CDI QUALITY INSTITUTE

Provider Led Entity

CDI Quality Institute PLE
Hip Pain AUC
2020 update

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Appropriateness of advanced imaging procedures* in patients with hip pain and the following clinical presentations or diagnoses:

*Including MRI, CT, MR arthrography, CT arthrography, bone scan, SPECT and PET

Abbreviation list:

AAOS	American Academy of Orthopaedic Surgeons
ACR	American College of Radiology
ANZHFR	Australian and New Zealand Hip Fracture Registry
APTA	American Physical Therapy Association
AVN	Avascular necrosis
BOA	British Orthopaedic Association
CT	Computed tomography
CTA	Computed tomography arthrogram
DOD	Department of Defense
EULAR	European League Against Rheumatism
FAI	Femoral acetabular impingement
MDCT	Multidetector computed tomography
MRA	Magnetic resonance arthrogram
MRI	Magnetic resonance imaging
NICE	National Institute for Health and Care Excellence
OA	Osteoarthritis
ON	Osteonecrosis
PD	Proton density
PET	Positron emission tomography
PLE	Provider Led Entity
SIGN	Scottish Intercollegiate Guidelines Network
SPECT	Single-photon emission computerized tomography
VA	Department of Veterans Affairs

Appropriate Use Criteria: How to Use this Document

The CDI Quality Institute follows the recommendation framework defined by the Appraisal of Guidelines for Research & Evaluation (AGREE II), AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) and a modified version of the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) to evaluate the strength of recommendations concerning advanced imaging. Considerations used to determine a recommendation are listed below.

Primary recommendation (green): A strong recommendation for initial imaging for this presentation; there is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): A conditional recommendation for imaging; the desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. The individual patient's circumstances, preferences, and values should be considered on a case-by-case basis. This may include: contraindication to the primary recommendation, specific clinical circumstances that require use of the alternative recommendation, or the primary recommendation has results that are inconclusive or incongruent with the patient's clinical diagnosis. Case-by-case indications to consider have been noted in brackets when appropriate.

Recommendation against imaging (red): The undesirable effects of imaging outweigh any desirable effects. Additionally, the recommendation may be impractical or not feasible in the targeted population and/or practice setting(s).

Hip Pain AUC Summary:

- In most instances, **MRI (without contrast)** is the initial advanced imaging procedure of choice for hip pain. It is indicated for suspected labral or tendon tears, bursitis, and suspected occult or stress fractures not identified on initial radiographs.
    - The addition of MRI contrast can be helpful for imaging indeterminate or aggressive bone lesions noted on radiographs, or to evaluate equivocal or indeterminate findings on recent noncontrast MRI when osteomyelitis or osteonecrosis is suspected.
    - MRI is otherwise generally indicated for patients whose pain and dysfunction persists after four to six weeks of conservative therapy and who have normal or nondiagnostic radiographs.
- **MR arthrography** may increase the sensitivity of MRI for labral tears. It can also be useful in patients with unexplained pain that is unresponsive to conservative therapy. **CT arthrography** is generally reserved for patients unable to undergo MRI.
- **CT (without contrast)** is generally recommended for further evaluation of equivocal or indeterminate findings on recent noncontrast MRI or for patients who are unable to undergo MRI. It can also be used in selected scenarios when surgical planning or evaluation of healing are necessary, or when the patient has increased or equivocal uptake on a previously performed bone scan.
- **Conventional radiographs** are commonly used for the initial evaluation of a suspected fracture, osteoarthritis, or other unexplained pain of suspected hip etiology.
- **Ultrasound**, while not defined as an advanced imaging modality, can be useful to assess suspected periarticular tendinopathy, tendon tears, and/or bursitis, particularly when MRI is not available. Its use should be limited to dedicated and trained experts.
- **Bone scan** can be useful for patients with suspected stress or occult fracture, osteonecrosis, or osteomyelitis for evaluating recent findings on noncontrast MRI, or when MRI is not available. It is also indicated whenever a possible metastatic lesion is suspected. The addition of SPECT or SPECT/CT, when available, may increase the specificity of a bone scan.

Hip, buttock or thigh pain with suspected stress (fatigue), fragility (insufficiency), or occult fracture of the hip and normal or indeterminate radiographs:

- Green – **MRI hip without IV contrast**
- Yellow – **CT hip without IV contrast**
  [further evaluate equivocal/indeterminate findings on recent MRI without IV contrast; or patient unable to undergo MRI; or patient has increased or equivocal uptake on previous bone scan; or evaluation of healing is necessary]
- Yellow – **Bone scan** (**bone scan/SPECT** or **bone scan/SPECT/CT** or **planar bone scan**)
  [further evaluate equivocal/indeterminate findings on recent MRI without IV contrast; or patient unable to undergo MRI]
- Red – **MRI hip with IV contrast**; **MRI hip without and with IV contrast**; **MR arthrography**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **CT arthrography**; **PET**; **Multiphase bone scan**

Level of Evidence: MRI: moderate; CT, bone scan, SPECT: low; MR with IV contrast, MR arthrography, CT arthrography, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:

Overview

Although insensitive, radiographs should be the initial imaging study of choice for suspected insufficiency or fatigue fractures in the pelvis or hip (Bencardino et al [*ACR*] 2017*). However, it is not advisable to wait 10–14 days for repeat radiographs, as some stress fractures of the hip are high risk, and delays in diagnosis may increase the risk of nonunion, delayed union, displacement, and/or avascular necrosis (Bencardino et al [*ACR*] 2017*; PLE expert panel consensus opinion). Therefore, MRI is the investigation of choice for suspected hip fracture that is not apparent on initial radiographs (*NICE* 2017). Other imaging modalities used to assist in the early detection of occult hip fractures may include CT or radionuclide scan (*NICE* 2017; Bussieres et al 2007). The type of secondary imaging modality is often determined by considerations of access, particularly outside normal working hours, and radiological expertise available (*NICE* 2017).

MRI

At least 90% of proximal femoral fractures will be identified on radiographs, and therefore, MRI without IV contrast is reserved for second-line imaging in instances of negative radiographs with continued clinical suspicion for fracture rather than as a first-line modality (Ross et al [*ACR*] 2019). Moderate evidence supports MRI as the advanced imaging exam of choice for diagnosis of presumed hip fracture not apparent on initial radiographs or when there is doubt regarding the diagnosis (*AAOS* 2014, moderate recommendation; *ANZHFR* 2014, consensus-based recommendation; *NICE* 2017; *SIGN* 2009, grade D recommendation; Ross et al [*ACR*] 2019; Bencardino et al [*ACR*] 2017*). MRI is usually considered the reference standard for this scenario, as numerous studies have found MRI to have the

highest accuracy (100% sensitivity and 93%-100% specificity), depending on experience and skill of radiologist interpreting the images (*NICE* 2017). In addition to increased sensitivity for fracture detection, MRI can be useful for characterizing fracture morphology (Ross et al [*ACR*] 2019). With the diagnostic accuracy of noncontrast MRI approaching 100%, there has been little need to explore the addition of IV gadolinium contrast solely for the purposes of fracture detection (Ross et al [*ACR*] 2019).

