



MEDICINE *of* THE HIGHEST ORDER



MSK Radiology – What to Order When, (and Why!)

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Ringside Physician for New York State Athletic Commission

Goals and Objectives

- Describe the role of diagnostic imaging as an extension of the physical exam
- Review the indications for x-ray
- Describe different x-ray views, why they are used and their interpretations
- Differentiate indications and contraindications for advanced diagnostic imaging such as US, MRI, CT and nuclear
- Recognize the growing utility of point of care MSK ultrasound
- Improve efficiency and efficacy in diagnosis
- Become familiar with ACR Appropriateness Criteria

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Appropriateness websites

- ACR Appropriateness criteria - Guidelines for types of studies to be ordered for different indications <https://www.acr.org/Quality-Safety/Appropriateness-Criteria>
- criteria assign values on a number scale to indicate the degree of appropriateness of many different types of imaging studies, which may be used for answering a specific clinical question, helping to provide guidance as to choice of imaging
- <http://www.choosingwisely.org>

Educational Websites

- <http://www.learningradiology.com>
- <http://uwmsk.org/RadAnatomy.html>
- <https://radiopaedia.org/encyclopaedia/all/musculoskeletal>
- <https://skeletalrad.org/web-resources>
- <http://www.radiologyassistant.nl/en/>
- <http://www.wikiradiography.net>
- <http://xrayhead.com>
- <https://www.radiologymasterclass.co.uk/>

Xray Basics

- “Plain film” / radiography / xray
- Oldest and most commonly used technology in medical imaging
- Discovered by Wilhelm Rontgen in 1895 earning Nobel Prize
- Utilizes electron sourced ionizing radiation to penetrate soft tissue and evaluate bone (50% total dose yearly)
- Same basic technology for “plain film”, computed tomography (CT) and fluoroscopy

Image from Wikipedia



X-ray Radiation

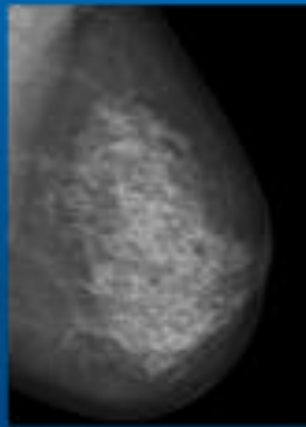
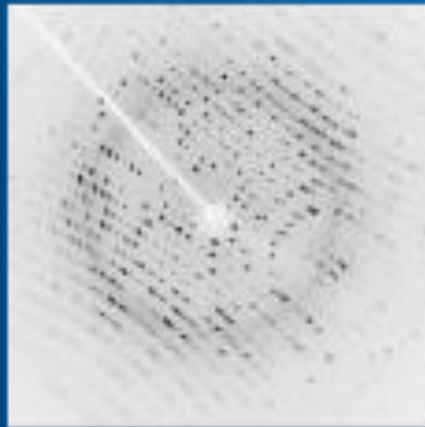
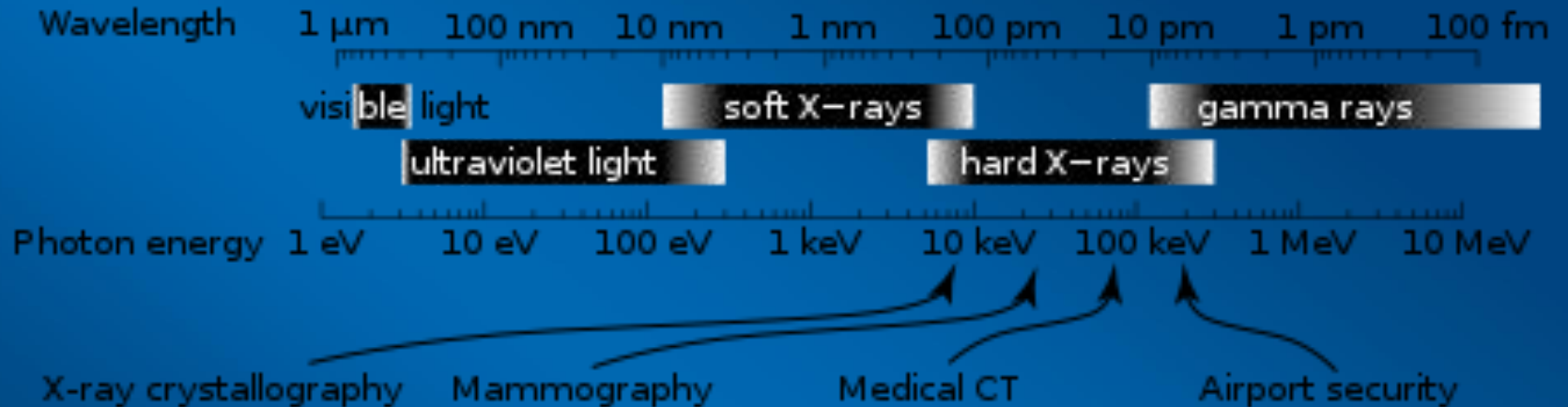


Image from Wikipedia

X-Ray Basics

- Any patient with “significant” trauma should have plain films done
- Consider imaging for pain > 6 weeks without trauma
- Any patient with concern for cancer or infection
- Quality of plain films altered by:
 - Positioning – often limited with injury/pain
 - Habitus
 - Atypical anatomy/biomechanics
- Always look at your own films!
 - Clinical correlation adds a lot to the image
 - Be clear when ordering “evaluate for “

Read your own film! Practice!



X-Ray Basics

Findings in Fracture

- Cortical interruption
- Deformity
- Periosteal reaction (Stress or insufficiency)

Findings for Tendon and cartilage injury

- Enthesophytes (spurs)
- Calcific tendonitis
- High riding humeral head (RTC tear)
- Patella alta (quad or patellar tendon tear)
- Chondrocalcinosis (OA or CPPD)

Findings in OA

- Joint space narrowing
- Subchondral sclerosis
- Osteophytes (spurs)
- Subchondral cysts

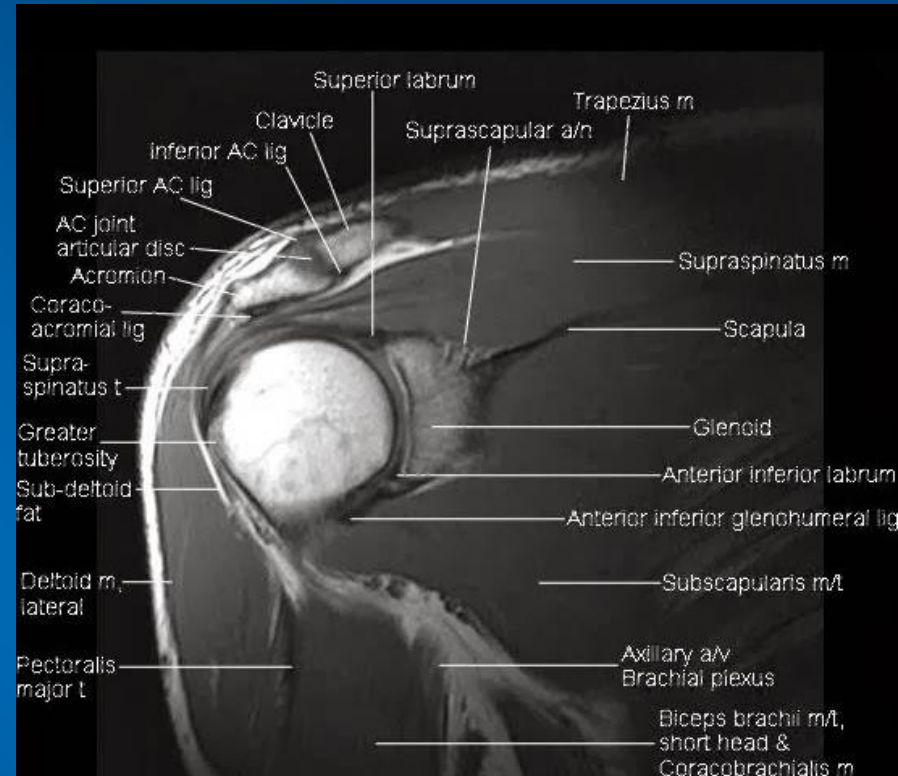
Why get a CT scan?

- Calcaneal fractures
- Fracture severity for surgical planning (e.g. depressed tibial plateau)
- Neck fracture concern (time sensitive)
- If a patient can't have a MRI (pacemaker, metal)
- Sternoclavicular joint
- CT myelogram in spine
- CT with 3D reconstruction for complex anatomy



Why get an MRI?

- Soft tissue tears and strains, sprains
- Concern for missed fracture on x-ray including stress, insufficiency
- Concern for tumor (benign or malignant)
- Concern for infection



MR or CT with contrast

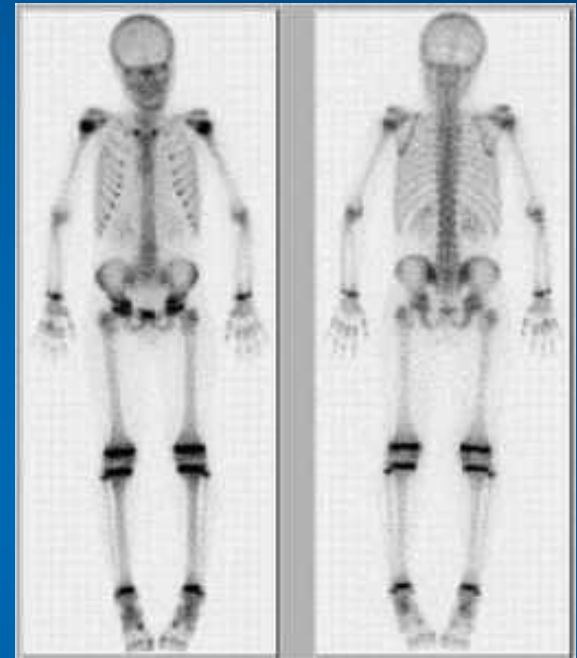
- IV contrast
 - Infection
 - Inflammation
 - Malignancy
 - Vascular injury
 - Caution with CKD or ARF (GFR needs to be > 30)
- Oral contrast
- Arthrogram
- Myelogram

MRI safety considerations

- Ask patient about metal fragments (bullets, shrapnel, shavings, etc) – may need xray first
- Metal contraindication if near vessels, nerves, eyes or hollow viscous, no concern in bone
- Pacemaker and AICD, aneurysm clips and pain pump safety- consult with manufacturer

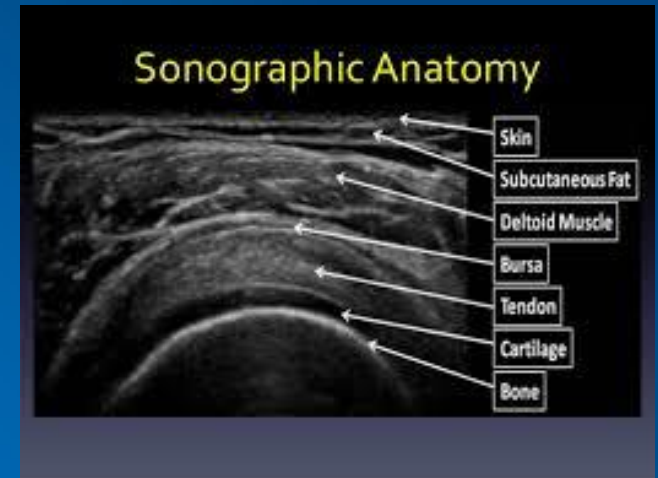
Why get a Bone Scan?

