

The following guidelines will be useful in after-hour cases or when an MSK radiologist cannot be reached. It may be useful to solve simple questions that may arise or adjust our standard protocols when a specific history is given.

TISSUE WEIGHTING

- **T1:** assume non-fat sat, unless stated otherwise (TE very short roughly 12-25)
- **T2:** assume fat sat (there's never an indication to use T2 in MSK without fat sat)
- **PD:** Proton Density. (TE roughly 20-45)
 - Short TE sequences are more sensitive to detect tendon and ligament pathology. The use of fat saturation with PD is personal preference. PD may be too sensitive at times, which is why T2 is also useful. T2 is also useful to detect fluid in tendon sheaths (tenosynovitis). T2 can also help interpret findings on PD (true pathology vs artifact).
- **IR:** Inversion Recovery. Never obtain with a short TE.
 - May be used, but is less optimal due to poor delineation within joint spaces

ANATOMY

Tears can be subtle and therefore we need smallest FOV possible. On several of our routine protocols, we use fat sat PD to look at tendon/ligament/meniscus/labrum, marrow, and muscles/soft tissues. To evaluate marrow using PD, a longer TE needs to be used (TE above 40). ***IV GAD is never needed for marrow disease/lesion (unless a bony tumor extends into the soft tissues - which is VERY rare).***

- **Tendons/Ligaments:** Use PD and T2
- **Labrum:** Similar to ligaments and tendons. PD and T2 are most useful. IR is much less useful. T1 after intraarticular GAD (arthrogram) is the most sensitive sequence. In general, with PD, a shorter TE (closer to 20) is more helpful for evaluating the labrum because it is more sensitive.
- **Marrow/Bones:** Possible pathology: Bone tumor, Bony metastatic disease, fracture, osteomyelitis, contusion (bone bruise), AVN (avascular necrosis), bone infarct.
 - T1 and T2 are essential. IR is the most sensitive sequence for the detection of marrow pathology and should be performed in at least one plane.
 - Non-fat sat PD and GRE is less useful to detect marrow pathology.
- **Physeal injuries:** pediatric, GRE is helpful

PELVIS / HIPS

- Small FOV PD fat sat in 3 planes is used to evaluate the labrum and cartilage.
- The entire bony pelvis needs to be imaged if the history is any of the following: Bone tumor, Bony metastatic disease, fracture, osteomyelitis, contusion (bone bruise), AVN (avascular necrosis), arthritis, Sacroiliac joint (SI joint) disease, bone infarct. Scan the entire sacrum and SI joints on coronals and axials. Also include the entire pubic symphysis on coronals and axials.
- If you are imaging multiple body parts along with an "MR HIP" in an older patient (>70), you may need to shorten the overall scan time. In these cases, it may be necessary change the hip protocol to a pelvis using the following 4 sequences: Coronal & Axial whole pelvis T1, Cor IR, Ax fat sat T2. (It could be argued that a hip protocol is not indicated in patients over 70...the ordering doctor is usually not looking for

cartilage loss or labral tears in these patients, and therefore the 3-plane small FOV fat sat PD's may not be necessary.)

- On the Axial whole pelvis PD sequence for standard hip protocol, keep the TE long (>40).

FINGERS

- Always scan the adjacent finger or 2 (this allows us to compare normal with abnormal).
- Use as thin of slices as possible.
- Smallest FOV possible
- On occasion, we'll need very thin cuts. For example: volar plate tear, extensor hood tear, flexor, or extensor tendon insertion tear. In these cases, it may be helpful to do a 3D volume acquisition using Gradient Echo and reformat the images at 1 mm in the SAGITTAL plane.
- For UCL tears (ulnar collateral ligament) of the thumb, scan relative to the thumbnail (coronal would be in the plane of the thumbnail, sag & axial would be perpendicular).

STERNOCLAVICULAR JOINTS

- Scan both right and left sternoclavicular joints.
- Give IV GAD if there is a question of infection
- Use T1 and IR/T2 in all 3 planes.
- PD's not necessary
- Small FOV
- Scanning prone may help limit respiratory motion artifact

FOOT / FOREFOOT

- "Morton's Neuroma" needs IV GAD (many are ordered without).
- On occasion, thin cuts are necessary. For example: plantar plate tear (at MTP joints), "turf toe", extensor hood tear, flexor or extensor tendon insertion tear. In these cases, it may be helpful to do a 3D volume acquisition using Gradient Echo and reformat the images at 1 mm in the SAGITTAL plane (ask Charre Smith or Matt Hodges, they seem to be the experts using gradient echo). Coronal plane reformats would also be helpful if possible.

KNEE

- If there is high signal in the marrow on T2 or fat sat PD, be quick to add a coronal T1.
- Insufficiency fractures and stress fractures are common in the knee (no history of fracture would be given).
- Add a coronal T1 if there is a history of trauma or possible fracture.

ELBOW

- If the word "biceps" is anywhere in the history, make sure you scan distally to include the radial tuberosity on the axial images (where the biceps tendon inserts). Often there will be significant fluid signal (bright T2) in the soft tissues above the elbow, and the technologist will therefore move the imaged portion of the elbow proximally, leaving out the radial tuberosity.
- All routine elbows should include the radial tuberosity.

WRIST

- Add a coronal T1 if the history contains any of the following words: Kienbock's, osteonecrosis, fracture, or scaphoid.

