Medicine of the Highest Order
MSK Radiology – What to Order When, (and Why!)

Mark H. Mirabelli, MD, FAAFP

Associate Professor, Departments of Orthopaedics, Family Medicine and Physical Medicine and Rehabilitation

University of Rochester
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Faculty: URMC Sports Concussion Center, Hip and Knee Arthritis Clinic

Team Physician: St John Fisher College, Rochester Rattlers, Rochester Knighthawks, SUNY Geneseo

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
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.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

Wavelength: 1 μm, 100 nm, 10 nm, 1 nm, 100 pm, 10 pm, 1 pm, 100 fm

Photon energy: 1 eV, 10 eV, 100 eV, 1 keV, 10 keV, 100 keV, 1 MeV, 10 MeV

- Visible light
- Soft X-rays
- Gamma rays
- Ultraviolet light
- Hard X-rays

Applications:
- X-ray crystallography
- Mammography
- Medical CT
- Airport security

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
Cervical Views

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

www.e-radiography.net
Odontoid (open mouth) View

AP Open Mouth View

Joint between C1 & C2

Mandibular Teeth

OdP=Odontoid Process (dens)
IFC1=Inferior Facet of C1
SFC2=Superior Facet of C2

SpinPr=Spinous Process of C2
C2=Cervical Vertebra 2 (Axis)

www.e-radiography.net
Oblique Views

www.e-radiography.net
Osteophytes on lateral C-spine
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”
Scapular Y View
Scapular Y for dislocation
Clavicle

AP

Zanca view
Sternoclavicular Joint

Anterior 2/3

CT is best for SC dislocation or fracture

Serendipity view

Open Reduction of Posterior Sternoclavicular Joint Dislocation

The x-ray used is called Serendipity View.
- 40 degrees Cephalic tilt view

Diagnosis of a sternoclavicular dislocation can be done with a combination of clinical examination, x-rays and CT scans.
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
Lateral Oblique

www.ceessentials.net

www.auntminnie.com
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
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, 1\textsuperscript{st} and 2\textsuperscript{nd} rib trauma and sternal fracture (consider 3D recon), not more useful than plain film for ribs
- MRI of chest wall for rib stress fracture
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)
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

Pelvis AP

- IliCr
- SAIS
- SIJ
- Scrn
- InH
- Fm
- SpBpR
- SymP
- InTL
- ShT
- IPbR
- ShS
- >Troc
- <Troc
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
Severe OA
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
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
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

http://uwmsk.org/RadAnatomy.html

15-20 degree medial rotation
Ankle

AP vs Mortise

![AP vs Mortise](image)
Foot

AP/lat/oblique
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


