PROVIDER LED ENTITY

Knee Pain AUC

2022 Update

02/22/2022

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

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

Abbreviation list:

AAOS	American Academy of Orthopaedic Surgeons
ACL	Anterior cruciate ligament
ACR	American College of Radiology
AVN	Avascular necrosis
AUC	Appropriate Use Criteria
CT	Computed tomography
CTA	Computed tomographic arthrography / computed tomographic angiography
DoD	Department of Defense
EULAR	European League Against Rheumatism
MDCT	Multidetector computed tomography
MRA	Magnetic resonance arthrography / Magnetic resonance angiography
MRI	Magnetic resonance imaging
NICE	National Institute for Health and Care Excellence
NZMA	New Zealand Medical Association
OA	Osteoarthritis
OKR	Ottawa Knee Rule
ON	Osteonecrosis
PET	Positron emission tomography
PLE	Provider Led Entity
SPR	Society of Pediatric Radiology
SSR	Society of Skeletal Radiology
US	Ultrasound
VA	Department of Veterans Affairs

Appropriate Use Criteria: How to Use this Document

The RAYUS 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): Strong recommendation for imaging. There is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): Conditional recommendation for imaging. The desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. Alternative imaging recommendations may be indicated with a contraindication to the primary recommendation, in specific clinical scenarios, or when the primary recommendation results 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 test may not be accurate, may not be reliable, or 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).

Knee Pain AUC Summary:

- In most instances, **MRI (without contrast)** is the initial advanced imaging procedure of choice for knee pain. It is indicated for suspected structural derangement following acute injury, severe or atypical osteoarthritis, and suspected occult or stress fractures not identified on initial radiographs.
    - MRI without and with IV contrast can be useful for the initial evaluation of osteonecrosis. The addition of MRI contrast can also be helpful to evaluate equivocal or non-diagnostic findings on recent noncontrast MRI when avascular necrosis 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 non-diagnostic radiographs.
- **CT arthrography** is generally reserved for patients unable to undergo MRI, while **MR arthrography** can be useful in patients with previous meniscal repair and/or ACL reconstruction.
- **CT (without contrast)** is typically recommended for further assessment of patellofemoral morphology when surgical planning is necessary. It can also be used in selected scenarios to further characterize or evaluate healing of a known fracture, or when previous MRI findings are non-diagnostic.
- **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. The addition of SPECT or SPECT/CT, when available, may increase the specificity of a bone scan.
- **Conventional radiographs** are commonly used for the initial evaluation of a suspected fracture, osteoarthritis, or other unexplained pain.
- **Ultrasound**, while not defined as an advanced imaging modality, can be useful in the initial assessment of a Baker's (popliteal) cyst.

Knee pain with suspected structural derangement* after an acute injury**:

- Green – **MRI knee without IV contrast**
- Yellow – **CT arthrography knee**
  [patient unable to undergo MRI]
- Yellow – **CT knee without IV contrast**
  [further characterize or evaluate healing of known fracture]
- Yellow – **MR arthrography knee**
  [patient has had previous meniscal repair and/or ACL reconstruction]
- Yellow – **CT angiography** or **MR angiography of the lower extremities**
  [evaluate for vascular injury or dislocation]
- Red – **MRI knee without and with IV contrast**; **MRI knee with IV contrast**; **CT knee with IV contrast**; **CT knee without and with IV contrast**; **bone scan**; **SPECT**; **PET**; **PET/CT**

* Signs and symptoms of structural derangement after an injury can include giving way, locking, catching, effusion, inability to bear weight, bone tenderness, loss of motion, and/or pathological laxity.

** Acute injury is defined as a discrete event resulting in excessive force on the knee, in contradistinction to overuse injuries that result from chronic repetitive injuries or insufficiency injuries that result from normal forces on structurally deficient bone.