CT

If MRI is not available within 24 hours, or is contraindicated, a CT should be considered (*ANZHFR* 2014, consensus-based recommendation; *NICE* 2017; Bencardino et al [*ACR*] 2017*). Due to the quality of existing literature, as well as potential harm with radiation exposure, CT is not recommended for initial evaluation of occult hip fracture (*AAOS* 2014). While CT is not typically used as a first or second line modality because of its decreased sensitivity, it may play an adjunctive role when other modalities are equivocal (Bencardino et al [*ACR*] 2017*).

Bone scan

In current practice, the role of bone scans as a secondary line of imaging in patients with contraindications to MRI has largely been usurped by CT (Ross et al [*ACR*] 2019). However, if MRI is not available or not feasible, a bone scan can be performed (*SIGN* 2009, grade D recommendation), as bone scanning is very sensitive for stress reactions. Bone scan is nonspecific, and supplemental imaging may therefore be required in areas of abnormal uptake to obtain a diagnosis and avoid false positives (Bencardino et al [*ACR*] 2017*). Additionally, in elderly and osteoporotic patients, abnormalities may not show up on bone scan for several days following injury (Bencardino et al [*ACR*] 2017*). When bone scan is used to evaluate for an occult fracture of the hip, SPECT technique should be used, if available, as it increases the specificity of the exam (Bencardino et al [*ACR*] 2017*; PLE expert panel consensus opinion).

*This guideline did not pass the AGREE II cutoff, but was included because of its direct relevance to the stress fracture clinical scenario.

<u>Clinical notes:</u>

- "Hip" insufficiency or fragility fractures refer to fractures of the proximal femur, acetabulum, and ischiopubic ring (PLE expert panel consensus opinion).
- Clinical features of stress fractures include exertional anterior hip pain, especially after an increase in training regimen, chronic repetitive overloads (typically in athletes) or reduced mechanical bone properties (athletic amenorrhea, osteoporosis, corticosterioid use) (Bussières et al 2007).
- Clinical features of an osteoporotic femoral neck fracture include age > 65 years, onset before or after a fall, inability to walk, and display of shortening and external rotation (Bussières et al 2007).
- A high index of clinical suspicion of hip fracture is required in patients with a typical history – usually hip pain following trauma – as typical features, such as the inability to bear weight or a shortened, abducted and externally rotated leg may be absent (*NICE* 2017; Bussières et al 2007).
- Conventional radiography is the initial study of choice for patients with suspected insufficiency, stress or osteoporotic fracture of the hip (Bencardino et al [*ACR*] 2017; *BOA* 2014; *SIGN* 2009); however, the diagnosis of hip fracture is easily missed and, in a small minority of patients, the fracture may not be apparent on conventional radiographs (*NICE* 2017; *SIGN* 2009).
- In patients with insufficiency fractures of the hip, consider dual-energy x-ray absorptiometry (DEXA) to assess for osteoporosis (Bussières et al 2007).

Imaging notes:

- Cross-sectional imaging of the hip for insufficiency fracture should also include the sacrum and pelvis. Sacral fractures commonly occur in this population and can also result in groin/hip pain (Bencardino et al [*ACR*] 2017; PLE expert panel consensus opinion).
- MRI for suspected fracture should include T1 and fluid sensitive sequences (STIR or T2 fat saturation) (PLE expert panel consensus opinion).
- Limited MR protocols (T1 coronal and STIR coronal images of the pelvis/hips) can be used in emergent settings to exclude a hip fracture (PLE expert panel consensus opinion).
- When CT is used, the "as low as reasonably achievable radiation dose" principle should be adhered to (e.g., Mayo-Smith et al 2014).

Evidence update (2016-present):

Haj-Mirzaian et al (2020), in a systematic review and meta-analysis, estimated the frequency of radiographically occult hip fracture in elderly patients and determined the diagnostic performance of CT and bone scanning by using MRI as the reference standard. Studies were included if patients were clinically suspected to have hip fracture but there was no radiographic evidence of surgical hip fracture (including absence of any definite fracture or only presence of isolated greater trochanter [GT] fracture). The pooled rate of occult fracture, diagnostic performance of CT and bone scanning, and strength of evidence (SOE) were assessed. A total of thirty-five studies were identified (n = 2992 patients; mean age, 76.8 years). The frequency of occult fracture was 39% (1110 of 2835 patients; 95% confidence interval [CI]: 35%-43%) in studies of patients with no definite radiographic fracture and 92% (134 of 157 patients; 95% CI: 83%-98%) in studies of patients with radiographic evidence of isolated GT fracture (moderate SOE). CT and bone scanning yielded comparable diagnostic performance in detecting radiographically occult hip fracture (P = .67), with a sensitivity of 79% and 87%, respectively (low SOE). The authors conclude that elderly patients with acute hip pain and negative or equivocal findings on radiography have a high frequency of occult hip fractures. Therefore, the performance of advanced imaging (preferably MRI) may be clinically appropriate in all such patients (high level of evidence).

Wilson et al (2020), in a systematic review and meta-analysis, evaluated the diagnostic accuracy of limited MRI protocols for detecting radiographically occult proximal femoral fractures. Articles of radiographically occult proximal femoral fractures compared with multiparametric MRI with or without clinical outcome as the reference standard were included. Eleven studies with 938 patients and 247 proximal femoral fractures met inclusion criteria, and five of these studies were included in the meta-analysis. The pooled and weighted summary sensitivity and specificity and the area under the summary ROC curve for limited MRI protocols in detecting radiographically occult hip fractures were 99% (95% CI, 91–100%), 99% (95% CI, 97–100%), and 1 (95% CI, 0.99–1), respectively. The aggregate sensitivity and specificity values for a single-plane T1-weighted sequence only, STIR sequence only, T1-weighted and STIR sequences, and T2-weighted sequence only were as follows: 97% (89/92) and 100% (76/76), 99% (126/127) and 99% (865/873), 100% (118/118) and 99% (867/874), and 86% (51/59) and 97% (137/141), respectively. Sensitivity was 100% (58/58) when images were acquired on 3-T scanners only and 99% (284/288) when interpreted only by certified radiologists. The mean scanning time for limited MRI protocols was less than 5 minutes. The authors conclude that limited protocols can be used as a standard of care in these patients; a protocol of coronal T1-weighted and STIR sequences is 100% sensitive (moderate level of evidence).

