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Musculoskeletal MRI Protocols

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Last Review Date: May 2022

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***Note to MR technologists:**

Please feel free to contact Dr. Tang if you have any questions. Thank you.

General parameters (1.5 T magnets):

For all T1 sequences, please keep TE below 20 (between 10 and 15 if possible); TR 500-600.

For all T2 FS sequences, use equivalent of FSE/TSE. TE of mid to upper 50's is the most ideal for Siemens, 60-65 for GE, and ~ 60 for Toshiba.

It is important to have TE long enough for T2 weighting but not so long that it is signal starved.

For STIR, TI = ~ 135

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Routine Knee

- ax T2 FS
- sag PD
- sag T2 FS
- cor T1
- cor T2 FS

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- **Routine Pelvis**
  Whole pelvis: All pelvis cor and ax sequences need to cover from bone to bone to be adequate.

  - cor T1
  - cor STIR
  - ax T1
  - ax T2 FS

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- **Sacrum and coccyx**
  All pelvis cor and ax sequences need to cover from bone to bone to be adequate.

  - cor T1 - whole pelvis
  - cor STIR - whole pelvis
  - ax T1 - whole pelvis
  - ax T2 FS - whole pelvis
    Add:
  - small for sacrum and coccyx (FOV = 24 cm)
  - sag T1
  - sag T2 FS (if FS fails, do STIR)

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- **Sacroiliiac Joints**
  All pelvis cor and ax sequences need to cover from bone to bone to be adequate.

  - cor T1 - whole pelvis
  - cor STIR – whole pelvis
    Add:
  - small FOV for sacrum and SI joints (FOV = 22 cm)
  - oblique cor T1
  - oblique cor T2 FS
  - oblique cor T1 FS pre contrast
  - oblique cor T1 FS post contrast

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- **Routine Hip**
  - cor T1 (whole pelvis)
  - cor STIR (whole pelvis)
  - ax T2 FS – small FOV, hip of interest only (FOV = 18 to 24 cm)
  - cor T2 FS – small FOV, hip of interest only
  - sag T1 – small FOV, hip of interest only
  - sag T2 FS – small FOV, hip of interest only
  - oblique ax T2 FS – small FOV, hip of interest only

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- **Trauma Hip**

Reserved for ER/urgent care/prompt care patients to “rule out hip fracture”

****All sequences done for the whole pelvis*

- cor T1 (whole pelvis)
- cor STIR (whole pelvis)
- ax T1 (whole pelvis)
- ax T2 FS (whole pelvis)

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- **Routine Shoulder**
  - ax T1
  - ax T2 FS
  - oblique cor T1
  - oblique cor T2 FS
  - oblique sag T1
  - oblique sag T2 FS

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- **Routine Elbow**
  - ax T1
  - ax T2 FS
  - cor T1 (use the interepicondylar line to determine cor plane)
  - cor T2 FS
  - sag T1
  - sag T2 FS

For distal biceps tendon rupture evaluation, please start the exam as routine elbow, radial tuberosity has to be included in coverage.

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- **Routine Wrist**
  - ax T1
  - ax T2 FS
  - cor T1
  - cor T2 FS
  - cor 3D gradient echo
  - sag T1
  - sag T2 FS

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- **Routine Hand/Finger (generalized hand/finger pain)**
  - ax T1
  - ax T2 FS
  - cor T1
  - cor T2 FS
  - sag T1
  - sag T2 FS

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- **Routine Ankle/Hindfoot (not for osteomyelitis)**
    - ax T1
    - ax T2 FS
    - cor T1
    - cor T2 FS
    - sag T1
    - sag STIR (TI = 135 for 1.5 T)

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- **Routine Forefoot or midfoot (not for osteomyelitis)**
    - short axis T1
    - short axis T2 FS
    - cor T1 (cor to foot)
    - cor T2 FS
    - sag T1
    - sag STIR

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- **Long Bone Pain Protocol (lower extremity)**
    - ax T1 – unilateral
    - ax T2 FS – unilateral
    - cor T1 –unilateral
    - cor T2 FS or STIR – unilateral
    - sag T2 FS or STIR – unilateral

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- **Long Bone Pain Protocol (upper extremity)**

  - All unilateral sequences
    - ax T1
    - ax T2 FS
    - cor T1

    - cor T2 FS or STIR
    - sag T2 FS or STIR

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MR Chest Pectoralis Protocol

- Unilateral
- Coverage: proximal half of humerus, medial half of clavicle (including clavicular head) and unilateral half of the sternum