Level of Evidence: MRI without contrast: moderate-high; CT without contrast: low; bone scan: very low; MRI without and with contrast, MRI with contrast, MR arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus summary:

Radiographs and the Ottawa criteria

Radiographs, while commonly performed in the evaluation of acute knee injury, have a low yield for showing fractures (Taljanovic et al [ACR] 2020). Because of this, the Ottawa knee rule, with a sensitivity of 0.99 and specificity of 0.49, has been developed and validated to assist in determining when to order radiographs in individuals with acute knee injury (Longerstedt et al [APTA] 2018). With one or more positive Ottawa rule criteria, including focal tenderness and/or inability to bear weight, radiographs should be the initial imaging modality for knee trauma (Taljanovic et al [ACR] 2020; Bussieres et al 2007; C level recommendation). A knee radiograph series is also required in patients with any of the following criteria (Longerstedt et al [APTA] 2018; Taljanovic et al [ACR] 2020):

- Aged 55 years or older
- Isolated tenderness of patella
- Tenderness of head of the fibula
- Inability to flex knee to 90^{o}
- Inability to bear weight both immediately and in the emergency department for 4 steps regardless of limping.

MRI

MRI is not routinely used as the initial imaging study for the evaluation of acute knee trauma (Taljanovic

et al [ACR] 2020), and some cases of meniscal lesion or ACL injury can even be diagnosed without the need for this investigation (Longerstedt et al [APTA] 2018; Meuffels et al [Dutch Orthopaedic Association] 2012: level 2 scientific evidence). However, MRI has many advantages in the evaluation of the injured knee following negative radiographs (Taljanovic et al [ACR] 2020; Bussieres et al 2007; C level recommendation), and there is strong evidence that it can provide confirmation of ACL injury (with 94% sensitivity and specificity) or identify concomitant knee pathology (Shea et al [*AAOS*] 2015; strength of recommendation: strong; Meuffels et al [Dutch Orthopedic Association] 2012: level 1 scientific evidence; PLE expert panel consensus opinion). MRI is particularly helpful for more complicated cases, and can assist in preoperative repair or restoration procedures (Longerstedt et al [APTA] 2018; Taljanovic et al [ACR] 2020). Its use can also aid in the diagnosis and characterization of injuries associated with transient lateral dislocation of the patella (Taljanovic et al [ACR] 2020), or to evaluate patients with tibial plateau fractures for associated meniscal tears, which can occur in a significant percentage of these patients (PLE expert panel consensus opinion). For example, Mustonen et al (2008) reported unstable meniscal tears in 36% of patients with tibial plateau fractures, while Stannard et al (2010) found a meniscus tear in 49% and at least one ligament tear in 71% of patients with a tibial plateau fracture.

CT

CT is generally not used as the initial imaging study for the evaluation of acute trauma to the knee, as MRI is superior in detection of bone marrow abnormalities and meniscal and ligamentous injuries (Taljanovic et al [ACR] 2020; PLE expert panel consensus opinion). However, CT has been shown to be superior to radiographs in further classification and characterization of fractures (Taljanovic et al [ACR] 2020). Specifically, CT has shown 100% sensitivity (vs. 83% sensitivity for radiographs) in detection of tibial plateau fractures (Taljanovic et al [ACR] 2020).

CT arthrography

CT arthrogram may be useful to evaluate intra-articular abnormalities of the knee, such as meniscal or ligamentous injuries, in patients who cannot undergo MRI (Bussieres et al 2007: C level recommendation; PLE expert panel consensus opinion).

MR arthrography

MR arthrography is not routinely used as the initial imaging study for the evaluation of acute knee trauma or internal derangement (Taljanovic et al [ACR] 2020). Its use, however, may be beneficial for imaging postoperative conditions (*ACR, SPR,* & *SSR* 2015), such as previous meniscal repair and/or ACL reconstruction (PLE expert panel consensus opinion).

CT angiography or MR angiography

MR angiography is not routinely used for the evaluation of internal derangement, but may be helpful for the evaluation of soft-tissue, osseous, and neural injuries following knee dislocation (Taljanovic et al [ACR] 2020). It can be performed simultaneously with MRI to evaluate internal derangement and vascular injury (Taljanovic et al [ACR] 2020). CT angiography is frequently used for suspected vascular injury in the setting of knee dislocation, and has similarly high accuracy as conventional angiography (Taljanovic et al [ACR] 2020).

Bone scan/SPECT

Bone scan with SPECT or SPECT/CT is not routinely used as the initial imaging study for the evaluation of acute trauma to the knee and/or suspected internal derangement (Taljanovic et al [ACR] 2020).

