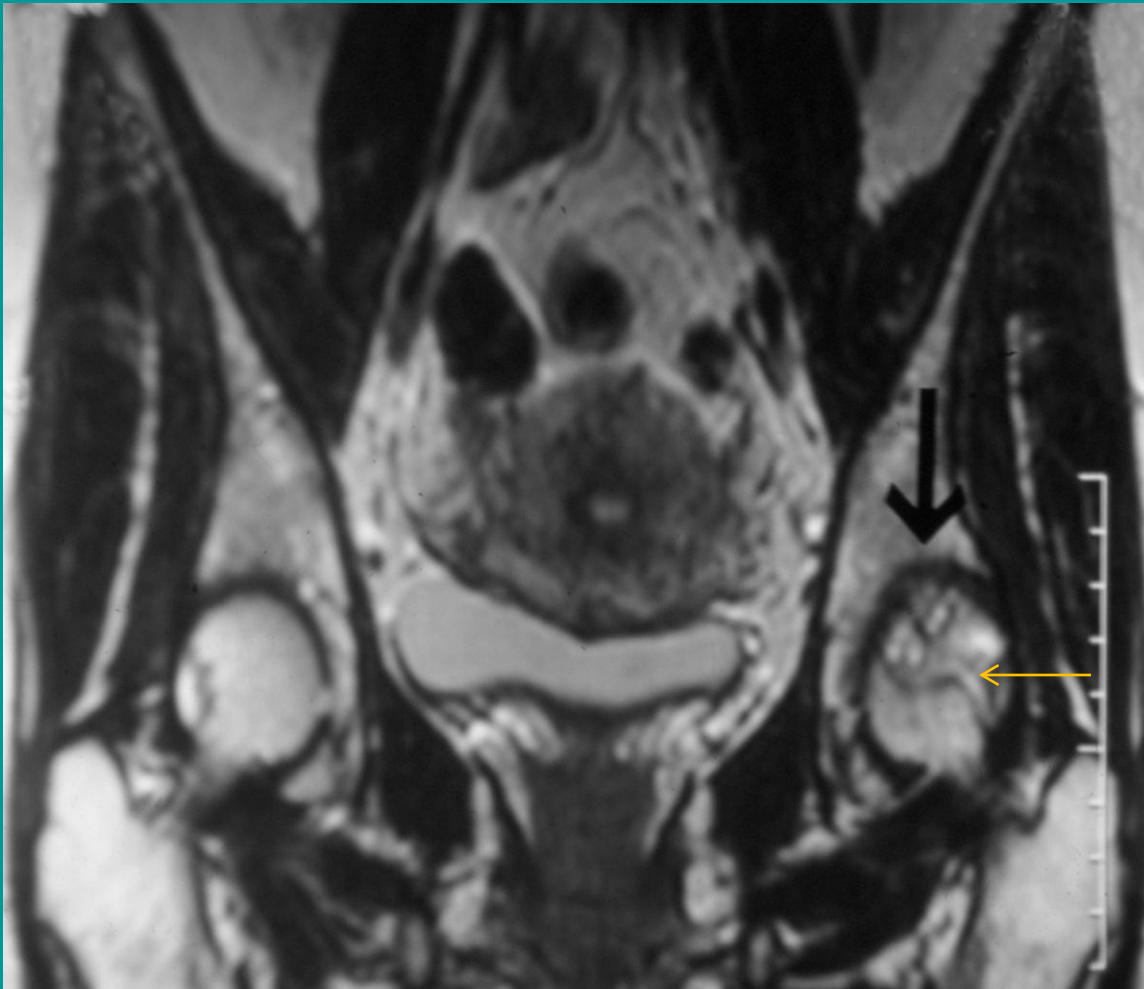


Hip AVN on T2 MRI

- In T2 MRI, a second high intensity line appears to represent hypervascular granulation tissue, known as the double line sign
- Amount of femoral head involvement seen on MRI can help predict likelihood of subsequent collapse



Companion Patient 3: Findings on T2 MRI



Double line/crescent sign indicative of hypervascular granulation tissue in AVN. This is pathognomonic for AVN.