- When you can't do an MRI and are concerned for fracture
- Rapidly becoming extinct in orthopaedics
- Continued use in oncology



Why get an US

- If you can perform the test yourself at time of service
 - Less expense
 - Faster
 - Excellent soft tissue resolution
 - Dynamic exam
- If patient cannot have an MRI for a soft tissue injury
- Operator dependent – not every radiology office can provide, emerging popularity with sports medicine, rheumatology and orthopaedics



Head

Skull films useless, nasal films ok

- Waters view for nasal bone

Difficult to see zygomatic arch fractures

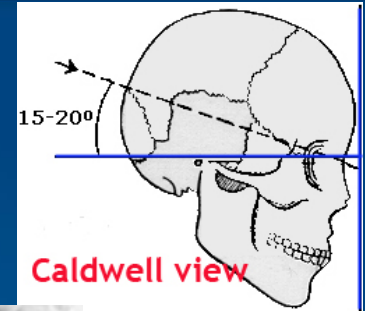
- Caldwell view

Jaw /Dental

- Jaw series
 - PA, Towne view (AP axial) and bilateral oblique
- Panorex

CT is more sensitive for skull and face

CT acutely for brain bleed, MRI better



Examples

Panorex



Nasofrontal Suture _____

Nasal Bone _____

Anterior Nasal Spine of Maxilla _____

wikiRadiography.com

C-Spine

Why order plain films

- Trauma
- Neurologic symptoms (radicular)
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Radicular pain that isn't responding to conservative therapy

Why order CT

- Trauma when you can't R/O fracture with plain films or clear C-spine clinically
- Disk herniation if pt cannot have MRI
- Consider myelogram

C-Spine

When to order plain films

- Immediately for any trauma
- Upon presentation for radicular symptoms
- After course of conservative treatment for neck pain (acute or chronic without neurologic symptoms)

When to order MRI

- After course of conservative treatment for radicular symptoms

When to order CT

- Immediately if fracture cannot be R/O by plain films or clinical exam
- Myelogram if pt cannot undergo MRI

Cervical X-ray

What films to order

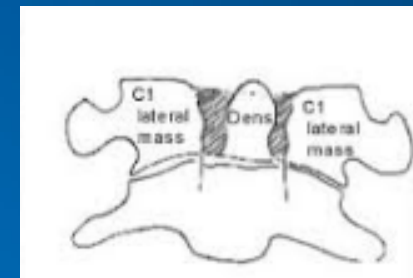
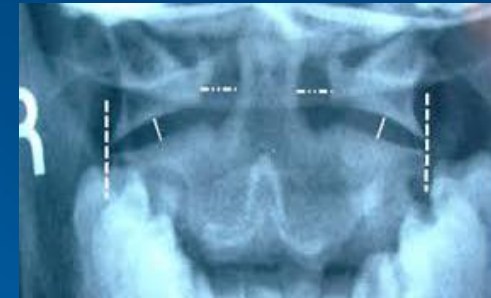
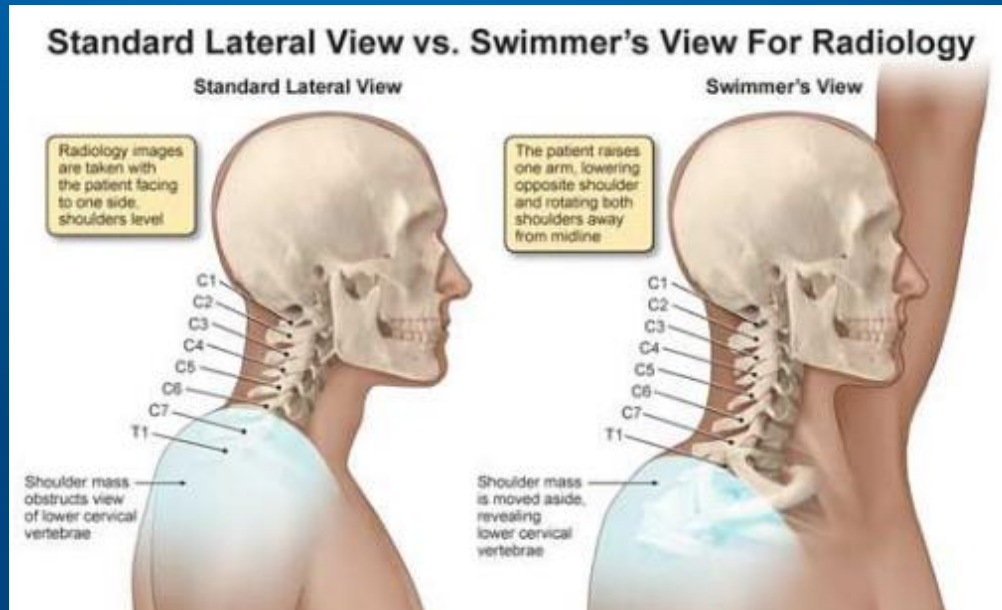
- AP and lateral – on all patients
- Odontoid view – on all trauma (standard though on most “C-spine series”)
- Flex/ex views – looking for instability
 - All athletes with Down syndrome need to have this prior to participating in Special Olympics
 - Patients with RA
 - Will also give info on loss of motion and spasm
- Lateral: disc space narrowing, disc spaces should get bigger going inferior from C2-C6 but with C6-C7 being slightly narrower
- Oblique: examine foramina for narrowing (stenosis)



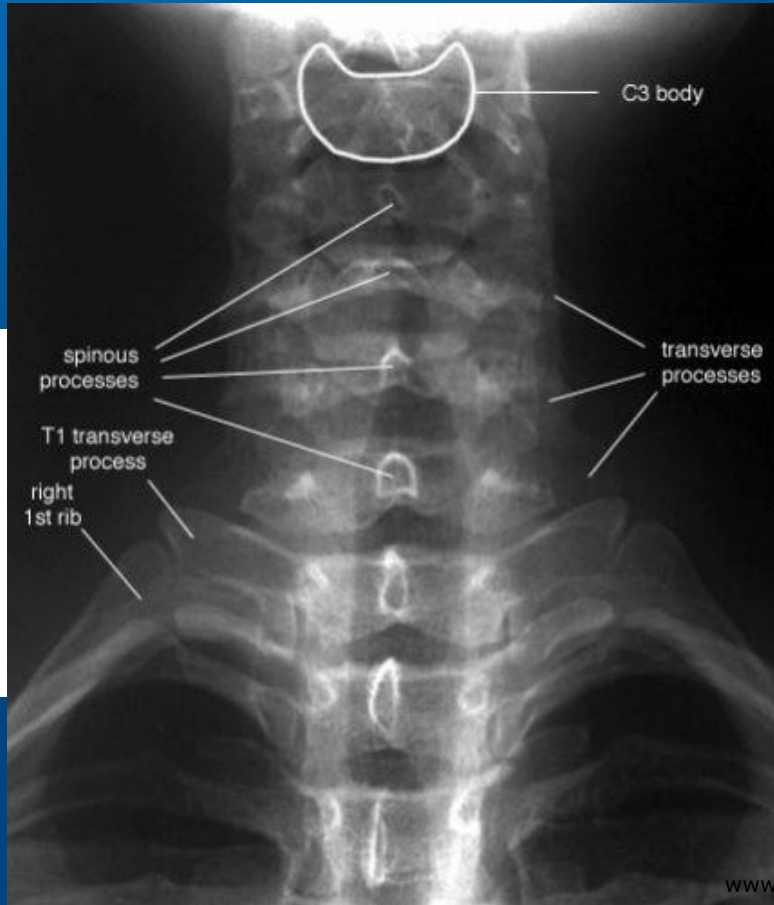
Cervical Spine Views

Odontoid (Open mouth) to examine atlantoaxial joint/dens

Swimmer's view for C7



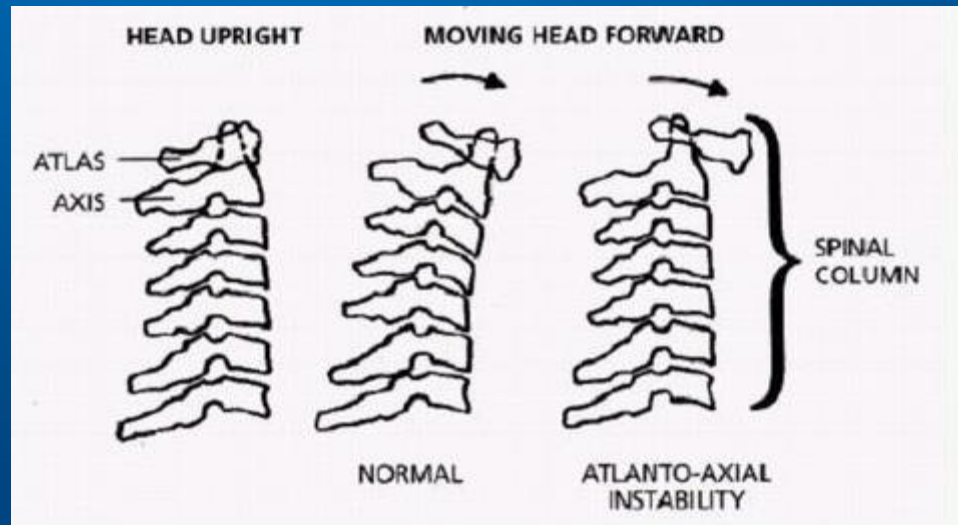
AP and Lateral Views



www.e-radiography.net

Cervical Views

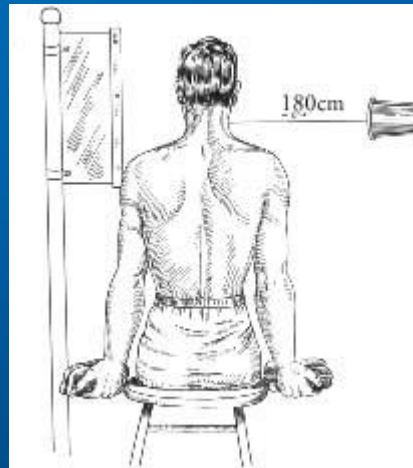
Flex/extend for concern for spondy or increase atlantodens interval (atlantoaxial instability) in RA or Downs



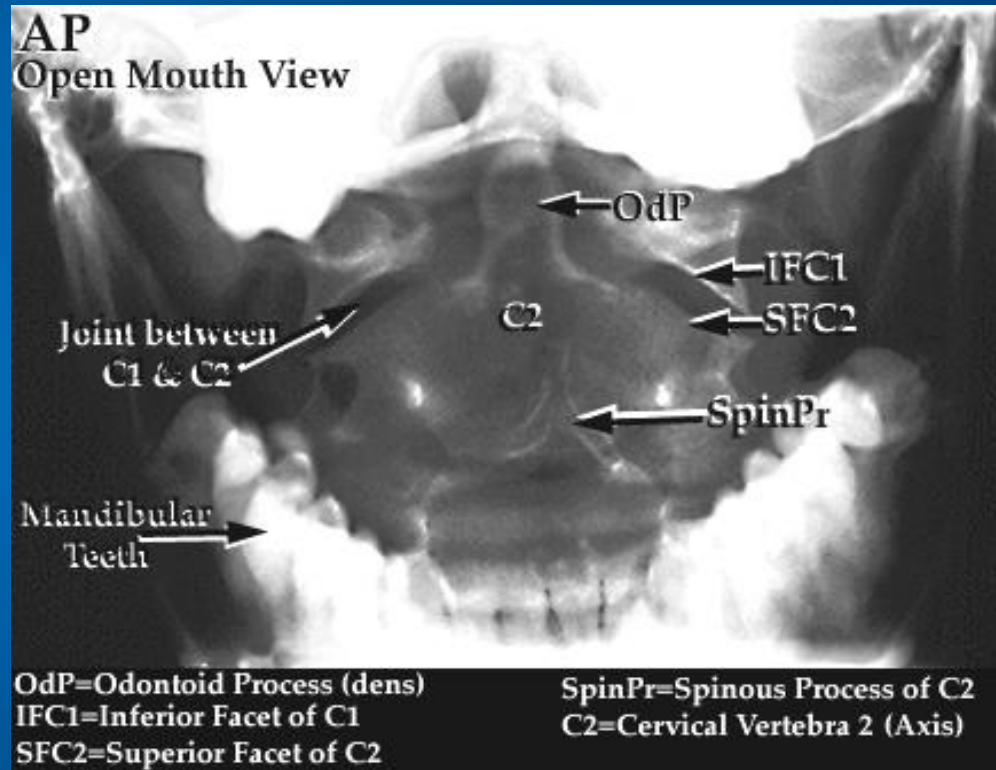
Flexion/Extension Views



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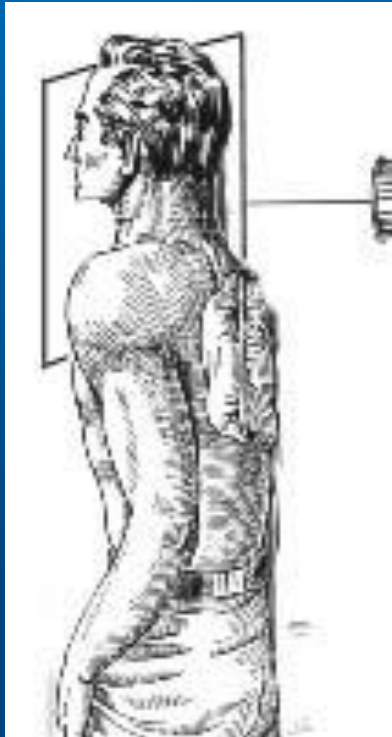