Hip pain with suspected labral tear (with or without femoral acetabular impingement syndrome):

- **Green** – **MRI hip without IV contrast**
- **Green** – **MR arthrography hip**
- **Yellow** – **CT arthrography hip**
  [patient unable to undergo MRI]
- **Yellow** – **CT bilateral hips without IV contrast (with 3D reformations)**
  [pre-surgical planning is necessary]
- **Red** – **MRI hip with IV contrast**; **MRI without and with IV contrast**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **bone scan**; **SPECT**; **PET**

Level of Evidence: MRI, MR arthrography: moderate; CT, CT arthrography: low; bone scan, SPECT, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences: Femoral acetabular impingement (FAI) is a clinical syndrome generally seen in younger patients. It is rare for patients over age 65 to present with primary FAI, and therefore MR arthrography may not be appropriate in this group (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Initial advanced imaging investigations for labral tear and femoroacetabular impingement include unenhanced MRI and MRI arthrography (MRA). MRI has a reported high accuracy (89%-95%) in detecting labral tears (Enseki et al [*APTA*] 2014), and the use of high-resolution 3T MRI may improve visualization and obviate the need for intra-articular contrast (Mintz et al [*ACR*] 2016). Currently, the most common imaging procedure used to confirm the diagnosis of intra-articular pathology, such as labral tears or chondral lesions, is MR arthrography (Enseki et al [*APTA*] 2014). Compared to the gold standard of arthroscopic visual inspection, MRA has a reported sensitivity of 71%-100% and a reported specificity of 44%-71% in detecting labral tears (Enseki et al [*APTA*] 2014). It has also been reported to have a high accuracy (90%) in patients undergoing diagnostic arthroscopy for labral resection (Bussières et al 2007, grade D recommendation). CT arthrography can be useful for patients who cannot undergo MR imaging (PLE expert panel consensus opinion). CT may be used to determine the osseous architecture of the hip, and thus provides additional information for purposes of surgical planning (Enseki et al [*APTA*] 2014). If CT is obtained for surgical planning, the examination should include 3D reformations (PLE expert panel consensus opinion).

Clinical notes:

- Clinical features of labral tear and femoroacetabular impingement typically include “knife sharp” groin pain, painful giving way syndrome, locking, painful clunk or snapping hip, and painful apprehension and impingement tests (Bussières et al 2007).
- Conventional radiographs are the first imaging study in the evaluation of hip pain (Enseki et al [*APTA*] 2014).
- An anteroposterior radiograph of the pelvis and a lateral femoral neck view of the symptomatic hip should initially be performed to obtain an overview of the hips, to identify cam or pincer morphologies, and to identify other causes of hip pain. Where further assessment of hip

morphology and associated cartilage and labral lesions is desired, cross-sectional imaging is appropriate (Griffin et al 2016).

- Radiographic evidence of femoroacetabular impingement is common in active patients with hip complaints. Descriptive studies based on retrospective observations report that osseous abnormalities were present in up to 87% of patients presenting with labral tears (Enseki et al [*APTA*] 2014).
- Many *asymptomatic* patients have imaging evidence of cam and pincer FAI. Frank et al, in a 2015 systematic review of 2114 asymptomatic subjects assessed by MR or x-ray, found that 37% had cam FAI measurements and 67% had pincer FAI measurements. Of those undergoing MR, 68% had labral tears (Frank et al. 2015). *Note: The PLE expert panel thought that this paper was important. It underscores the concept that FAI is a clinical syndrome and that FAI morphologic features are only important in young patients presenting with the appropriate symptoms and clinical signs. Conversely, the presence of these features in asymptomatic patients does not invalidate their importance in the treatment of patients with femoral acetabular impingement syndrome.*
- FAI is a clinical syndrome generally seen in younger patients. It is rare for patients over 65 to present with primary FAI and MR arthrography may not be appropriate in this group (PLE expert panel consensus opinion).
- Chondral lesions are an important component of the pathology related to FAI and labral tears, with a strong correlation between chondral loss/delamination adjacent to labral tears in patients with cam FAI (Enseki et al. [*APTA*] 2014). The integrity of the articular cartilage is of paramount importance to the health of the hip (PLE expert panel consensus opinion).
- Morphology is better characterized on cross-section imaging, either CT or MRI. This is particularly important if surgery is being considered (Griffin et al 2016).
- Intra-articular hip injection can be performed with local anesthetic, with or without cortisone, to determine if the patient's symptoms are arising from the hip. Local anesthetic can be injected at the time of MR arthrography or CT arthrography if indicated (Mintz et al [*ACR*] 2016; Enseki et al [*APTA*] 2014).

<u>Imaging notes:</u>

- Cartilage specific sequences (PD, PD fat saturation or T2 fat saturation) should be part of any MRI or MRA examination of the hip in patients being evaluated for an acetabular tear or femoral acetabular impingement (PLE expert panel consensus opinion).
- The presence of subchondral marrow edema and subchondral cyst has an adverse effect on the prognosis of patients with FAI. Any MRI or MRA obtained for labral tears or femoral acetabular impingement should include a fluid-sensitive sequence (STIR or T2 fat saturation) in the coronal plane (PLE expert panel consensus opinion).

<u>Evidence update (2014-present):</u>

Saied et al (2019), in a retrospective study, assessed the reliability of direct MR arthrography (MRA) and conventional MRI in diagnosing labral lesions in patients with symptoms of femoroacetabular impingement (FAI). Imaging and surgical data were collected from 5 high-volume centers, with a total of 490 patients included. Preoperative imaging findings were compared with actual surgical findings regarding labral condition in order to assess the effectiveness of MRI and MRA. Results found accuracy to be slightly higher for MRI (71.4%) compared to MRA (68.2%), while MRA had higher sensitivity (74.4%,) compared to MRI (66.9%). The authors conclude that these results indicate that MRI and MRA may both be useful for the diagnosis of acetabular labral lesions (low level of evidence).

Neumann et al (2019), in a retrospective study, sought to validate *scoring hip osteoarthritis with MRI* (*SHOMRI*) gradings in preoperative hip MRI with intra-arthroscopic evaluation of intraarticular hip abnormalities. Preoperative non-arthrographic 3.0-T MRIs of 40 hips in 39 patients with femoroacetabular impingement (FAI) syndrome, refractory to conservative measures, that underwent hip arthroscopy were retrospectively assessed by two radiologists for chondrolabral abnormalities and compared with intra-arthroscopic findings as the reference standard. Arthroscopically accessible regions were compared with the corresponding SHOMRI subregions and assessed for presence and grade of cartilaginous pathologies in the acetabulum and femoral head. 58.8% of surgical cases showed chondral defects. SHOMRI scoring showed a sensitivity of 95.7% and specificity of 84.8% in detecting cartilage lesions. Labral tears were present in all cases and the MR readers identified 92.5% correctly. ICC showed good interobserver agreement of 86.3% (95% CI 80.0-90.6%). The authors conclude that SHOMRI grading of the hip proves to be a reliable and precise method to assess chondrolabral hip joint abnormalities (low level of evidence).