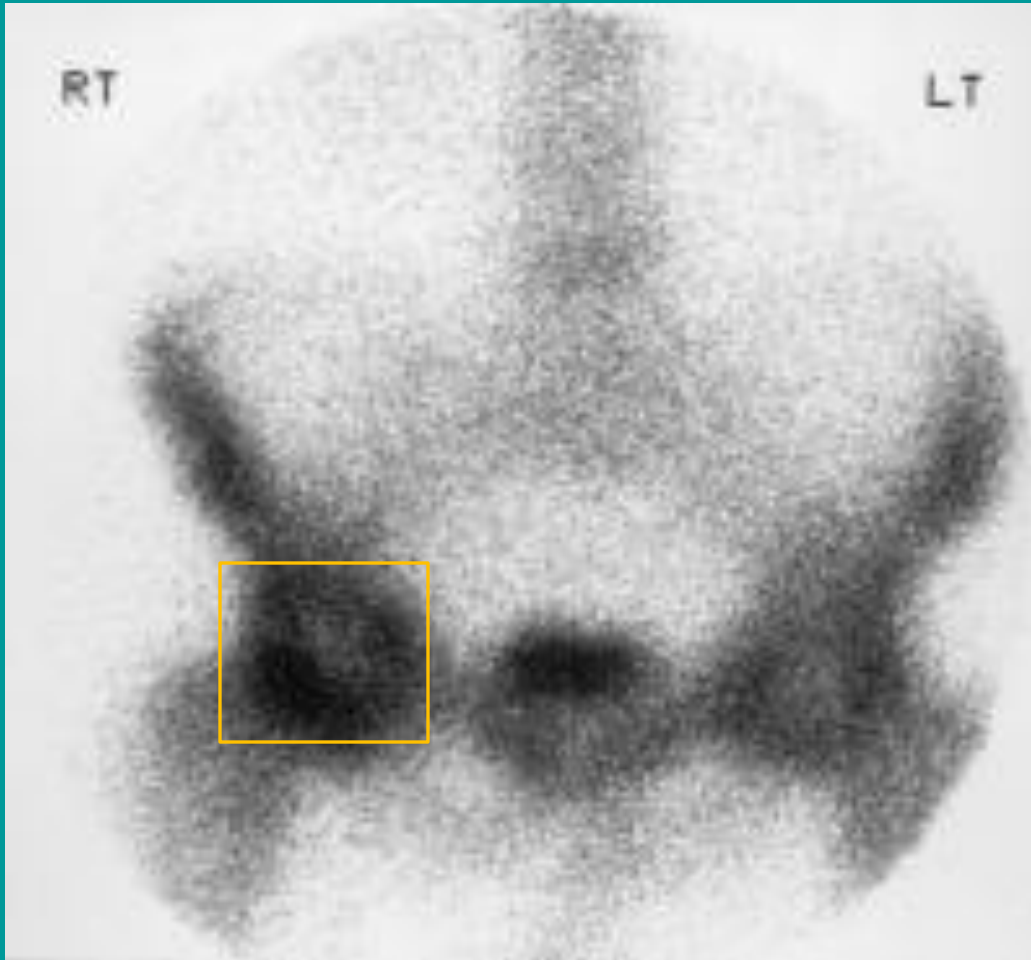


Hip AVN on Tc-99 Bone Scan

- Technetium-99 bone scanning used for patients with suspected disease who have negative radiographs and unilateral symptoms
- Increased bone turnover at the bridge between dead and reactive bone
- Increased uptake surrounded by a cold area leads to a radiographic donut sign