Odontoid (open mouth) View



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Oblique Views



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Osteophytes on lateral C-spine



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Shoulder

Why order plain films

- Trauma/acute injury – order at time of exam
- Look for fracture, dislocation
- Presentation of radicular symptoms
- Chronic pain >6 weeks that isn't responding to conservative therapy, looking for OA, crystal diseases, tumor, chronic RTC disease

Why order MRI

- Suspicion of RTC tear- order at time if suspected massive tear
- Chronic pain > 6 weeks with negative x-rays
- Suspicion of labral injury (get MRI Arthrogram)

Why order U/S

- Suspicion of RTC tear (only in some markets)
- Dynamic studies for impingement, biceps subluxation

Shoulder

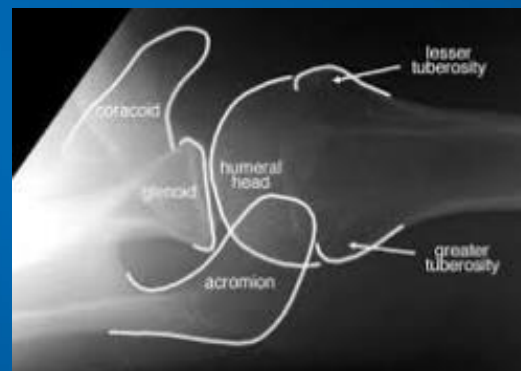
What films to order

- AP and a lateral view – on all patients
 - Lateral views include: axillary, scapular Y
- Supraspinatus outlet view – shoulder impingement/RC tendinopathy
- Clavicle views – with clavicle injury
- AC joint Views – with AC injury (shoulder separation)

Shoulder views

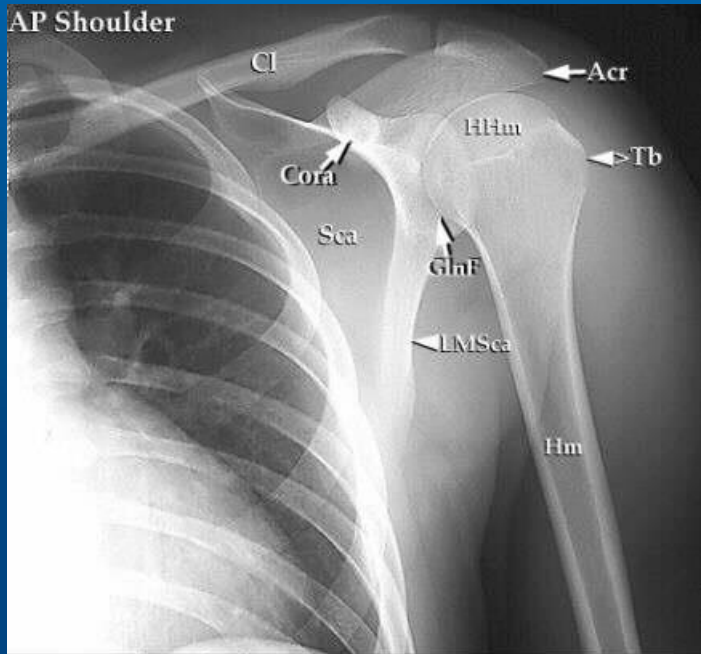
ER: can see Hill-Sachs/humeral head

Axillary view: Hill-Sachs, OA

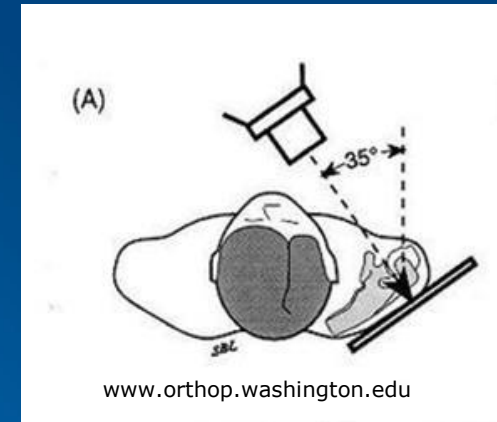


Y/scapula view: scapular fractures

AP vs. "True AP"



www.e-radiography.net



www.orthop.washington.edu

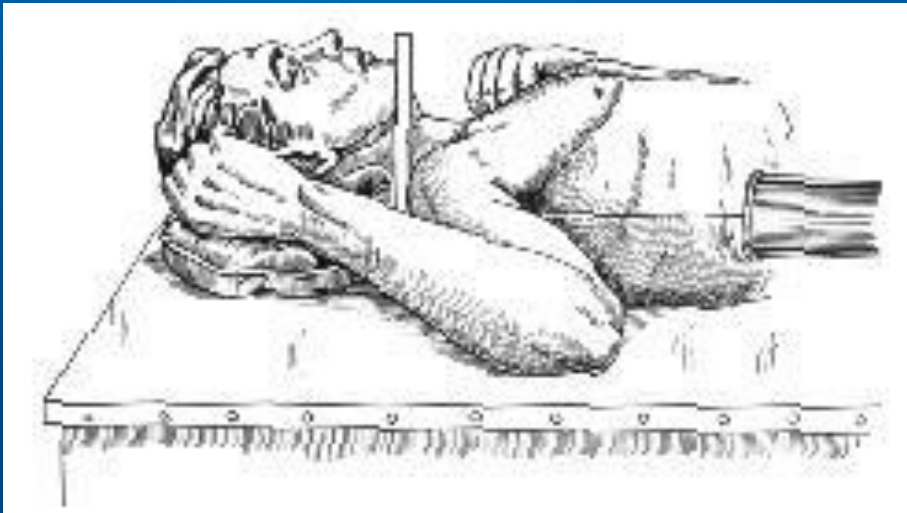


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Axillary



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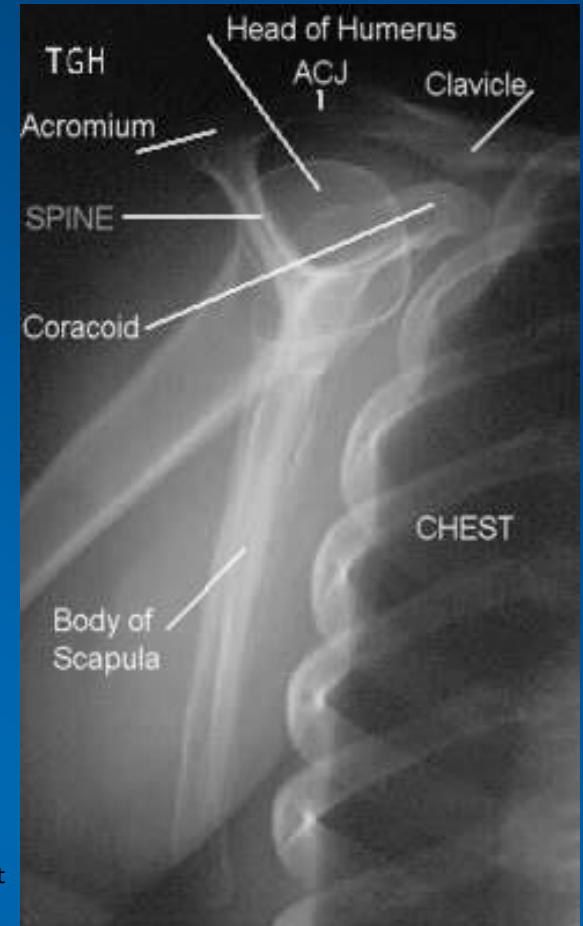


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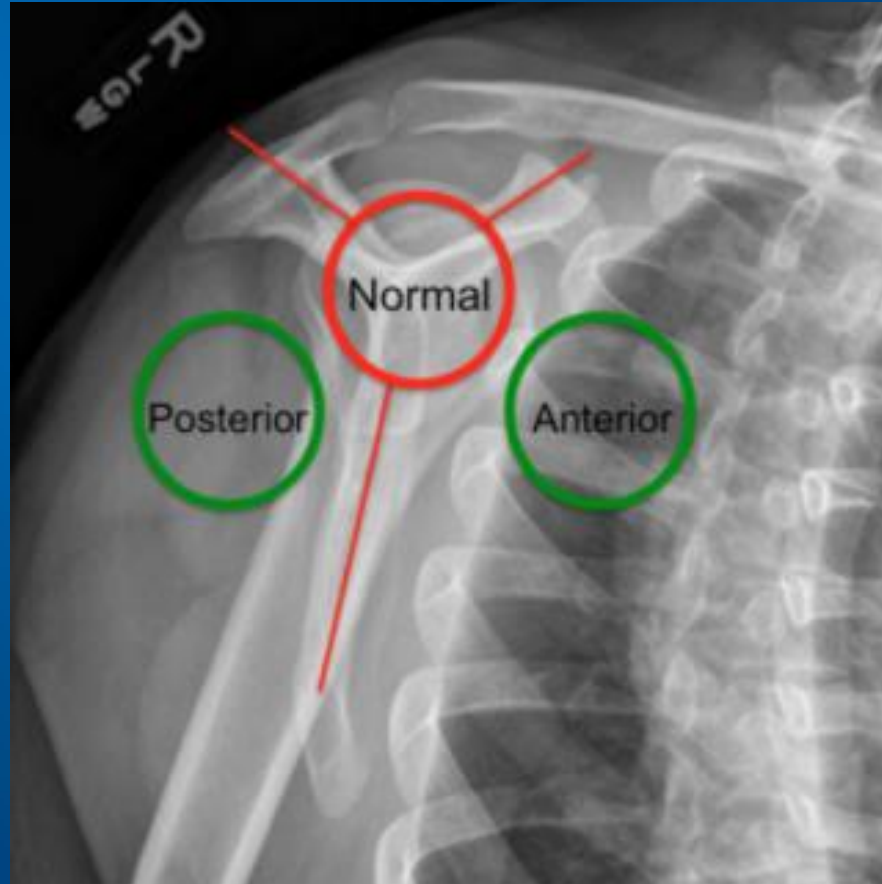
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Scapular Y View