Yan et al (2018) compared femoroacetabular anatomy on 3DCT and 3D MRI in 25 consecutive patients presenting for preoperative evaluation of hip pain. All patients received an MR arthrogram on 1.5T or 3T scanners and a CT scan as part of pre-surgical assessment; all had a final diagnosis of either hip dysplasia or FAI. Two blinded readers (R1, R2) performed quantitative angular measurements on 3DCT and 3DMR. 3DMR and 3DCT of the hips were qualitatively and independently evaluated by a radiologist (R3), surgeon (R4), and fellow (R5). The intraclass correlation coefficient (ICC) was good to excellent for all measurements between R1 and R2 (ICC:0.60-0.98). The quality of reconstructions from both 3DCT and 3DMR did not significantly affect diagnostic assessment of the readers, with good to excellent intermodality agreements (kappa: 0.62–0.93). For all readers, qualitative diagnosis based on both 3DCT and 3DMR reconstructions showed good to excellent agreements to final diagnosis (average prevalence-adjusted bias-adjusted kappa: 0.80 on CT and 0.72 on MR). The authors conclude that 3D MR offers similar qualitative and quantitative analysis as 3D CT in painful hips (low level of evidence).

Annabell et al (2018) analyzed the sensitivity and specificity of non-contrast 3T MRI in identifying intra-articular hip pathology in 68 patients (71 hips). Two MSK radiologists reported data independently, and all arthroscopies were performed by a single surgeon. Accuracy of MRI for ligamentum teres tears, labral damage, and chondral rim lesions was 85.92% for each instance. Sensitivity/specificity of MRI was 91.2%/47% for ligamentum teres tears, 90.2%/70% for labral damage, and 91.4%/61.5% for chondral rim lesions. MRI findings most consistent with labral tears include presence of linear high signal traversing the articular surface into the labrum, presence of intra-labral fluid signal, and loss of homogenous low signal triangular morphology. The authors conclude that tears and synovitis of the ligamentum teres as potential sources of hip pain can be accurately identified on conventional non-arthrographic MRI. However, MRI has poor specificity and negative predictive value, and thus, a negative MRI result may warrant further investigation (low level of evidence).

Grace et al (2018) utilized the *Scoring Hip Osteoarthritis with Magnetic Resonance Imaging* (*SHOMRI*) system to assess intraarticular pathology in 43 symptomatic FAI patients and correlated the *SHOMRI* scores with chondrolabral changes found during hip arthroscopy. Prior to surgery, radiographs, and MRI were obtained and all patients completed the *Hip disability and Osteoarthritis Outcome Score* (*HOOS*) questionnaire. Each MRI was graded using the *SHOMRI* system. Scores were then correlated with intraoperative cartilage and labral grades, preoperative radiographic findings, and *HOOS* scores. *SHOMRI* total scores correlated with intraoperative femoral cartilage grade ($\rho = 0.42$; $p = 0.002$), acetabular cartilage grade ($\rho = 0.30$; $p = 0.046$), and labral tear grade ($\rho = 0.42$; $p = 0.003$) as well as with

preoperative Tönnis grade (ρ = 0.37, p = 0.013), *HOOS* pain score (ρ = −0.33; p = 0.039), *HOOS* ADL score (ρ = −0.39; p = 0.007), and *HOOS* sports score (ρ = −0.30; p = 0.037). The authors conclude that the *SHOMRI* system showed significant correlation with arthroscopic findings and radiographic gradings and clinical symptoms in patients with FAI (low level of evidence).

Chopra et al (2018) compared the diagnostic accuracy of conventional 3T MRI vs. 1.5T MRA in 68 consecutive patients (median age 32 years) with FAI. All patients underwent both MRI and MRA, and two blinded MSK radiologists scored images for internal derangement, including labral and cartilage abnormality. A total of 39 (57%) patients subsequently underwent hip arthroscopy, and surgical results and radiology findings were analyzed. Results found both readers had higher (but not statistically significant) sensitivities for detecting labral tears with 3T MRI. For acetabular cartilage defect, both readers had higher (statistically significant) sensitivities using 3T MRI (p=0.02). Both readers had a slightly higher (not statistically significant) sensitivity for detecting delamination with 1.5T MRA. The authors conclude that conventional 3T MRI is equivalent to 1.5T MRA in detecting acetabular labral tears and possibly superior to 1.5T MRA in detecting acetabular cartilage defects in patients with suspected FAI. 3T MRI is equivalent to 1.5T MRA for diagnosing cartilage delamination (moderate level of evidence).

Saied et al (2017), in systematic review and meta-analysis, aimed to detect the accuracy of conventional MRI (cMRI), direct MRA (dMRA) and indirect MRA (iMRA) for the diagnosis of chondral and labral lesions in FAI. A total of 21 studies (n = 828 patients; mean age 34 years), using surgical comparison as the reference test, were included, with 12 studies included for meta-analysis. For labral lesions, the pooled sensitivity, specificity and area under the curve (AUC) were 0.864, 0.833, and 0.88 for cMRI and 0.91, 0.58, and 0.92 for dMRA. In chondral lesions, the pooled sensitivity, specificity and AUC were 0.76, 0.72, and 0.75 for cMRI and 0.75, 0.79, and 0.83 for dMRA. The sensitivity and specificity for iMRA were 0.722 and 0.917. The authors conclude that diagnostic test accuracy of dMRA was superior to cMRI for detection of labral and chondral lesions. Promising results were found for iMRA, but further studies will need to fully assess its diagnostic accuracy (moderate level of evidence).

Reiman et al (2017), in a systematic review and meta-analysis, summarized and evaluated the diagnostic accuracy and clinical utility of various imaging modalities and injection techniques relevant to hip FAI/acetabular labral tear (ALT). A total of 25 articles were included: no studies investigating FAI qualified for meta-analysis; twenty articles on ALT qualified for meta-analysis. Positive imaging findings increased the probability that a labral tear existed by a minimal to small degree with use of MRI/MRA and ultrasound, and by a moderate degree for CTA. Negative imaging findings decreased the probability that a labral tear existed by a minimal degree with use of MRA and ultrasound, a small to moderate degree with MRA, and a moderate degree with CTA. The meta-analysis showed that CTA demonstrated the strongest overall diagnostic accuracy, with pooled sensitivities of 0.91 (95% CI: 0.83-0.96) and pooled specificities of 0.89 (95% CI: 0.74-0.97) (moderate level of evidence).