Companion Patient 4: Findings on Tc-99 Bone Scan



Increased uptake of radiotracer in
the right femoral head, indicative of
AVN

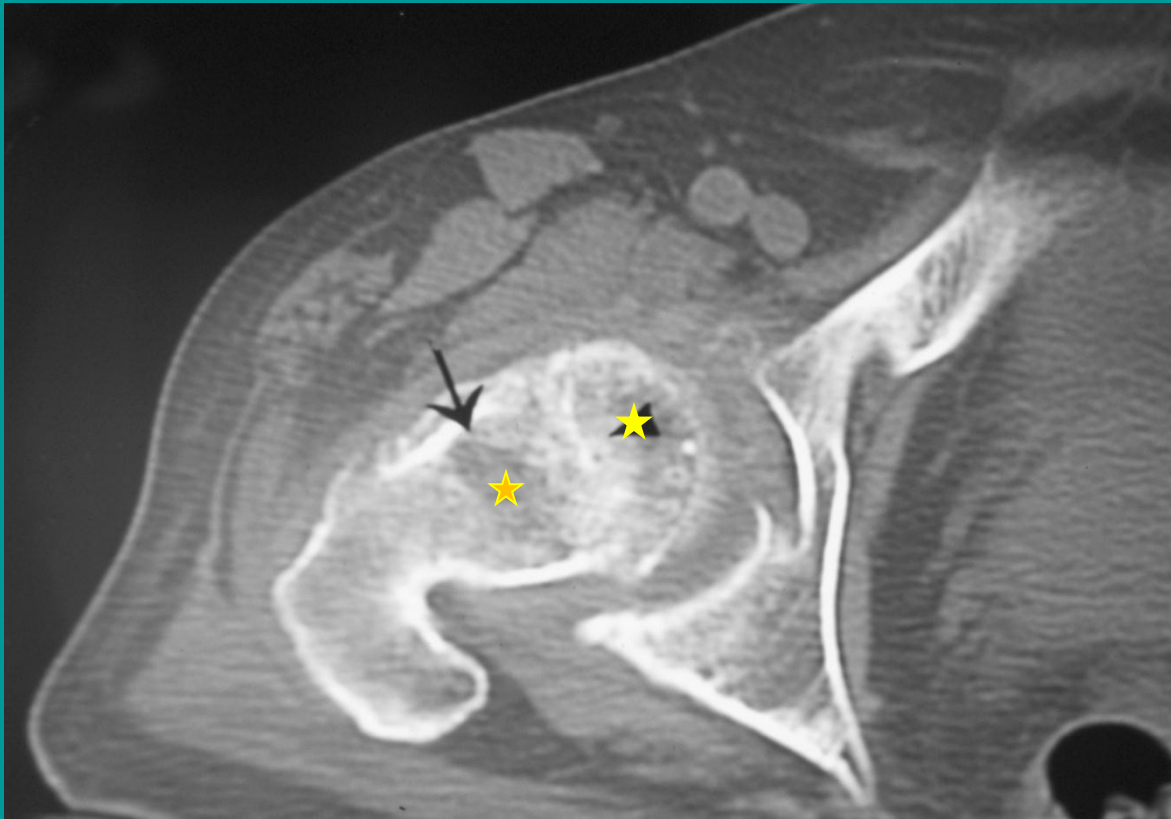


Hip AVN on CT

- CT scans do not demonstrate early AVN
- Osteoporosis is the first visible sign of AVN on CT
- Later, see hyperdense “roads” or clumping in the trabecular meshwork, representing sclerotic junction between viable and non-viable bone



Companion Patient 5: Findings on Non-Contrast CT



Low density area
indicative of reparative
change

Clumping and distortion of
trabeculae in right femoral
head



Our Index Patient

- Middle-age male presents with left back and buttock pain
- History of recent incarceration, multiple suicide attempts, and multiple gunshot wounds in chest and pelvis
- History of alcohol and drug abuse
- Physical exam significant for 1) mild tenderness on lower back and sacrum 2) Pain when walking on toes
- Note that patient left AMA before full workup was completed

Our Patient: Differential Diagnosis

- Radicular pain
- Fracture of the femoral neck
- Stress fracture
- Groin injury
- Dislocation
- Hip overuse syndrome