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Scapular Y for dislocation



Supraspinatus Outlet View



www.ORIF.com

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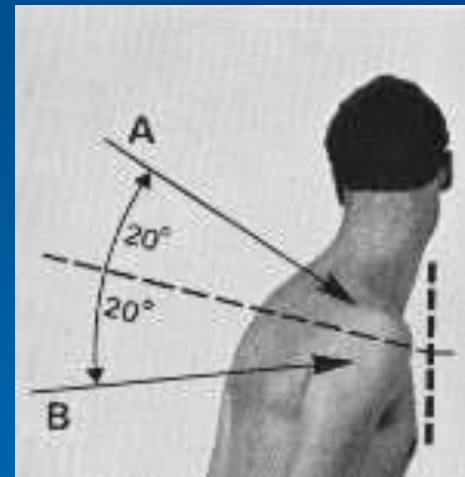


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Clavicle

AP

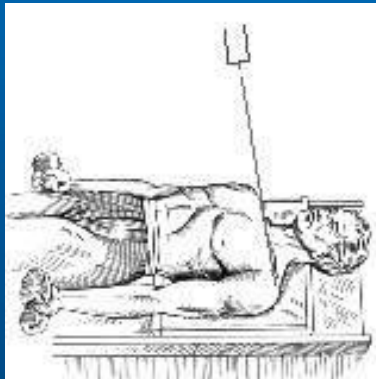
Zanca view



AC Joint View



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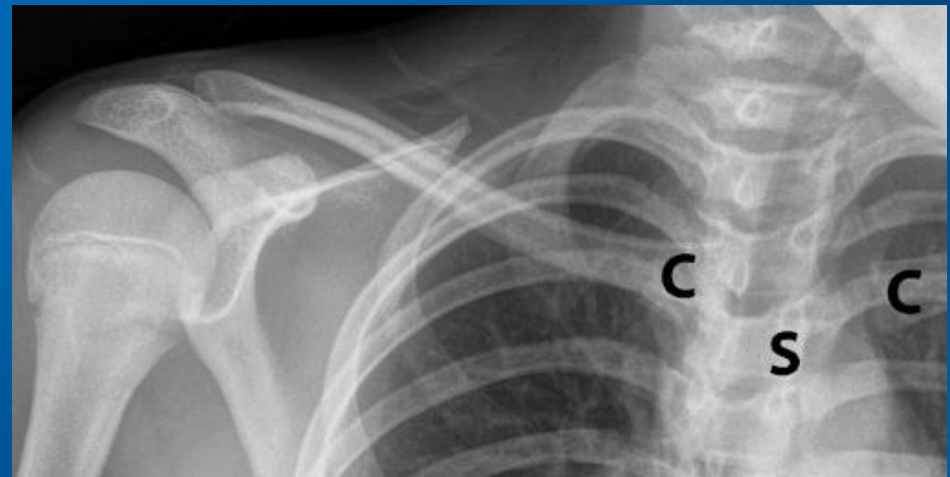
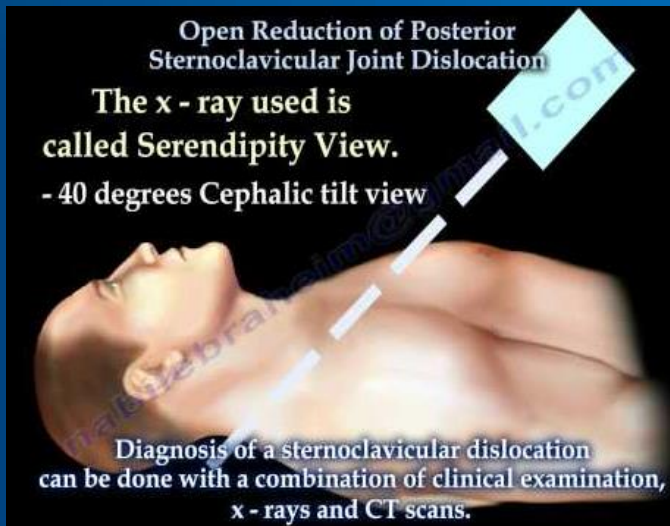
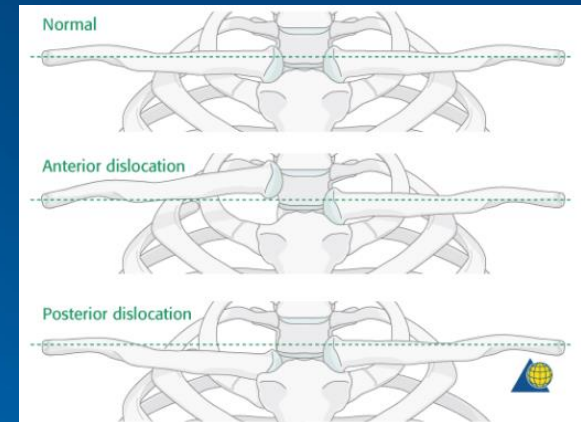
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Sternoclavicular Joint

Anterior 2/3

CT is best for SC dislocation or fracture

Serendipity view



Elbow

Why order plain films

- Trauma/acute injury
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Suspicion of more severe joint injury
- Suspicion of more severe soft tissue injury

Why order CT

- Classification of complex fracture (3D Recon's)

Elbow

When to order plain films

- Immediately for any trauma
- After course of conservative treatment for pain (acute or chronic without trauma)

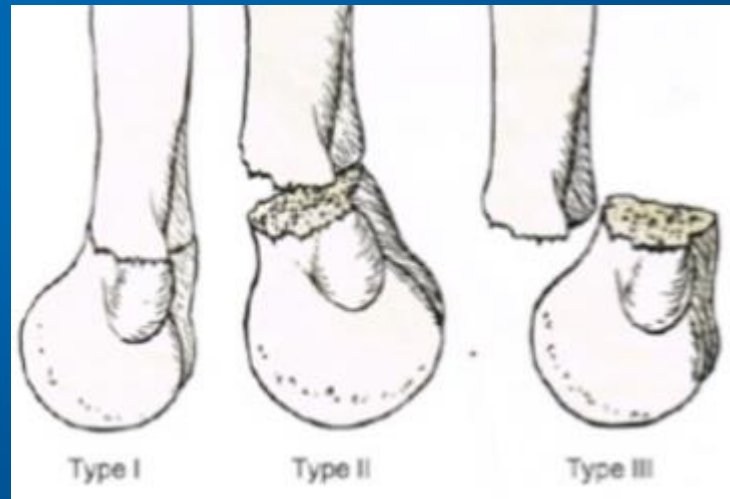
When to order MRI

- After a course of conservative treatment
- Consider acutely with arthrogram for MCL /UCL (Tommy John) ligament injury
- Consider acutely for dislocation (Terrible Triad)

Elbow

What films to order

- AP, lateral and oblique views – on all patients
- Radial head view – if radial head fracture suspected



AP and Lateral



www.e-radiography.net

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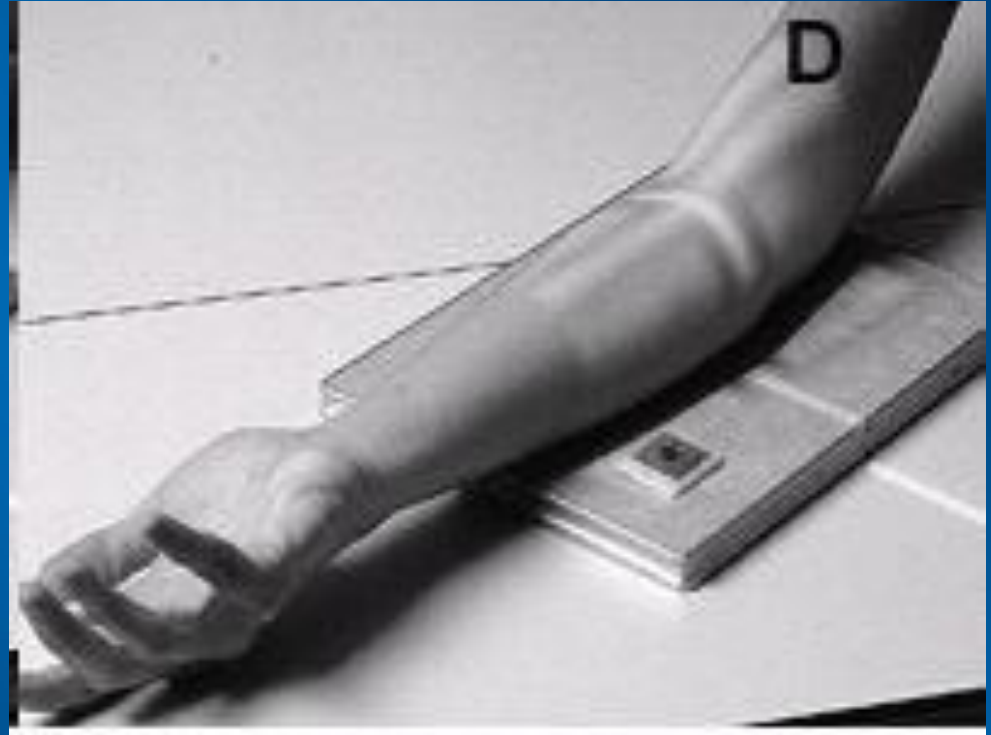


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Lateral Oblique



www.ceessentials.net



www.auntminnie.com

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Radial Head View



Hand/Wrist

Why order plain films

- Trauma/acute injury
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Suspicion of more significant soft tissue injury
- Suspicion of scaphoid fracture not seen on plain film
- Evaluation of AVN of scaphoid with nonunion

Why order CT

- Evaluation of nonunion of scaphoid

Hand/Wrist

When to order plain films

- Immediately for any trauma
- After course of conservative treatment for pain (acute or chronic without trauma)

When to order MRI

- After a course of conservative treatment if scaphoid fracture is suspected and plain films remain negative

When to order CT

- After course of appropriate treatment for scaphoid fracture and pain remains (nonunion vs. AVN)

Hand/Wrist

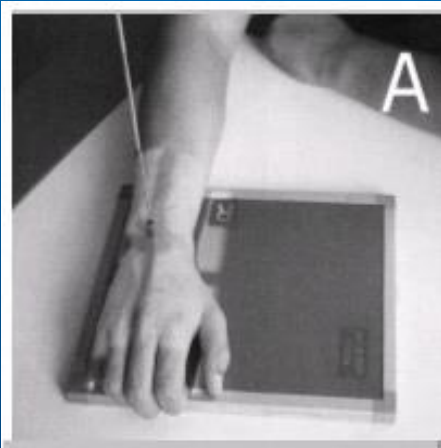
What films to order - Wrist

- PA, lateral and oblique views – on all patients
- Scaphoid view – if fracture suspected

What films to order – Hand

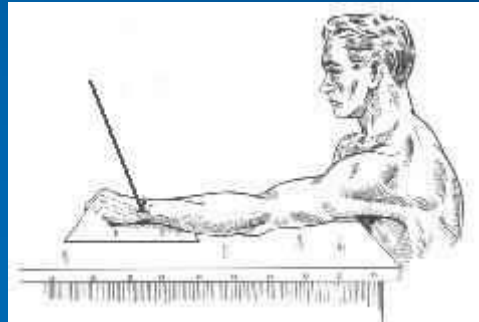
- PA, lateral and oblique views – on all patients
- Fingers – as warranted for finger injuries