- ax T1
- ax T2 FS
- oblique cor T1 (align with pectoralis major muscle)
- oblique cor T2 FS
- sag T2 FS

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- **Routine Thumb: MCP Joint Collateral Ligaments or Thumb Pain**
    - ax T1
    - ax T2 FS
    - oblique cor T1 (cor to the MCP joint)
    - oblique cor T2 FS (cor to the MCP joint)
    - sag T1
    - sag T2 FS

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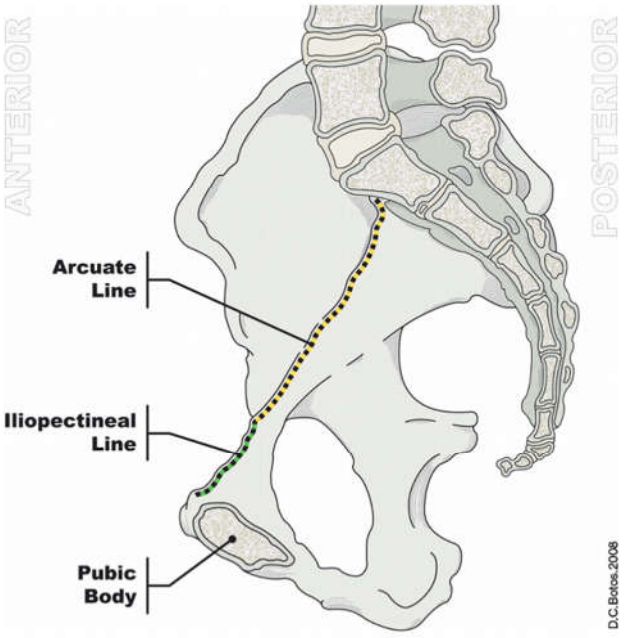
- **Sports Hernia/Athletic Pubalgia**

  - cor T1 – whole pelvis
  - cor STIR – whole pelvis

  - Small FOV to center at symphysis pubis
  - cor T1 FOV 28 – 32 cm
  - cor STIR FOV 28 – 32 cm
  - ax T2 FS FOV 28 cm
  - sag T2 FS FOV 20 cm
  - oblique ax T1 FOV 20 cm
  - oblique ax T2 FS FOV 20 cm

Note: oblique axial plane set up after sagittal sequence – plane approximately parallel to the arcuate line and iliopectineal line (see illustration on the next page). Do not hesitate to call MSK radiologist to check the sequences.



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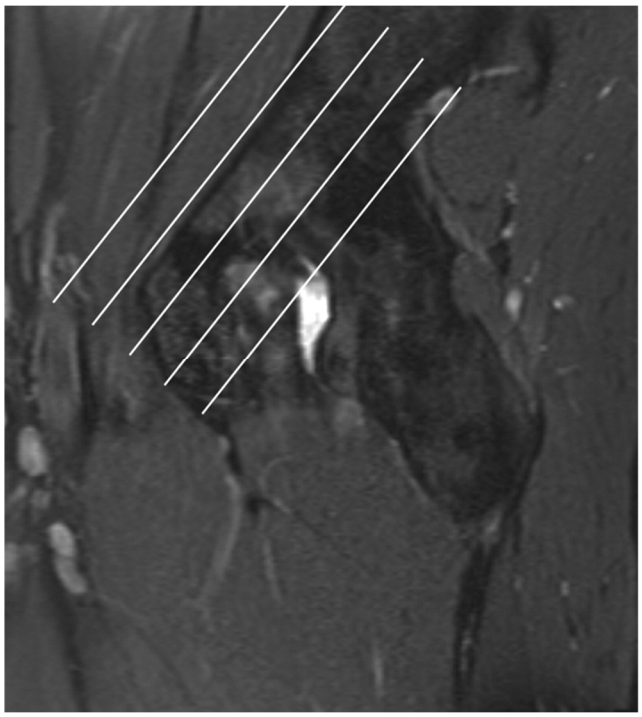

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- **Hands/Wrists for Arthritis/Inflammatory Arthropathy (e.g. rheumatoid arthritis, psoriatic arthritis)**

Extremity coil
FOV: cor 16-17 cm; ax 15 cm
Coverage: the entire wrist(s), MCP joints, to PIP joints. DIP can be excluded from the FOV to ensure optimal coverage of the wrist(s) and MCPs.
Key joints: wrist(s) and MCP joints; must have good signals on scouts from distal radius to PIPs.