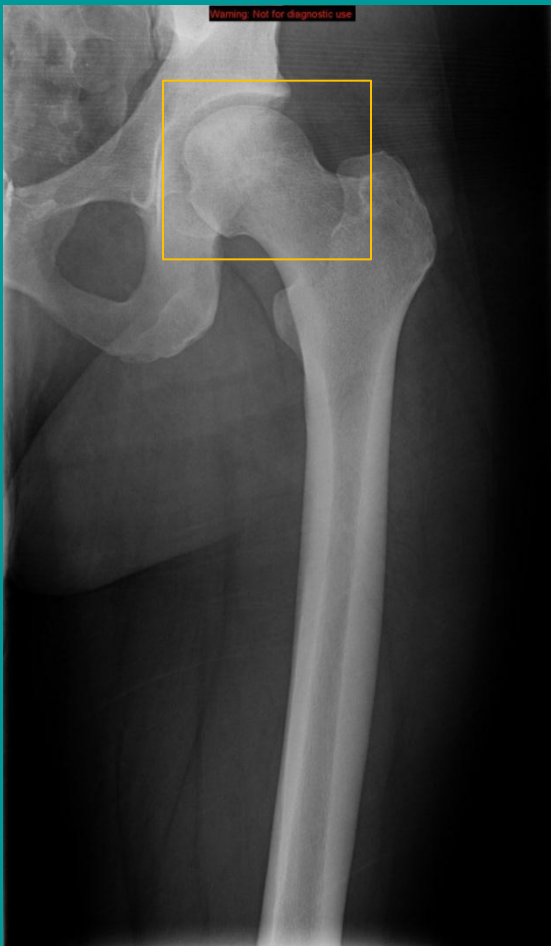


Our Patient: Plain Films

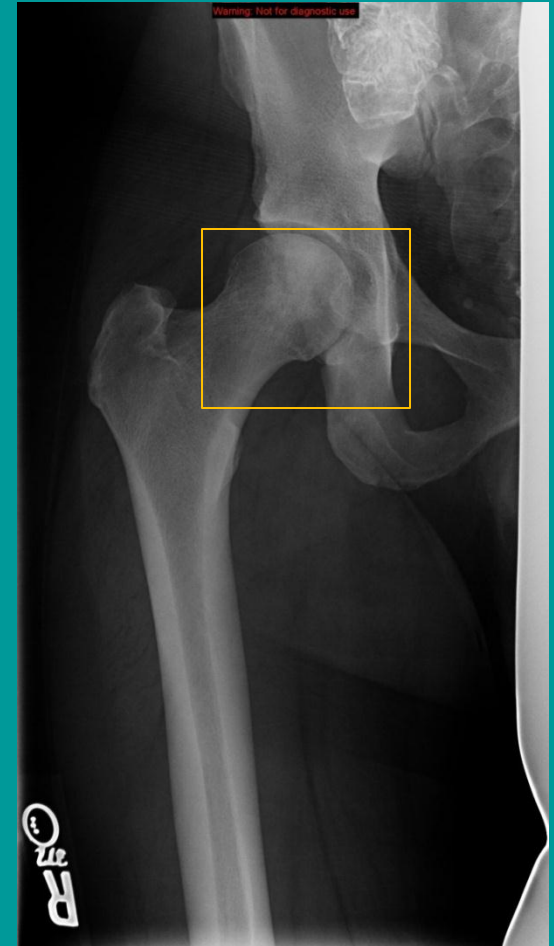




Our Patient: Findings on Plain Films



Sclerosis of
femoral heads
bilaterally
with patchy
areas of
lucency
amidst
hyperdensity,
consistent
with AVN



Index Patient: Follow-Up

- Patient left hospital AMA with no further workup



Management of Femoral AVN

- Conservative therapy for lesions that cover less than 15% of femoral head
 - bedrest, weightbearing with crutches, analgesics
- Bisphosphonates
- Joint Preserving Procedures
- Joint replacement
- Vascularized femoral graft
- Bone marrow grafting
- Osteotomy

Summary

- Avascular necrosis of the femoral head involves compromise of the bone vasculature, leading to bone death and mechanical failure
- Plain film radiography, MRI, bone scanning, and CT are the main modalities for imaging AVN of the femoral head
- Radiologic findings include sclerosis, flattening of the femoral head, subchondral lucencies, and increased bone uptake
- Depending on the severity of necrosis, conservative therapy, joint replacement, grafts, or osteotomies are options for management



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