SHOULDER

- Attempt to externally rotate the humerus (palm up). If the patient can't tolerate external rotation, try to rotate some. Every little bit counts.
- Internal rotation severely limits evaluation of the supraspinatus tendon for a cuff tear (which is the most common injury on a shoulder MR).
- In the axial plane, the bicipital groove should be at about the 12 o'clock position (or lateral to 12).

PATHOLOGY

- **Cartilage:** Fat sat T2 is best. Fat sat PD can be used, although some believe it is not as sensitive (may not show milder or smaller areas of cartilage damage). IR is not quite as good as T2's because of worse resolution.
 - With metal artifact or suboptimal FS, IR is commonly obtained. On occasion, a T2 is acquired before artifact was known to be present. If this is the case, send the T2's also so the cartilage can be better evaluated (knees & shoulders). Otherwise, no need to run an extra T2 if the IR was already obtained.
 - Need smaller FOV
- **Bony tumor, lesion, metastatic disease, bony anything NEVER needs IV GAD**
 - These bony lesions ALWAYS require X-rays, however. EVERY bone tumor imaged with MRI needs an accompanying XR (or CT) or else the MRI cannot be read. If there isn't an XR in the patient's jacket (or previous CT), we need to get it from the ordering doctor's office. If they don't have one, call the radiologist to get an order for an XR. X-rays tell us how aggressive (likelihood of being malignant) a lesion is.
- **Soft tissue tumors:** same principles apply as discussed with Marrow
 - T1 and T2 are essential. IR is the most sensitive and should be obtained in at least one plane (preferably axial)
 - PD is less useful and should not be obtained
 - Give IV GAD (this is debatable, but most rads in the MSK section like IV gad with soft tissue tumors).
 - Use a skin marker over the suspected mass
- **Muscle disease:** muscle tear, muscle strain, trauma, myositis, compartment syndrome, fasciitis, tumors, denervation, infarction. Same principles as with soft tissue tumors and marrow
 - T1 and T2 are essential. IR is the most sensitive and should be obtained in at least the plane, preferably the AXIAL plane
 - As with bone disease, PD is less useful and probably should be avoided. Non-FS PD are useless to detect acute muscle pathology
- **Infection:** cellulitis, osteomyelitis, abscess. Same principles as marrow, soft tissue tumors, and muscle disease.
 - T1 and T2 are essential. IR is the most sensitive and should be obtained in at least one plane
 - PD is less useful and should not be obtained
 - IV GAD is not necessary to diagnose osteomyelitis. IV GAD is used to evaluate for an abscess or fistula in the soft tissues (see "IV GAD" section below). Without GAD we can still diagnose osteomyelitis, but evaluation for a soft tissue abscess is limited.
 - If there is a skin ulcer, use a skin marker. It is also very helpful if you tell the radiologist the location of the ulcer using the notes. Osteomyelitis usually occurs next to skin ulcers, so this information tells the radiologist where to look. Use smallest FOV possible if an ulcer is present.
- **Trauma:** If there is a history of trauma or possible fracture, a T1 should be added. Most protocols already have a T1. Add a T1 for KNEES, WRISTS, and FINGERS in the coronal plane. Adding a SAG T1 to our standard ankle protocol would be very helpful in trauma/fracture cases.

IV CONTRAST

Delayed contrast imaging allows for optimal tissue enhancement. This is accomplished by performing a standard T2 sequence immediately after injection to provide 3+ minutes of uptake. IR may be used, but is less useful due to possible artifacts with the change in TI time.

- Determine solid tumor vs. cyst in the soft tissues. If a lesion is bright on T2, it can be a solid mass or a cyst. IV GAD will separate the two (cysts don't enhance, solid masses do).
- Delineate joint fluid vs. synovium (arthritis).
- Infection cases to evaluate for the presence of an abscess in the soft tissues. With soft tissue infections, inflammation (phlegmon) and abscesses are bright on T2. With IV GAD, inflammation will enhance, abscesses will not enhance centrally (same principle as cyst vs solid tumor).
- Soft tissue tumors.

METAL ARTIFACT

Add an IR in at least one plane if the fat sat is suboptimal on T2 or PD. It would be preferable to add an IR anywhere a fat sat T2 or fat sat PD is used. In general, if there is poor fat sat, obtain an IR. Obtaining a non-FS T2 is not at all helpful.

ARTHROGRAMS

Only one plane using T2 is included on our protocol. If you see something abnormal outside the joint space on T2, be quick to add another T2 sequence in the axial plane after all the routine sequences are acquired (shoulders, wrists, elbows, knees).

- If there is metal artifact and you need to run an IR, you still need to obtain a fat sat T2. The GAD will make the joint fluid low in signal with IR.
- If the history is "fracture", add a non-FS T1. If there seems to be odd looking marrow, add a non-FS T1.
- On shoulders, obtain the ABER sequence last. This is the least helpful sequence
- Our basic protocol for MR arthrograms is 3 plane fat sat T1

HISTORY

Please provide as much accurate and pertinent information as possible. The tech can obtain valuable information for the radiologist. Please make sure the information put in Synapse is accurate, because it can significantly change the diagnosis (and ultimately the treatment).

Important questions to ask the patient and document in Synapse:

- Is there a history of surgery?
- Is there a history of cancer?