- **Unilateral**

  - cor T1
  - cor T2 FS
  - ax T1
  - ax T2 FS
  - ax T1 FS pre contrast
  - ax T1 FS post contrast
  - cor T1 FS post contrast

- **Bilateral**

Image both sides together: line up palms and fingers, skin-to-skin leaving no space in between, tape together;
Mark the dorsum of the right hand with an MR compatible marker; Preacher position.

  - cor T1
  - cor T2 FS
  - ax T1
  - ax T2 FS
  - ax T1 FS pre contrast
  - ax T1 FS post contrast
  - cor T1 FS post contrast

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- **Hand/Finger Infection.**

  - If w/o contrast only
    - ax T1
    - ax T2 FS
    - cor T1
    - cor T2 FS
    - sag STIR

  - add the following if w/o and w/ contrast
    - ax T1 FS pre contrast

    - ax T1 FS post contrast
    - cor T1 FS post contrast
    - sag T1 FS post contrast

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- **Long bone soft tissue mass vs. cyst protocol (lower extremity)**

  - ax T1 – unilateral
  - ax T2 FS – unilateral

if lesion anterior or posterior	if lesion medial or lateral
sag T1 – unilateral	cor T1 – bilateral
sag T2 FS or STIR – unilateral	cor T2 FS or STIR – bilateral
ax T1 FS pre contrast	ax T1 FS pre contrast
ax T1 FS post contrast	ax T1 FS post contrast
sag T1 FS post contrast	cor T1 FS post

If the mass is thought to be a lipoma, no intravenous contrast is needed. Single plane T1 FS sequence should do – may need radiologist to check.

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- **Long bone soft tissue mass vs. cyst protocol (upper extremity)**

  - ax T1
  - ax T2 FS

  - if lesion anterior or posterior
  - sag T1
  - sag T2 FS or STIR
  - ax T1 FS pre contrast
  - ax T1 FS post contrast
  - sag T1 FS post contrast

  if lesion medial or lateral
  cor T1
  cor T2 FS or STIR
  ax T1 FS pre contrast
  ax T1 FS post contrast
  cor T1 FS post contrast

If the mass is thought to be a lipoma, no intravenous contrast is needed. Single plane T1 FS sequence should do – may need radiologist to check.

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- **Osteomyelitis forefoot or mid-foot (ulcer at tip of foot – distal ulcer)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

- ***If intravenous contrast cannot be administered due to severe renal insufficiency or allergy, please refer to routine protocol to scan the patient.***

- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Imaging planes:**
  - short axis – cross section of the metatarsals
  - cor – cor to the foot
  - sag – sag to the foot

  Imaging Sequences:
  - short axis T1
  - short axis T2 FS
  - sag T1
  - sag STIR
  - sag pre contrast T1 FS
  - sag post contrast T1 FS
  - short axis post contrast T1 FS
  - ***cor (to foot) T1 post contrast, no FS – for anatomic correlation

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- **Osteomyelitis forefoot or mid-foot (ulcer at dorsal or plantar foot)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

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- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Imaging planes:**
  - short axis – cross section of the metatarsals
  - cor – cor to the foot
  - sag – sag to the foot

  Imaging Sequences:
  - short axis T1
  - short axis T2 FS
  - sag T1
  - sag STIR
  - short axis pre contrast T1 FS

  - short axis post contrast T1 FS
  - sag post contrast T1 FS
  - ***cor (to foot) T1 post contrast, no FS – for anatomic correlation

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- **Osteomyelitis forefoot or mid-foot (ulcer at medial or lateral foot)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

- ***If intravenous contrast cannot be administered due to severe renal insufficiency or allergy, please refer to routine protocol to scan the patient.***

- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Imaging planes:**
  - short axis – cross section of the metatarsals
  - cor – cor to the foot
  - sag – sag to the foot

  Imaging Sequences:
  - short axis T1
  - short axis T2 FS
  - cor T1
  - cor T2 FS (if FS fails, cor STIR)
  - short axis pre contrast T1 FS
  - short axis post contrast T1 FS
  - cor post contrast T1 FS

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- **Osteomyelitis hindfoot or ankle (ulcer at posterior or anterior hindfoot/ankle)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

- ***If intravenous contrast cannot be administered due to severe renal insufficiency or allergy, please refer to routine protocol to scan the patient.***

- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Setup and Imaging Planes:**
- Setup as ankle MR:
- ax – axial to tibia/fibula
- cor – coronal distal tibial sigmoid notch
- sag – perpendicular to coronal plane

Imaging Sequences:
  - ax T1
  - ax T2 FS
  - sag T1
  - sag STIR
  - sag pre contrast T1 FS
  - sag post contrast T1 FS
  - ax post contrast T1 FS