Frank et al (2015), in a systematic review, addressed the incidence of radiographic findings suggestive of FAI in asymptomatic individuals. The prevalence of an asymptomatic cam deformity was 37%-54.8% in athletes, versus 23.1% in the general population. The prevalence of asymptomatic hips with pincer deformity was 67% (range 61%-76% between studies). Only 7 studies reported on labral injury, which was found on MRI without intra-articular contrast in 68% of hips. The authors concluded FAI morphologic features and labral injuries are common in asymptomatic patients (high level of evidence).

Hip pain with suspected periarticular tendinopathy, tendon tear, and/or bursitis:

- **Green** – **MRI hip without IV contrast**
- **Yellow** – **CT hip without IV contrast**
  [patient unable to undergo MRI and ultrasound expertise is not available]
- **Red** – **MRI hip with IV contrast**; **MRI hip without and with IV contrast**; **MR arthrography**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **CT arthrography**; **bone scan**; **SPECT**; **PET**

Level of Evidence: MRI, CT and bone scan: very low; MR arthrography, CT arthrography, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences: Where expertise is available, ultrasound has also been shown to be accurate in the evaluation of periarticular tendons and bursitis of the hip.

Guideline and PLE expert panel consensus opinion summary:
For the clinical diagnoses of strain, tendinitis, tendinosis, or other abnormalities involving the surrounding soft tissue of the hip, noncontrast MRI is the primary imaging modality, as it is both highly sensitive and specific (Mintz et al [*ACR*] 2016; Bussières et al 2007, grade D recommendation). It is particularly useful in detecting musculotendinous pathologies such as iliopsoas tendinopathy or chronic/recurrent bursitis (Enseki et al [*APTA*] 2014; Bussières et al 2007, grade D recommendation). CT is less sensitive than MRI or ultrasound for evaluation of soft tissue, and should only be considered if the patient is unable to undergo MRI and ultrasound expertise is also not available (Mintz et al [*ACR*] 2016; PLE expert panel consensus opinion). Nuclear medicine does not currently play a role in the workup of these conditions (Mintz et al [*ACR*] 2016).

Clinical notes:

- If the patient is unable to undergo MRI, ultrasound should be considered to evaluate for periarticular tendinopathy, tendon tear and/or bursitis (PLE expert panel consensus opinion).
- Ultrasound is useful to evaluate periarticular musculotendinous abnormalities although the accuracy may vary significantly depending on user expertise and experience. Ultrasound is also useful to guide periarticular injections and can be useful to diagnose dynamic abnormalities such as snapping iliopsoas tendons (Mintz et al [*ACR*] 2016).
- In nontraumatic trochanteric and iliopsoas bursitis, ultrasound is an easy-to-perform and fast alternative. However, it fails to demonstrate iliopsoas bursitis in about 40% of cases (Bussières et al 2007).
- Image-guided bursal and/or periarticular tendon injections with local anesthetic, with or without cortisone, can be useful for diagnostic and therapeutic purposes in patients with suspected periarticular tendon and bursal abnormalities (Mintz et al [*ACR*] 2016).

Evidence update (2015-present): No new low, moderate, or high level evidence addressing the utility of advanced imaging in this clinical scenario.

Moderate or severe osteoarthritis of the hip on conventional radiography with any of the following

- **New-onset severe pain, and/or**
- **Significant change in symptoms, and/or**
- **Pain that is disproportionate to findings on repeat radiography:**

- Green – **MRI hip without IV contrast**
- Yellow – **CT hip without IV contrast**
  [patient unable to undergo MRI]
- Yellow – **CT arthrography hip**
  [patient unable to undergo MRI]
- Yellow – **Bone scan** (**bone scan/SPECT** or **bone scan/SPECT/CT** or **planar bone scan**)
  [patient unable to undergo MRI]
- Red – **MRI hip with IV contrast**; **MRI without and with IV contrast**; **MR arthrography**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **PET**; **Multiphase bone scan**

Level of Evidence: MRI: moderate; CT, CT arthrography, bone scan: low; MRI with IV contrast, MR arthrography, SPECT, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Imaging is typically not required to make the diagnosis in patients with typical presentation of OA (Sakellariou et al [*EULAR*] 2017, Level of Evidence III-IV). However, in atypical presentations, it may be recommended to help confirm the diagnosis of OA and/or make alternative or additional diagnoses (Sakellariou et al [*EULAR*] 2017, Level of Evidence, IV). Imaging is also recommended if there is unexpected rapid progression of symptoms or change in clinical characteristics to determine if this relates to OA or an additional diagnosis (Sakellariou et al [*EULAR*] 2017, Level of Evidence III-IV). If imaging is needed, conventional radiography should be used prior to other modalities. To make additional diagnoses, soft tissues are best imaged by US or MRI, and bone by CT or MRI (Sakellariou et al. [*EULAR*] 2017, Level of Evidence III-IV). The VA/DOD suggests against obtaining magnetic resonance imaging for the diagnosis of osteoarthritis of the hip (*VA/DOD* 2020, "weak against" recommendation). They do note, however, that some surgeons may elect to obtain MRIs occasionally to answer specific clinical or surgical questions on a case-by-case basis (*VA/DOD* 2020).

Clinical notes:
- Clinical features of osteoarthritis typically include age ≥ 40 years, hip pain only with possible protective limp, activity-induced symptoms, improvement with rest, stiffness in the morning or with periods of inactivity, and significant decrease in pain with weight loss and exercise in patients aged > 60 years (Bussières et al. 2007).
- Conventional radiography should be the initial study for the evaluation of hip pain, and may be useful for the detection and evaluation of arthritis (Mintz et al. [*ACR*] 2016; Bussières et al. 2007, grade D recommendation).

Evidence update (2013-present):
Crim et al (2019), in a retrospective study, assessed the concordance of radiographic assessment of osteoarthritis severity with findings of gross and microscopic evaluation analysis in the preoperative assessment for hip arthroplasty. Radiology and pathology reports from 953 consecutive femoral head resections were reviewed to establish correlation of findings. In 83 cases, MRI images were also available for review. Both radiologists and pathologists prospectively used a four-grade scale of absent, mild, moderate, or severe osteoarthritis. Radiographs showed severe osteoarthritis in 62.3% of patients, moderate in 20%, and no/mild in 17.7%. Observed agreement between radiology and pathology findings was 90%. There were significant discrepancies between radiography grade and pathology grade in 2.2% of cases. Observed agreement between radiography and MRI was 78%. The authors conclude that radiography findings are a reliable indicator of severity of osteoarthritis (low level of evidence).