PA and Lateral Wrist Views

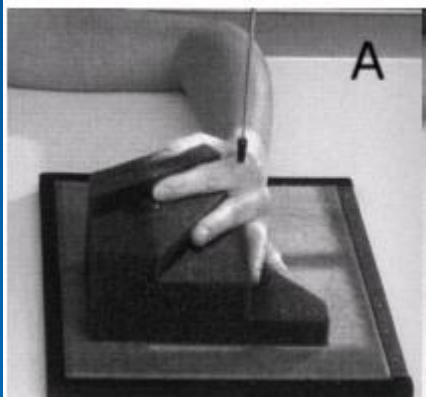
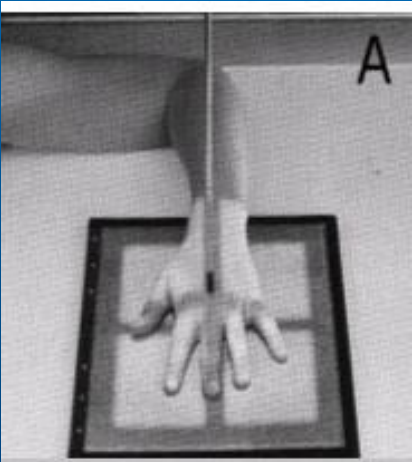


www.auntmimie.com
www.e-radiograph.net

Oblique Wrist and Scaphoid Views



PA and Fan Lateral Hand Views



Oblique Hand View



Ball-Catch (Norgaard's) View

- Hands are in a “ball-catching” position
- Best view to look for early erosions at the base corners of the proximal phalanges

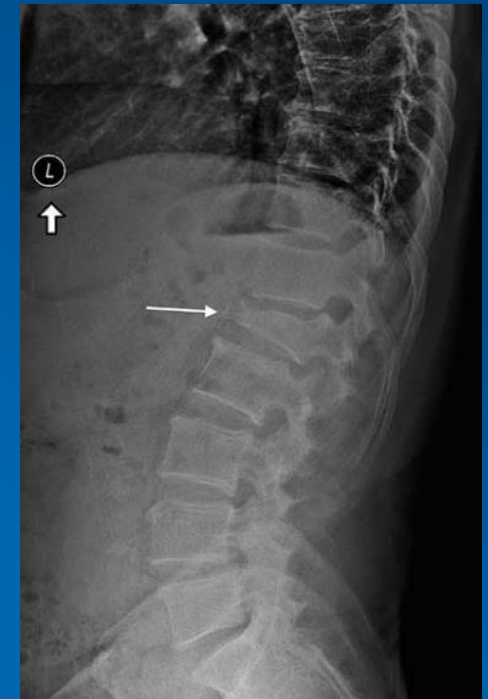
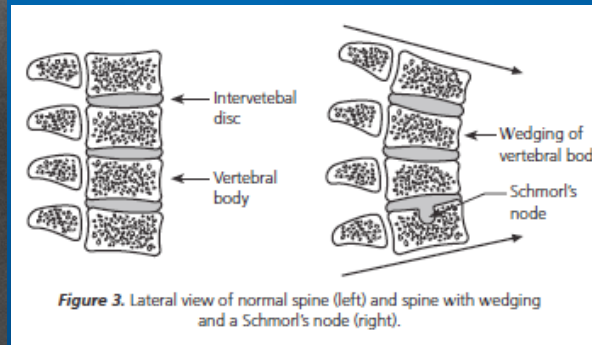
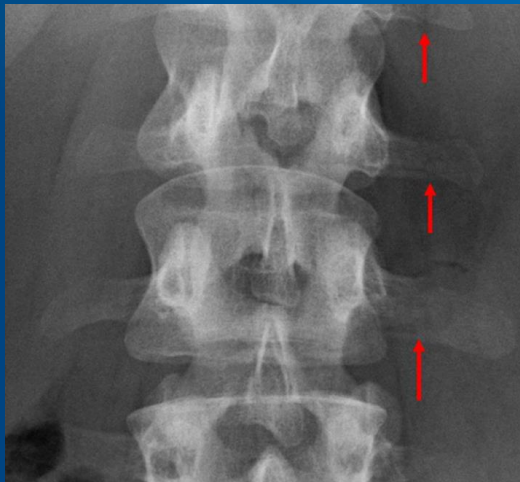


Thoracic Spine

Why to order?

- Scheuermann's kyphosis, wedge/compression or transverse process fractures

What to order? AP/lateral



Chest and Ribs

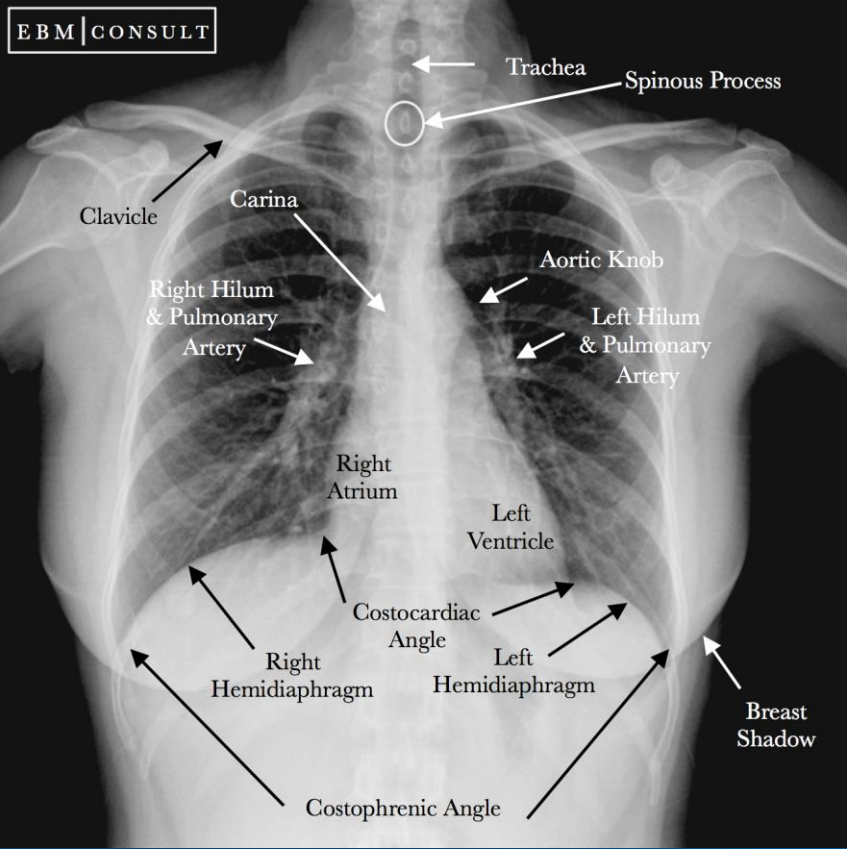
Why to Order?

- Rib fractures
- Sternal fracture
- Concern for pneumothorax or lung pathology

What to Order?

- Chest AP and Lateral
- Obliques of chest x 2 (rib films)
- CT is better for small pneumothorax, 1st and 2nd rib trauma and sternal fracture (consider 3D recon), not more useful than plain film for ribs
- MRI of chest wall for rib stress fracture

Chest Views



L-spine

Why order plain films

- Trauma
- Neurologic symptoms (radicular)
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Radicular pain that isn't responding to conservative therapy

Why order CT

- Trauma when you can't R/O fracture with plain films
- With myelogram if pt cannot have MRI

L-Spine

When to order plain films

- Immediately for any trauma
- Upon presentation for radicular symptoms
- After course of conservative treatment for low back pain (acute or chronic without neurologic symptoms)

When to order MRI

- After course of conservative treatment for radicular symptoms

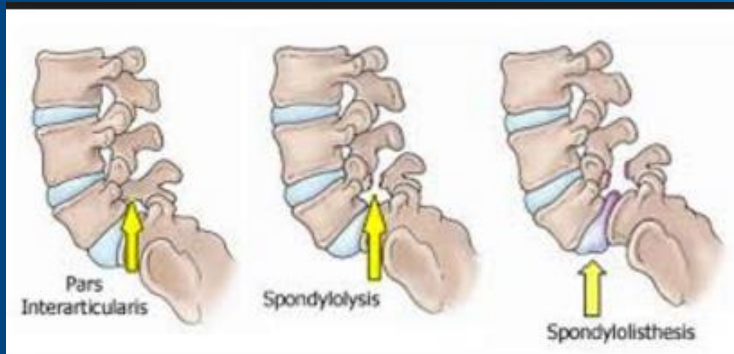
When to order CT

- Immediately if fracture cannot be R/O by plain films

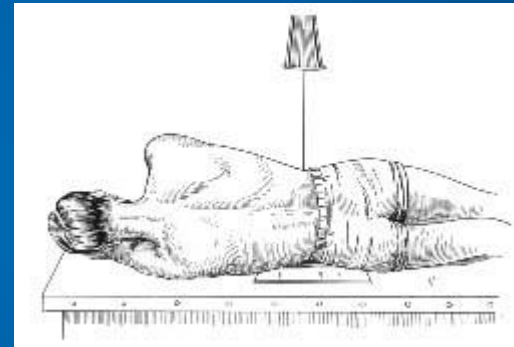
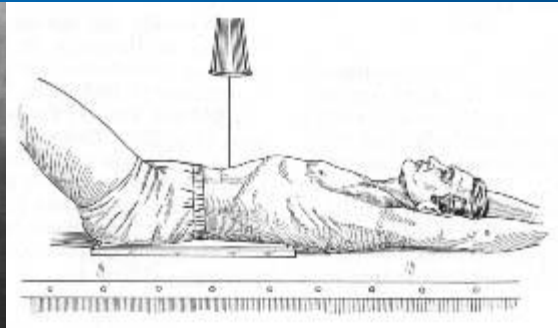
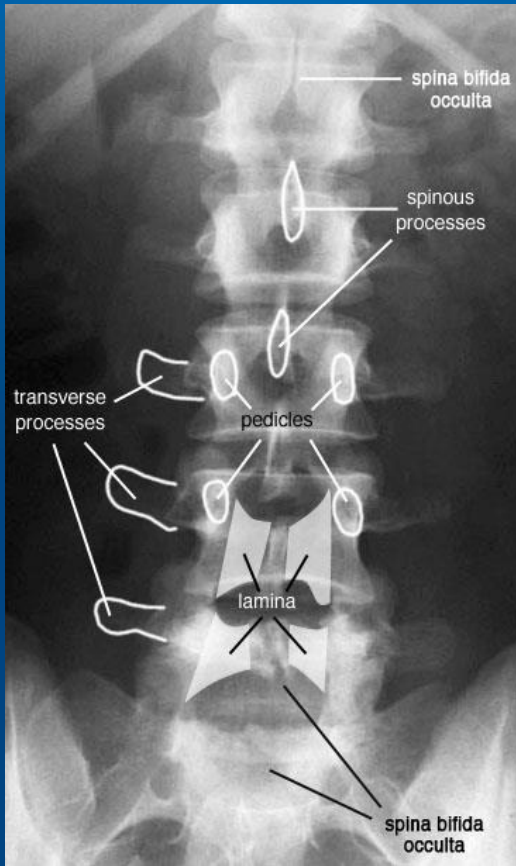
L-Spine

What films to order

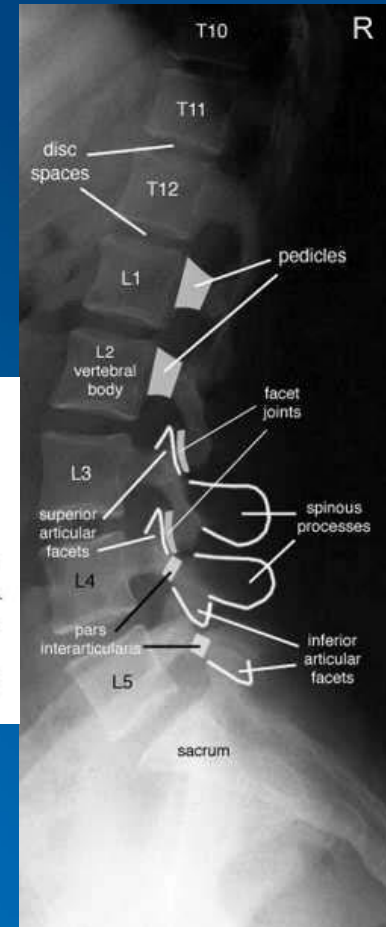
- AP and lateral– on all patients
- Coned down view of L5-S1 – mostly unnecessary with digital radiology
- Flex/ex views – looking for instability
 - Will give info on loss of motion and spasm
- Oblique views – looking for foraminal stenosis and spondylolysis (pars defect)