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- **Osteomyelitis hindfoot or ankle (ulcer at dorsal or plantar hindfoot)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

- ***If intravenous contrast cannot be administered due to severe renal insufficiency or allergy, please refer to routine protocol to scan the patient.***

- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Setup and Imaging Planes:**
- Setup as ankle MR:
- ax – axial to tibia/fibula
- cor – coronal distal tibial sigmoid notch
- sag – perpendicular to coronal plane

Imaging Sequences:
  - cor T1
  - cor T2 FS
  - sag T1
  - sag STIR
  - sag pre contrast T1 FS
  - sag post contrast T1 FS
  - cor post contrast T1 FS

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- **Osteomyelitis hindfoot or ankle (ulcer at medial or lateral hindfoot/ankle)**
- The purpose of this seemingly complicated approach to osteomyelitis is to streamline the protocol so we can perform the exams on a consistent basis to obtain adequate diagnostic information with a reasonable amount of scanning time.

- For all osteomyelitis cases, post-contrast sequences are needed for evaluation of bone viability.

- ***If intravenous contrast cannot be administered due to severe renal insufficiency or allergy, please refer to routine protocol to scan the patient.***

- ***Ulcers should be marked before scanning is initiated.***

- ***Please acquire sequences in the order listed in the protocol.***

- If there is difficulty completing the last post-contrast sequence (e.g. pt. motion, pt. pain, scanner shut down etc.), there is no need to repeat the specific sequence.

- **Setup and Imaging Planes:**
- Setup as ankle MR:
- ax – axial to tibia/fibula
- cor – coronal distal tibial sigmoid notch
- sag – perpendicular to coronal plane

Imaging Sequences:
  - ax T1
  - ax T2 FS
  - cor T1
  - cor T2 FS (if FS fails, STIR)
  - cor pre contrast T1 FS
  - cor post contrast T1 FS
  - ax post contrast T1 FS

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- **Osteomyelitis bilateral foot**

  - When doing MR of both feet for osteomyelitis in one setting, please mark the dorsum of the RIGHT foot with two MR compatible markers.
  - Image one foot at a time.

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Osteomyelitis post-surgical stump (below the knee or above the knee amputation)

- ax T1
- ax STIR
- cor T1
- cor STIR
- cor T1 FS pre contrast
- cor T1 FS post contrast
- ax T1 FS post contrast
- sag T1 FS post contrast

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- **Other long bone osteomyelitis**
  - Please refer to ankle osteomyelitis for plane selection of pre and post contrast sequences.

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- **Osteomyelitis pelvis (sacrum and coccyx)**
  - ax T1 – whole pelvis
  - ax STIR – whole pelvis
  - cor T1 – whole pelvis
  - cor STIR – whole pelvis
  - sag T1 (sacrum and coccyx)
  - sag STIR (sacrum and coccyx)
  - sag T1 FS pre contrast (sacrum and coccyx)
  - sag T1 FS post contrast (sacrum and coccyx)
  - ax T1 FS post contrast (whole pelvis)

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- **Osteomyelitis pelvis (other than sacrum and coccyx)**
  - whole pelvis
    - ax T1
    - ax STIR
    - cor T1
    - cor STIR
    - ax T1 FS pre contrast
    - ax T1 FS post contrast
    - sag T1 FS post contrast (whole pelvis as well)

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MSK MR Arthrogram Protocols

- **Shoulder Arthrogram**

  - Add ABER T1 (no FS) if the patient is 40 y.o. or younger

  - ax T1
  - ax T2 FS
  - oblique cor T1 FS
  - oblique cor T2 FS
  - oblique sag T1
  - oblique sag T2 FS
  - *Is the patient 40 y.o. or younger? (ABER T1 no FS)*

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- **Wrist Arthrogram**
  - ax T1
  - ax T2 FS
  - cor T1 FS
  - cor T2 FS
  - cor 3D gradient echo
  - sag T1

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- **Elbow Arthrogram**
  - ax T1
  - ax T2 FS
  - cor T1 FS (use the interepicondylar line to determine cor plane)
  - cor T2 FS
  - sag T2 FS

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- **Hip Arthrogram**
  - cor T1 – whole pelvis
  - cor T2 FS – whole pelvis

  - small FOV – hip of interest
  - ax T1
  - ax T2 FS
  - cor T2 FS
  - oblique ax T1 (NO FS)
  - sag T1 FS
  - sag T2 FS

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- **Knee Arthrogram**

  - ax T2 FS
  - sag PD
  - sag T2 FS
  - sag T1 FS
  - cor T1
  - cor T2 FS