Nguyen et al (2018), in a prospective study, assessed clinical significance of increased FDG uptake on PET/CT in joints (65 patients) for evaluation of symptomatic OA and prediction of progression. Patients completed the *Western Ontario and McMaster Universities Osteoarthritis Index* (*WOMAC*) questionnaire to assess joint pain, stiffness, and physical function. Standardized uptake values (SUVs) were measured in hip, knee, AC and GH joints. Scout PET/CT images were evaluated for OA using the Kellgren/Lawrence (K/L) system. Patients were followed for five years to determine progression of OA (follow-up imaging or surgical intervention). SUV of hip ($r=0.260$, $p=0.0027$) joints correlated with WOMAC overall scores and SUV of hip ($r=0.203$, $p=0.0199$) joints also correlated with K/L scores. SUV ROC AUC was 0.678 for hip for symptomatic OA detection. The authors conclude that FDG PET/CT may be helpful with localization of painful abnormalities in the inflamed regions of joints, which could potentially be used to direct individualized treatment in moderate and severe OA (low level of evidence).

Unexplained pain (hip, groin, buttock, thigh, knee) of suspected hip etiology that is unresponsive to 4-6 weeks of conservative therapy, with normal or nondiagnostic radiographs:

- Green – **MRI hip without IV contrast**
- Yellow – **MR arthrography hip**
- Yellow – **CT arthrography hip**
  [patient unable to undergo MRI]
- Yellow – **Bone scan** (**bone scan/SPECT** or **bone scan/SPECT/CT** or **planar bone scan**)
  [further evaluate equivocal/indeterminate findings on recent MRI without IV contrast; or patient unable to undergo MRI]
- Yellow – **CT hip without IV contrast**
  [patient unable to undergo MRI; or pre-surgical planning is necessary; or patient has increased or equivocal uptake on previous bone scan]
- Red – **MRI hip with and without IV contrast**; **MRI hip with IV contrast**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **PET**; **Multiphase bone scan**

Level of Evidence: MRI, MR arthrography: very low; CT, CT arthrography, bone scan, SPECT, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Radiographs of the pelvis and hip should be the first test ordered for the evaluation of patients with chronic hip pain (Mintz et al [*ACR*] 2016; Enseki et al [*APTA*] 2014). Clinicians should also consider a course of conservative management prior to advanced imaging (Enseki et al [*APTA*] 2014; PLE expert panel consensus opinion). While some guidelines note that a trial of conservative therapy is 4 weeks (e.g., Bussieres et al 2007), the PLE expert panel thought that 6 weeks was a more appropriate interval to allow initial therapeutic interventions to show effectiveness (PLE expert panel consensus opinion). Following normal or equivocal radiographs, advanced imaging investigations for the evaluation of patients with chronic hip pain unresponsive to conservative therapy include MRI without contrast and MR arthrography (Bussières et al. 2007, grade D recommendation; Mintz et al [*ACR*] 2016). MRI hip without IV contrast is typically the most appropriate modality to exclude the hip as a source of pain in patients presenting with chronic hip pain and low back, pelvic, or knee pathology (Mintz et al [*ACR*] 2016). While MRI provides better detail for assessing soft tissue integrity, MRA (or CTA if MR imaging is contraindicated) is more commonly used for the assessment of intra-articular structures (Enseki et al [*APTA*] 2014; PLE expert panel consensus opinion). CT can be useful to assess osseous architecture of the hip and assist with pre-surgical planning (Enseki et al [*APTA*] 2014). Tc-99m bone scan whole body can be considered if better localization of symptoms is necessary (PLE expert panel consensus opinion). Bone scan can also be used to identify insufficiency or fragility fractures and early AVN (PLE expert panel consensus opinion).

Clinical notes:

- Hip, buttock, groin and medial thigh pain may arise from the hip, spine, sacroiliac joints and

knee, or from abdominal disorders (*BOA* 2014; Mintz et al [*ACR*] 2016).

- Intra-articular hip injection can be performed with local anesthetic, with or without cortisone, to determine if the patient's symptoms are arising from the hip. Local anesthetic can be injected at the time of MR arthrography or CT arthrography, if indicated (Mintz et al. [*ACR*] 2016).
- Anesthetic injection can be considered in patients with chronic hip pain unresponsive to conservative therapy (Bussières et al. 2007, grade D recommendation; Mintz et al [*ACR*] 2016).

Imaging notes:

- MRI protocol of an ipsilateral hip should include two sequences of the entire bony pelvis to include T1 and water sensitive sequences (STIR or T2 fat saturation) (PLE expert panel consensus opinion).

Evidence update (2014s-present):

Keeney et al (2014), in a retrospective study, evaluated a number of parameters including the clinical indications that most commonly influence treatment decisions and likelihood that hip MRI influences treatment decisions separate from conventional radiographs. The authors concluded that although MRI can be valuable for diagnosing or staging specific conditions, it is not cost-effective as a screening tool for hip pain that is not supported by history, clinical examination, and conventional radiographic findings in patients between 40 and 80 years of age (low level of evidence).

Neiman et al (2016), in a retrospective study, evaluated the prevalence of non-suspected pathologies revealed by hip MRA in 229 patients (mean age 36.5; age range 18-67 years). The authors reported significant non-targeted pathologies in 76/229 (33%) MRAs, including athletic pubalgia, sacroiliitis, fractures, and muscle/tendon abnormalities. Physical examination/pain level could not differentiate between patients with and without non-suspected pathologies (low level of evidence).

Hip pain with suspected avascular necrosis (AVN)/osteonecrosis:

- Green – **MRI hip without IV contrast**
- Yellow – **MRI hip with IV contrast** or **MRI hip without and with IV contrast**
  [further evaluate equivocal/indeterminate findings on recent* MRI without IV contrast]
- Yellow – **Bone scan (bone scan/SPECT** or **bone scan/SPECT/CT** or **planar bone scan)**
  [patient unable to undergo MRI]
- Yellow – **CT bilateral hips without IV contrast**
  [patient unable to undergo MRI; or pre-surgical planning is necessary]
- Red – **MR arthrography**; **CT arthrography**; **CT hip with IV contrast**; **CT hip without and with IV contrast**; **PET**

*Recent is typically defined as < 1 month (PLE expert panel consensus opinion).

Level of Evidence: MRI: moderate; CT, bone scan, SPECT: low; MR arthrography, CT arthrography, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
In patients with hip pain who are at risk for osteonecrosis, radiographs should be the initial imaging examination (Murphey et al [*ACR*] 2015. MRI is the most sensitive and specific imaging modality for the detection of osteonecrosis and is useful when radiographs are normal, especially in high-risk patients (Bussières et al 2007, grade B recommendation). MRI without IV contrast can be used to establish the diagnosis and also exclude other potential causes of pain (Murphey et al [*ACR*] 2015). The addition of IV contrast to MRI may on occasion be useful in patients with previous noncontrast MRI if findings are indeterminate for AVN versus subchondral fracture (PLE expert panel consensus opinion). MRI without and with IV contrast may also rarely be indicated to follow-up previously indeterminate MRI exams or previous MRI exams with transient osteoporosis (PLE expert panel consensus opinion). When MRI is unavailable or the patient is unable to undergo MRI, nuclear medicine or CT can be used (Bussières et al 2007). CT may also be useful for surgical planning to assess the severity and locations of femoral head collapse, and to assess for secondary osteoarthritis (Murphey et al [*ACR*] 2015). SPECT imaging can improve the accuracy of radionuclide imaging for diagnosing osteonecrosis (Murphey et al [*ACR*] 2015).