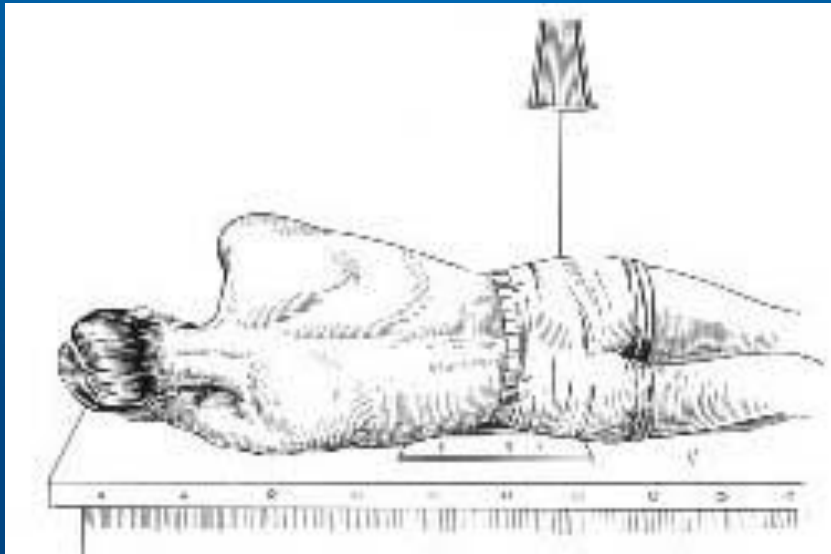
AP and Lateral



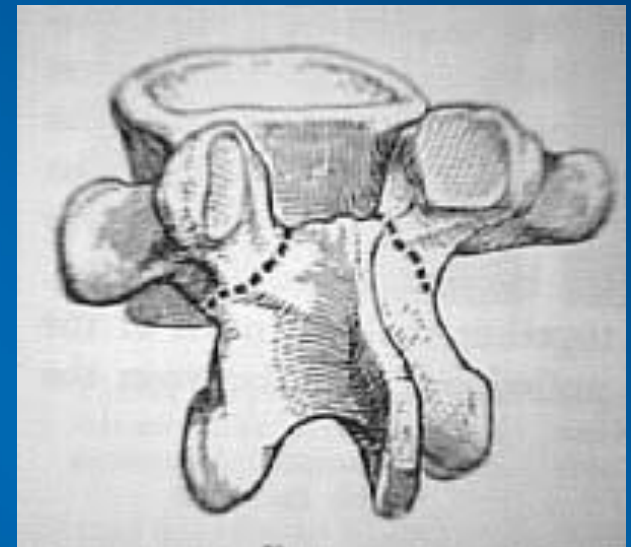
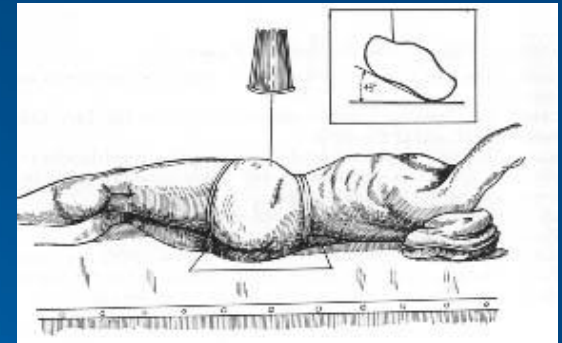
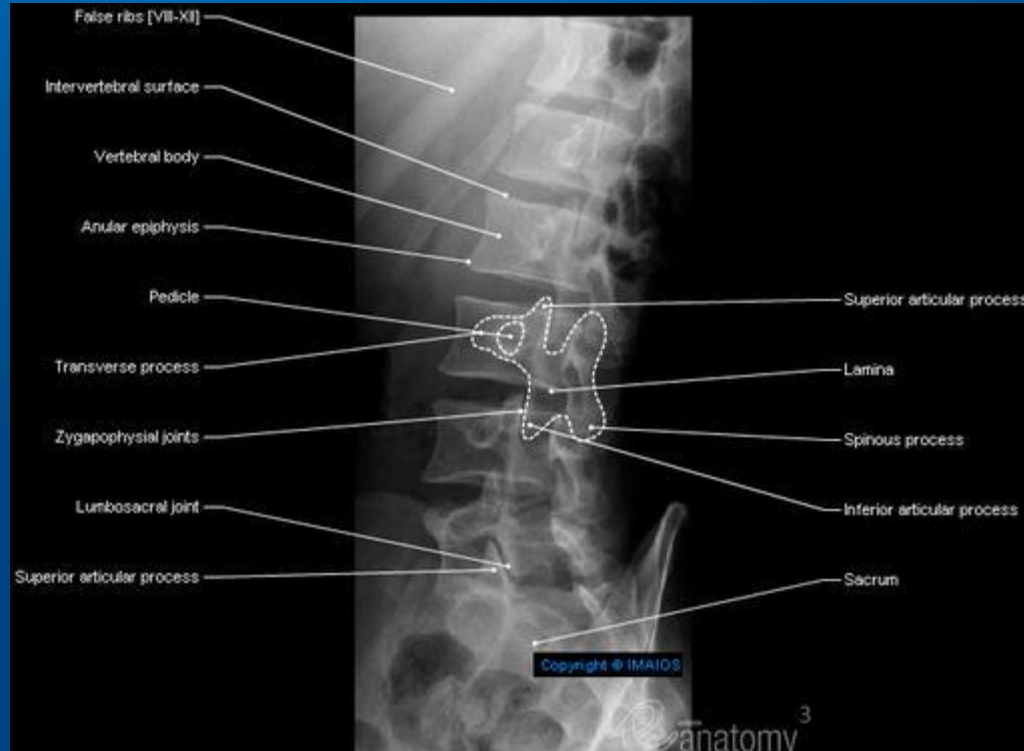
<http://uwmsk.org/RadAnatomy.html>



L5-S1 Coned View



Oblique

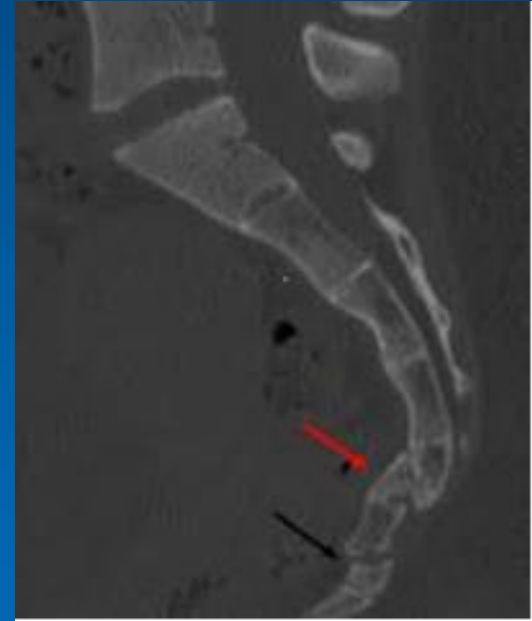
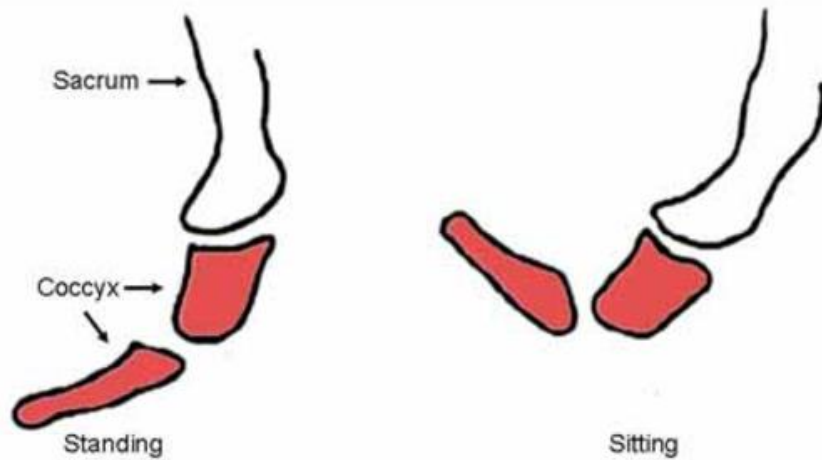


Coccyx

Sit/stand

Ap/lat

The pictures below show unstable coccyxes.



Scoliosis

PA /Lateral full spine

If available, EOS technology

- Low dose, standing biplanar x-ray

Red flags

- L thoracic curve
- >30 degs
- Pain



Hip

Why order plain films

- Trauma
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Chronic pain that isn't responding to conservative therapy
- Concern for labral tear

Why order CT

- Concern for AVN
- Concern for nonunion fracture

Hip / Pelvis

When to order plain films

- Immediately for any trauma
- Immediately if SCFE or Perthes Disease suspected
- After course of conservative treatment

When to order MRI

- If concern for labral tear (arthrogram)
- If concern for other pelvic pathology (e.g. sports hernia)

When to order CT

- To classify complex fracture or anatomy (3-D Recon)

Hip

What films to order

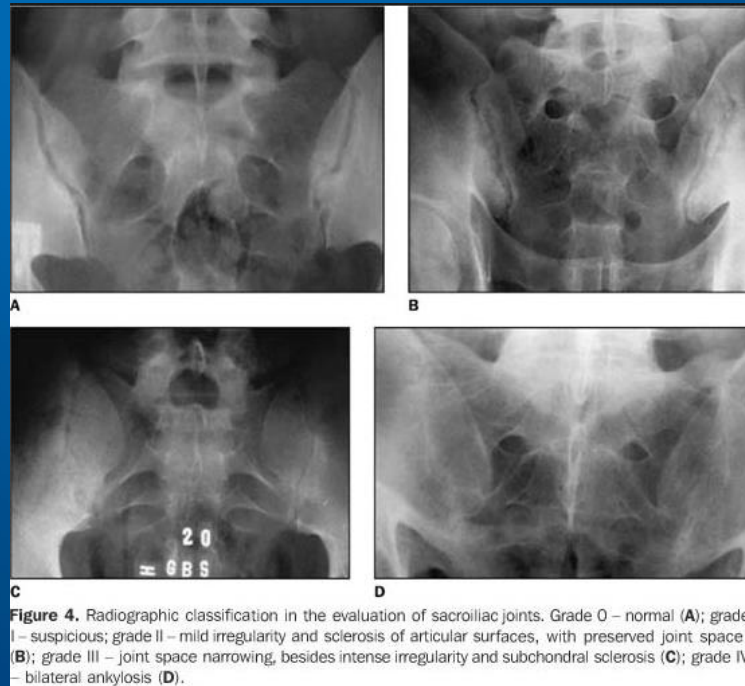
- AP and a lateral – on all patients
 - Frog leg or cross table laterals
- WEIGHT-BEARING AP – if OA suspected
 - With comparison view



Pelvis

AP

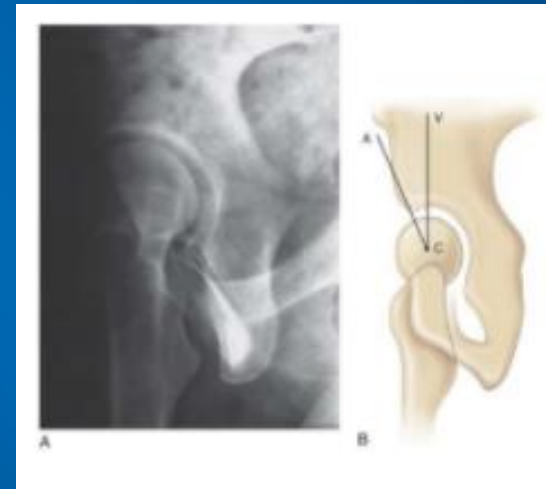
Can get specific SI views for ankylosis spondylitis



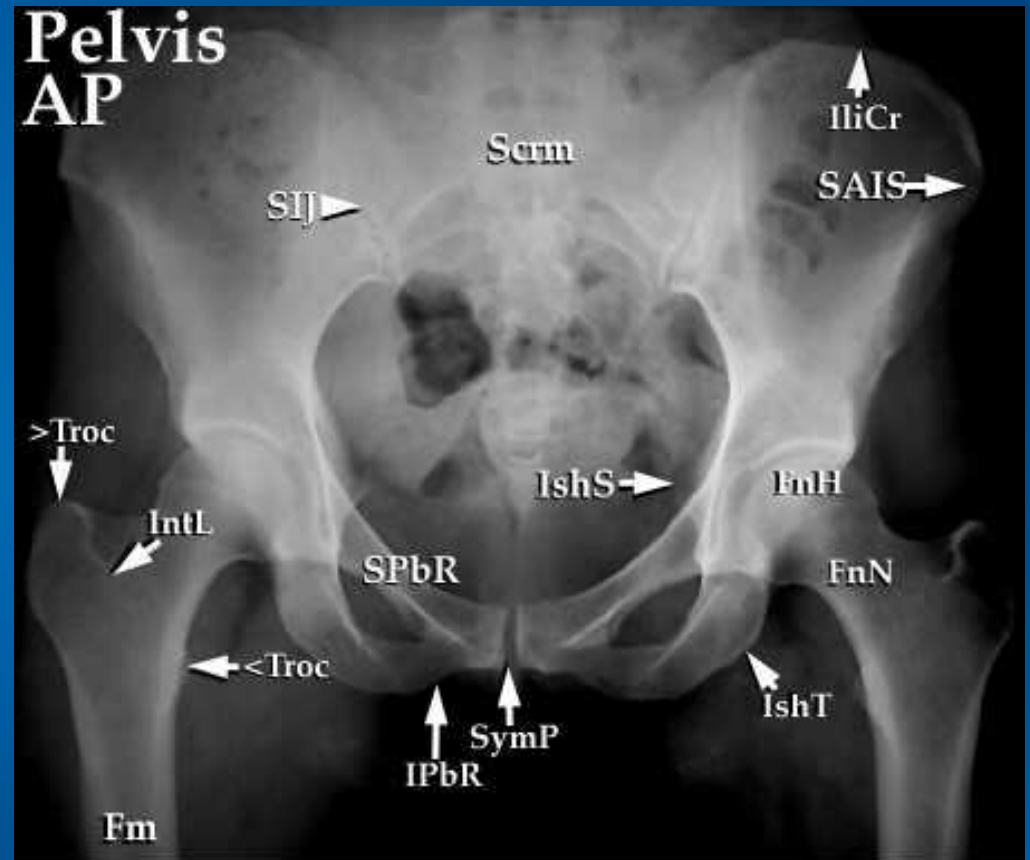
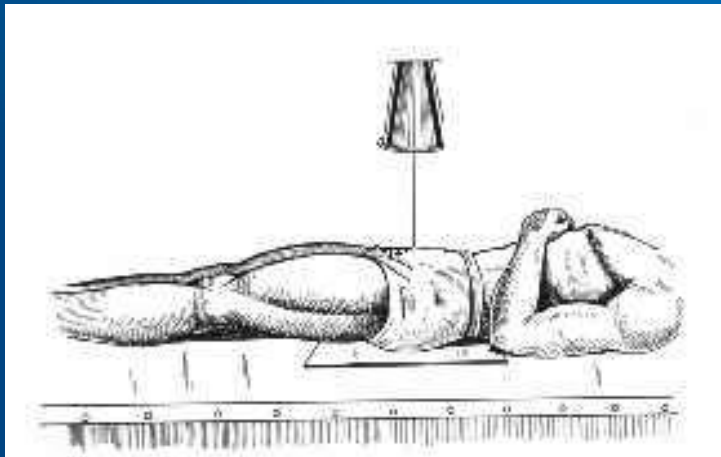
Hip

Judet for acetabulum fractures

Dunn and false profile for FAI



AP of the Pelvis

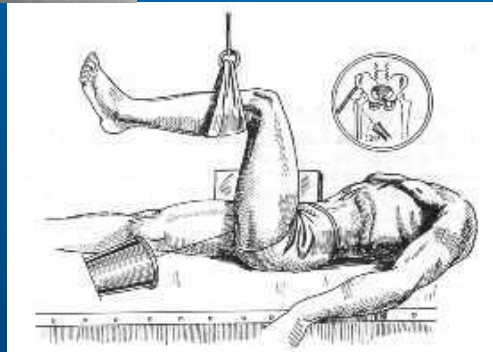
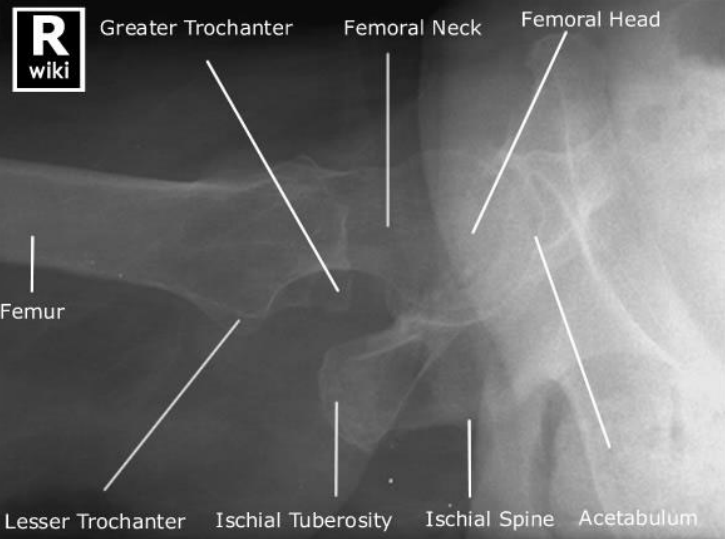


Hip

Frog legs



Frog Leg and Cross Table Laterals



Knee

Why order plain films

- Trauma
- Chronic pain that isn't responding to conservative therapy

Why order CT

- Tibial plateau fracture

Why order MRI

- Suspect internal derangement that needs surgery
- Patient isn't responding to conservative treatment and something more serious is suspected

Knee

When to order plain films

- Immediately for any trauma –Ottawa Knee rules
- At presentation for suspected OA
- After course of conservative treatment for young patients

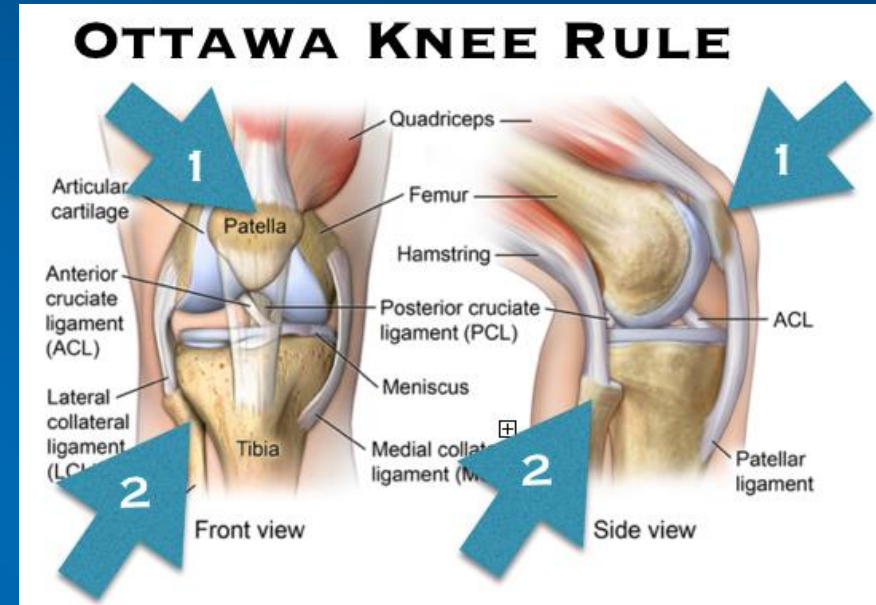
When to order MRI

- At presentation for probable internal derangement that needs surgery
- After course of conservative treatment that fails for young patients (not typically helpful if OA is the etiology)

Ottawa Knee Rules

XR knee for acute injury if meets 1 of the following criteria:

- >55 y/o
- Isolated tenderness of patella
- Tenderness of head of the fibula
- Inability to flex knee to 90 degrees
- Inability to bear weight for 4 steps



Knee

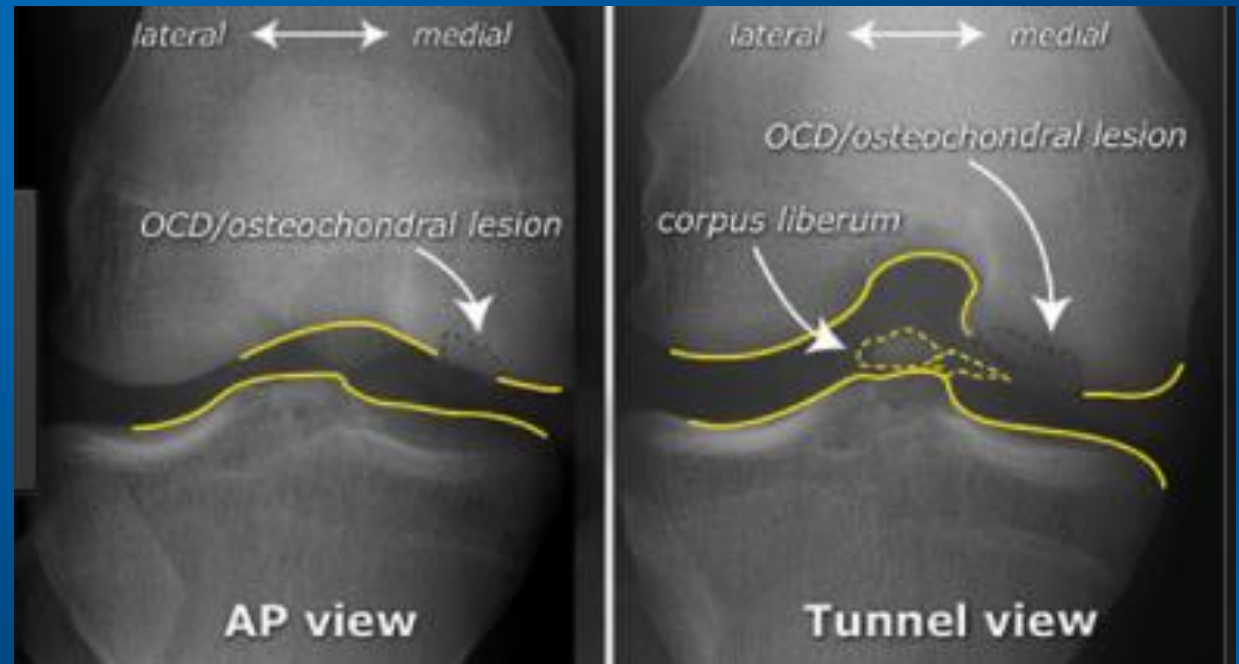
What films to order

- AP, lateral, merchant – on all patients
- Weightbearing if possible
- Oblique view for trauma for fibular head and tibial plateau
- Weight-bearing PA (Skier's view or Tunnel or Rosenberg views) – on all patients over age 40 and those with suspected OA
 - With comparison view