Clinical notes:
- Clinical features of osteonecrosis typically include progressive groin pain that may refer to the knee, normal range of motion in early stages, and limitation of extension, internal rotation and abduction, limping and atrophy in advanced stages (Bussières et al 2007).
- Factors which place patients at high risk for AVN include: hip fractures or dislocation, chronic steroid use, organ transplant surgery, chronic alcohol abuse, hemoglobinopathy, decompression illness [barotrauma], and chronic antiretroviral medication use (Shah et al 2015).
- Conventional radiographs are the initial study of choice in patients with suspected osteonecrosis or avascular necrosis (Murphey et al [*ACR*] 2015).

- Avascular necrosis needs to be differentiated from transient osteoporosis and subchondral insufficiency fracture on MRI. MRI with IV contrast may be useful in this regard with enhancement of immediate subchondral bone being absent in patients with AVN (Murphey et al [*ACR*] 2015).
- CT is less sensitive than MRI and bone scintigraphy, however, multidetector CT may be superior to MRI in the detection of femoral head collapse (Murphey et al [*ACR*] 2015).

Imaging notes:

- If AVN is detected on a unilateral hip exam, then the contralateral hip should also be imaged to screen for asymptomatic AVN (PLE expert panel consensus opinion).
- In patients who are at high risk for AVN, consider T1 coronal images and fluid sensitive sequences (STIR or T2 fat saturation) through the pelvis, including both hips, to evaluate for asymptomatic AVN in the contralateral hip (PLE expert panel consensus opinion).
- The use of bone scan with SPECT imaging should include pinhole collimation, scatter correction and iterative reconstruction (Murphey et al [*ACR*] 2015).

Evidence update (2014-present):

Hu et al (2015), in a study of 30 femoral head specimens collected from 23 patients, reported that there was a high correlation between MRI, CT, and coronal sectional gross specimens on the location, shape and size of avascular lesions. CT was superior to MRI, however, in identifying subchondral fracture (low level of evidence).

Hip pain with clinical and/or radiological suspicion for septic arthritis or osteomyelitis:

- Green – **MRI hip without IV contrast** or **MRI hip without and with IV contrast**
- Yellow – **MRI hip with IV contrast**
  [further evaluate equivocal/indeterminate findings on recent* MRI without IV contrast]
- Yellow – **CT hip with and/or without IV contrast**
  [patient unable to undergo MRI]
- Yellow – **Multiphase bone scan** or **multiphase bone scan/SPECT** or **multiphase bone scan/SPECT/CT****
  [patient unable to undergo MRI]
- Red – **CT arthrography**; **MR arthrography**; **PET**; **planar bone scan**

*Recent is typically defined as < 1 month (PLE expert panel consensus opinion).

**This document does not address use of white blood cell scintigraphy, which has utility in the assessment of osteomyelitis.

Level of Evidence: MRI, CT, bone scan: very low; MR arthrography, CT arthrography, PET: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
MRI is the advanced imaging modality of choice for suspected bone and extremity soft-tissue infections, and has a 100% negative predictive value for excluding osteomyelitis (Bussières et al 2007, grade D recommendation; Beaman et al [*ACR*] 2017). The addition of IV contrast is useful in patients with septic arthritis and/or osteomyelitis to evaluate for periarticular abscess on MRI or CT (PLE expert panel consensus opinion). When a patient is unable to undergo MRI, CT can be useful for diagnosis of chronic osteomyelitis (Beaman et al [*ACR*] 2017). Nuclear medicine is very sensitive, but not specific, for suspected septic arthritis and osteomyelitis (Bussières et al 2007, grade D recommendation). Its role is generally limited to cases where MRI is contraindicated, infection is multifocal, or infection is associated with orthopedic hardware, trauma, or surgery (Beaman et al [*ACR*] 2017).

Clinical notes:
- Clinical features of septic arthritis of the hip typically include significant pain on movement and weight bearing, fever, and malaise (Bussières et al 2007).
- Conventional radiographs should be the initial study for the evaluation of hip pain, and may be useful for the detection and evaluation of arthritis (Mintz et al [*ACR*] 2016; Bussières et al 2007, grade D recommendation).
- WBC, ESR and CRP should be considered in patients with a high clinical suspicion for septic arthritis (PLE expert panel consensus opinion). In patients with hip pain and elevated inflammatory markers, consider ultrasound (if appropriate expertise available) to evaluate for

an effusion and for joint aspiration (PLE multidisciplinary committee opinion).

- The procedure of choice for suspected infection is joint aspiration, which can be performed under fluoroscopy or ultrasound (Mintz et al [*ACR*] 2017; Bussières et al 2007, grade D recommendation; PLE expert panel consensus opinion).
- In patients with proven septic arthritis, MRI shows effusions, synovial enhancement and synovial thickening in all patients, abscesses in 38%, bone marrow edema in 77%, erosions in 62% and myositis/cellulitis in 77%. MR is also useful to follow patients during treatment to assess resolution of effusions and abscesses (Bierry et al 2012).

Evidence update (2014-present):

Keeney et al (2014), in a retrospective study of 213 patients (218 consecutive hip MRI studies), evaluated a number of parameters including the clinical indications that most commonly influence treatment decisions and the likelihood that hip MRI influences treatment decisions separate from conventional radiographs. The authors concluded that although MRI can be valuable for diagnosing or staging specific conditions, it is not cost-effective as a screening tool for hip pain that is not supported by history, clinical examination, and conventional radiographic findings in patients between 40 and 80 years of age. MR of the hip affected treatment decisions in 40% of patients undergoing assessment for infection (low level of evidence).

Hip pain with an indeterminate or aggressive bone lesion noted on radiographs:

- **Green** – **MRI hip without IV contrast** or **MRI hip without and with IV contrast**
- **Yellow** – **MRI hip with IV contrast**
  [further evaluate equivocal/indeterminate findings on recent* MRI without IV contrast]
- **Yellow** – **CT hip without IV contrast** or **CT hip without and with IV contrast**
  [patient unable to undergo MRI; or pre-surgical planning is necessary]
- **Yellow** – **PET** or **PET/CT**
  [further evaluate possible metastatic lesion(s)]
- **Yellow** – **Whole-body bone scan (bone scan/SPECT** or **bone scan/SPECT/CT** or **planar bone scan)**
  [further evaluate possible metastatic lesion(s)]
- **Red** – **CT hip with IV contrast**; **MR arthrography**; **CT arthrography**; **Multiphase bone scan**

*Recent is typically defined as < 1 month (PLE expert panel consensus opinion).

Level of Evidence: MRI, CT: very low; PET/CT moderate level of evidence; MR arthrography, CT arthrography: PLE expert panel consensus opinion

Notes concerning applicability and/or patient preferences:
Nuclear medicine studies fused with CT (or MRI) are not yet widely available, and therefore may have applicability or generalizability issues in the community outpatient setting (PLE expert panel consensus opinion).

Guideline and PLE expert panel consensus opinion summary:
Radiographs are usually appropriate for the initial imaging of a suspected primary bone tumor (Bestic et al [*ACR*] 2020). Following radiographs, special investigations for tumors and metastatic lesions include MRI, CT, or nuclear medicine (Bussières et al 2007, grade D recommendation). MRI without IV contrast or MRI without and with IV contrast are indicated for a suspected primary bone tumor but negative radiographs (Bestic et al [*ACR*] 2020). A noncontrast MRI should also be used for imaging of a suspected primary bone tumor when radiographs show indeterminate or aggressive appearing lesions suggestive for malignancy (Bestic et al [*ACR*] 2020). MRI is not routinely used in the evaluation of lesions that are definitely benign on radiographs; however, if such lesions are symptomatic, MRI may be useful to identify unusual complications, such as stress fracture, secondary aneurysmal bone cyst formation, or malignant transformation (Bestic et al [*ACR*] 2020). CT can be a viable alternative for patients who are unable to undergo MRI (Bestic et al [*ACR*] 2020; PLE expert panel consensus opinion). FDG-PET is a valuable adjunct to conventional imaging in the diagnosis, staging, restaging, and surveillance of primary bone tumors (Bestic et al [*ACR*] 2020). Recent advances in technology, such as SPECT/CT, may provide a useful tool in the evaluation of primary bone tumors (Bestic et al [*ACR*] 2020).

Clinical notes:
- The term “bone tumor” may be applied to a broad range of entities, including tumor-like lesions related to developmental, metabolic, hematopoietic, lymphatic, or reactive abnormalities that affect bone (Bestic et al [*ACR*] 2020).
- In patients with lesions that are clearly benign on conventional radiographs (bone cyst, nonossifying fibroma, fibrous dysplasia, bone island, fibrocortical defect, etc.), consider follow-up radiograph in 6 months to ensure stability (PLE expert panel consensus opinion).

- Refer patients with lesions which are indeterminate or aggressive on radiography for subspecialist consultation (PLE expert panel consensus opinion).
- On a per lesion basis, the sensitivity of PET, CT, MRI and bone scintigraphy for bone metastases is 86.9%, 77.1%, 90.4% and 75.1%. The specificities are 97%, 83.2%, 96% and 93.6% respectively (Yang et al 2011).
- The sensitivity and specificity of PET/CT for osseous and soft tissue sarcoma is 0.96 and 0.95 respectively (Muheremu et al 2017).
- FDG-PET/CT has been shown to be accurate in the differentiation of benign from malignant cartilaginous lesions, and is accurate in the differentiation of benign from malignant pathologic fractures (Bestic et al [*ACR*] 2020).

Imaging notes:

- If the patient is undergoing MRI evaluation, T1 and fluid-sensitive sequences (STIR, T2 fat saturation or PD fat saturation sequences) should be obtained through the entire bony pelvis for acetabular bone lesions and the entire femur for proximal femoral lesions in at least one plane (PLE expert panel consensus opinion).

Evidence update (2007-present):
Muheremu et al (2017), in a systematic review and meta-analysis, evaluated 16 articles with 883 patients and 2,214 lesions. Nine studies with 738 patients and 2,069 lesions reported the diagnostic accuracy of PET/CT for osseous and soft tissue sarcomas. On a lesion-based analysis, the overall sensitivity and specificity were 0.96 and 0.95. They concluded that PET/CT is a reliable method with high accuracy for the diagnosis of bone and soft tissue sarcomas, although the present findings require verification by larger-sample studies. The authors reported similar results with respect to the accuracy of PET/CT to assess the effect of neoadjuvant therapy on osseous and soft tissue sarcomas (high level of evidence).

Yang et al (2011), in a meta-analysis, compared 18F FDG PET, CT, MRI and bone scintigraphy for the diagnosis of bone metastases. 67 articles consisting of 145 studies fulfilled the inclusion criteria. On a per-lesion basis, the pooled sensitivities for PET, CT, MRI and bone scintigraphy were 86.9%, 77.1%, 90.4% and 75.1%. The specificities were 97%, 83.2%, 96% and 93.6% respectively. The authors concluded that PET and MRI were comparable and both were significantly more accurate than CT and bone scintigraphy for the diagnosis of bone metastases (high level of evidence).

Keeney et al (2014), in a retrospective study, evaluated a number of parameters, including the clinical indications that most commonly influence treatment decisions and the likelihood that hip MRI influences treatment decisions separate from conventional radiographs. The authors concluded that although MRI can be valuable for diagnosing or staging specific conditions, it is not cost-effective as a screening tool for hip pain that is not supported by history, clinical examination, and conventional radiographic findings in patients between 40 and 80 years of age. MR of the hip affected treatment decisions in 58% of patients undergoing assessment for neoplasm (low level of evidence).

O'Sullivan et al (2015), in a review paper, state that MRI is the imaging modality of choice for assessing metastatic spread in the marrow cavity, extension of tumor from the marrow cavity, and involvement of surrounding structures. The sensitivity and specificity of MRI for bone metastases is 95% and 90% respectively, CT 74% and 56%, planar bone scintigraphy 78% and 48%, and SPECT 87% and 91% respectively. 18F NaF-PET is substantially more sensitive and specific than scintigraphy and SPECT for the detection of skeletal metastases, and has a higher sensitivity than 18F FDG-PET. The sensitivity and

specificity of 18F NaF-PET/CT for the detection of bone metastases is 100% and 97% (low level of evidence – clinical review).

Guideline exclusions:

- Inflammatory arthritis, other than septic arthritis
- Crystal deposition disease
- Metabolic bone disease
- Primary synovial abnormalities such as pigmented villonodular synovitis (PVNS) or osteochondromatosis
- Primary soft tissue neoplasm
- CT navigation or modeling for hip arthroplasty
- Painful hip arthroplasty
- High energy trauma
- Pediatric patients
- Pregnant patients
- Advanced MRI imaging sequences, including diffusion sequences, T2 mapping, T1rho, dGEMRIC, sodium imaging
- White Blood Cell scintigraphy.

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Posting Date:	Approved By:
12/01/2020	n/a	12/08/2020	CDI Quality Institute's Multidisciplinary Committee

Information on our evidence development process, including our conflicts of interest policy is available on our website at **https://www.mycdi.com/ple**