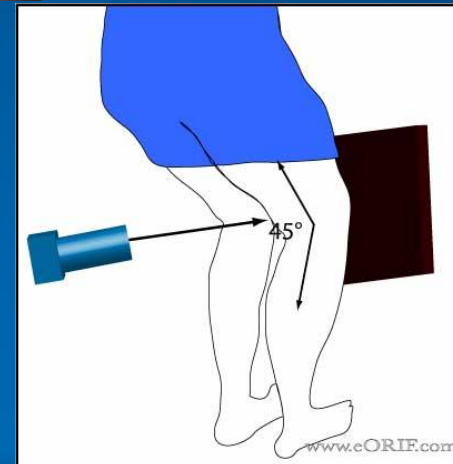
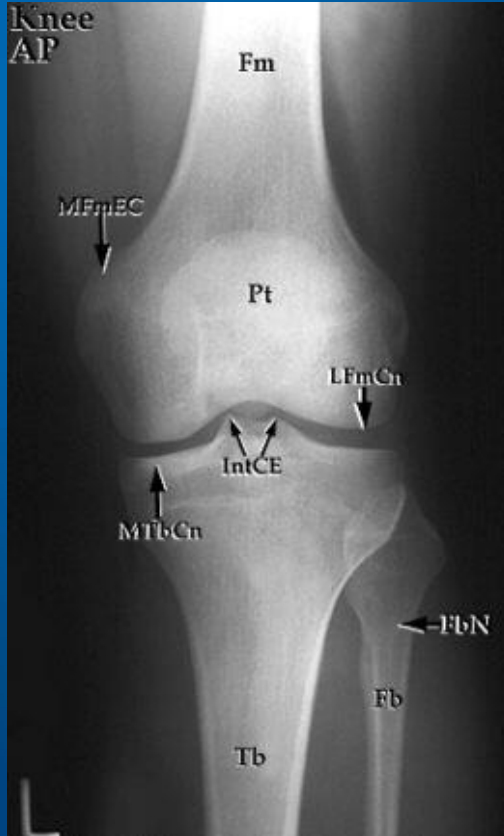
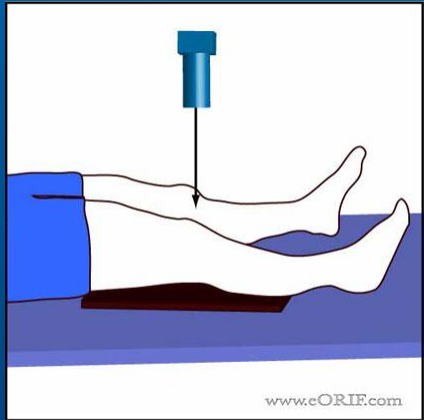
Knee AP vs PA

Tunnel view

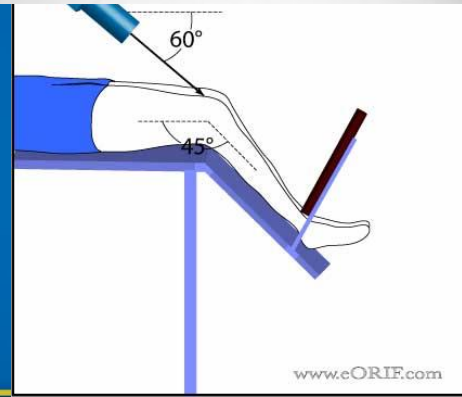
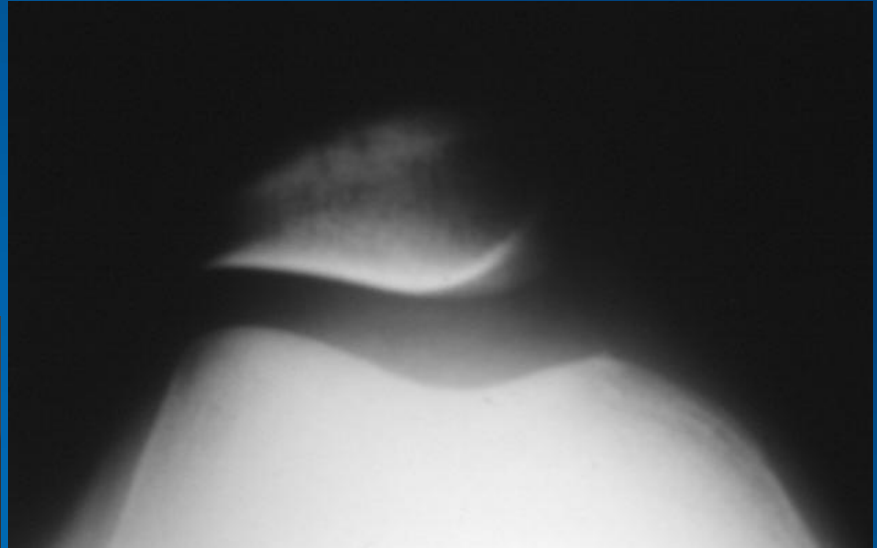
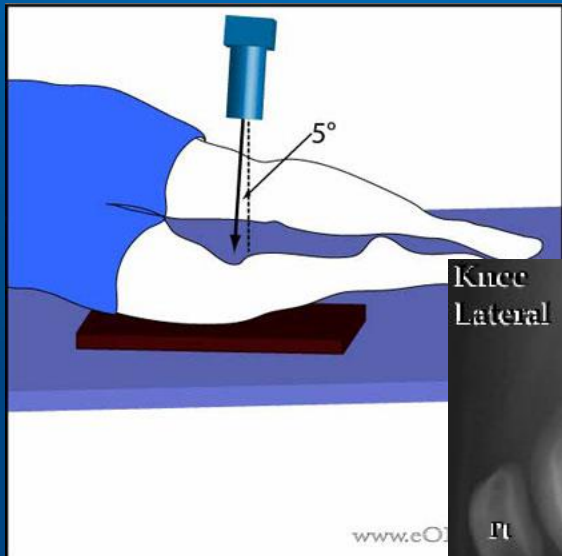
Arthritis views are
weightbearing



AP and Tunnel (Flexion PA/ Skier's / Notch)



Lateral and Merchant Views



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Severe OA



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Ankle/Foot

Why order plain films

- Trauma
 - Ottawa ankle and foot rules
- Chronic pain that isn't responding to conservative therapy

Why order MRI

- Pain that isn't responding to conservative therapy and more significant injury is suspected

Ankle/Foot

When to order plain films

- Immediately for any trauma that meets Ottawa Criteria or there is deformity, etc.
- After no improvement from a course of conservative treatment

When to order MRI

- After course of conservative treatment and a more significant injury is suspected

Ankle/Foot

What films to order – Ankle

- AP, lateral and mortise – on all patients
- Weight bearing AP and lateral – if OA suspected

What films to order – Foot

- AP, lateral and oblique
- Weight bearing AP and lateral – if OA is suspected

Ottawa Ankle Rules

An ankle x-ray series is only necessary if there is pain near the malleoli and any of these findings:

1. Inability to bear weight both immediately and in emergency department (four steps)
or
2. Bone tenderness at the posterior edge or tip of either malleolus

6 cm

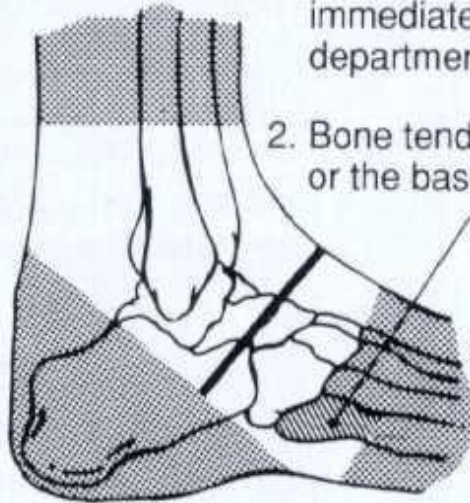
Lateral

Medial

Ottawa Foot Rules

A foot x-ray series is only necessary if there is pain in the midfoot and any of these findings:

1. Inability to bear weight both immediately and in emergency department (four steps)
or
2. Bone tenderness at the navicular or the base of the fifth metatarsal



Lateral



Medial

AP and Lateral Views of the Ankle



Mortise View of the Ankle



15- 20 degree medial rotation

Ankle

AP vs Mortise



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Foot

AP/lat/oblique

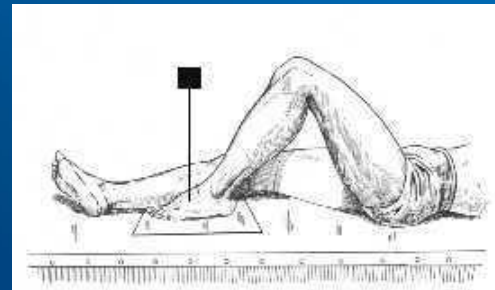
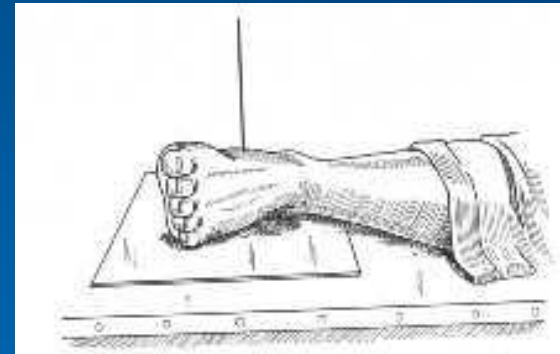


MEDICINE *of* THE HIGHEST ORDER

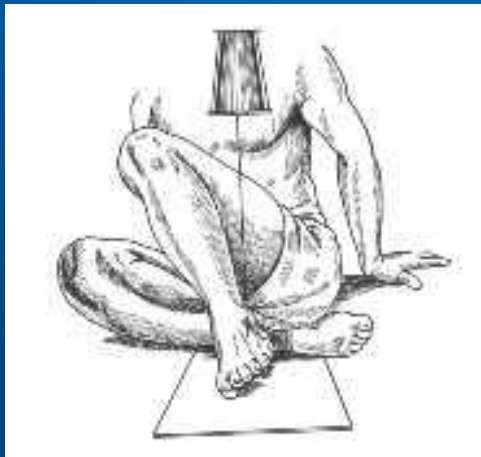


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AP and Lateral of the Foot



Oblique View of the Foot



www.e-radiography.net



Conclusion

Rapid review of the Why, When and What of MSK Radiology

Important to order the proper views

Important to get weight bearing views for lower extremity OA eval

Get x-ray films regularly

Use judgement on when to get advanced imaging

Important to review your own films to correlate with what you are seeing clinically

References

- Bernstein JB. *Musculoskeletal Medicine*, American Academy of Orthopaedic Surgeons, American Academy of Family Physicians, American Academy of Pediatrics 2003
- Armstrong, A and Hubbard M. *Essentials of Musculoskeletal Care 5th Edition*, American Academy of Orthopaedic Surgeons, American Academy of Pediatrics 2015
- Hoppenfeld S. *Physical Examination of the Spine & Extremities*, Appleton 1979.
- Novelline, Robert. *Squire's Fundamentals of Radiology, 6th Ed.* Harvard University Press, 2004
- Johnson, TR and Steinbach L. *Essentials of Musculoskeletal Imaging*, American Academy of Family Physicians, American Academy of Pediatrics 2003
- Hollenberg, G, Weinberg, E, and Myers, S. *Differential Diagnosis in MSK MRI*. Thieme, 2015.
- Jacobson, J. *Fundamentals of MSK Ultrasound, 3rd Ed.* Elsevier, 2017.