Clinical notes:

- In the initial evaluation of a person with a knee injury and associated symptoms (giving way, locking, catching) and signs (effusion, inability to bear weight, bone tenderness, loss of motion, and/or pathological laxity), it is recommended that the practitioner obtain AP and lateral knee radiographs to identify fractures or dislocations (Shea et al 2015 [*AAOS*]; work group consensus recommendation).
- Adults with acute knee injury but negative findings on the Ottawa Knee Rule indicates that a fracture is very unlikely and routine radiographs are not routinely indicated (Bussieres et al 2007; B level recommendation).
- A lower threshold of suspicion of a meniscal tear is warranted in middle-aged and elderly patients (Longerstedt et al [APTA] 2018).

Technical notes:

- Sagittal oblique T2 FSE MRI sections can be useful in patients with previous ACL reconstruction (PLE expert panel consensus opinion).
- Metal reduction technique should be used in patients with metallic instrumentation and/or previous knee arthroplasties (PLE expert panel consensus opinion).
- Thin section CT with multiplanar reconstructions can be useful to characterize tibial plateau fractures in consideration of operative reduction and internal fixation (PLE expert panel consensus opinion).

Evidence update (2014-present):

Moderate Level of Evidence

Decary et al (2017) conducted an umbrella systematic review of 17 systematic reviews (SRs) (total n = 16,662) to evaluate the diagnostic validity of physical examination tests for knee disorders. Based on six SRs, only the Lachman test for ACL injuries was diagnostically valid when individually performed (likelihood ratio (LR+): 10.2, LR-: 0.2). Based on two SRs, the OKR is a valid screening tool for knee fractures (LR-: 0.05). Based on two SRs, a complete physical examination by a trained health provider was found to be diagnostically valid for ACL, PCL, and meniscal injuries, and also for cartilage lesions. The authors concluded that clinicians may diagnose or exclude ACL injuries with the Lachman test and exclude knee fractures using the OKR. For other knee disorders (e.g., meniscal injury, PFP, PCL injury), the available evidence does not demonstrate that tests used individually are diagnostically valid.

Smith et al (2016) conducted a meta-analysis of 13 studies (n = 1,197 patients) to assess the diagnostic efficacy of 3-T MRI for meniscal and ACL injuries using arthroscopy as the reference standard, and to compare results with a previous meta-analysis assessing 1.5-T MRI. The mean sensitivities and specificities of 3-T MRI for knee injuries by location were as follows: medial meniscus, 0.94 (95% CI, 0.91–0.96) and 0.79 (95% CI, 0.75–0.83), respectively; lateral meniscus, 0.81 (95% CI, 0.75–0.85) and 0.87 (95% CI, 0.84–0.89); and ACL, 0.92 (95% CI, 0.83–0.96) and 0.99 (95% CI, 0.96–1.00). There was no significant difference between 1.5-T and 3-T studies for detecting medial or lateral meniscal injuries. The specificity of 3-T MRI for injuries of the lateral meniscus was significantly lower than that of 1.5-T MRI (p = 0.0013). The authors concluded that 3-T MRI scanners have excellent diagnostic efficacy for ACL and meniscal injuries. However, the diagnostic studies published do not provide evidence that 3-T scanners are superior when compared with a previous meta-analysis of studies performed using 1.5-T machines.

Phelan et al (2016) conducted a systematic review of 21 prospective studies (n = 1,339 patients with nonspecific knee pain) to determine the diagnostic accuracy of MRI and ultrasound (US) in the diagnosis

of ACL, medial meniscus, and lateral meniscus tears. Sensitivity and specificity of MRI were 87% (95% CI: 77–94%) and 93% (95% CI: 91–96%), respectively, for ACL tears; 89% (95% CI: 83–94%) and 88% (95% CI: 82–93%), respectively, for medial meniscal tears; and 78% (95% CI: 66–87%) and 95% (95% CI: 91–97%), respectively, for lateral meniscal tears. The analysis found wide variability in study findings for test sensitivity. There was an insufficient number of studies that evaluated US to perform a meta-analysis. The authors concluded this review highlights the lack of high-quality evidence in support of a common diagnostic test. While MRI will continue to play an important role in the management of ACL and meniscal injuries, surgeons should be aware of the level of evidence supporting its use.

Patel et al (2012) conducted a randomized controlled trial to investigate whether early MRI in acute knee injury is more effective compared to conventional physiotherapy and reassessment. A total of 46 patients with knee injury were randomized to either MRI (within two weeks; n = 23) or control (conventional management and physiotherapy; *n* = 23). The MRI group had fewer mean physiotherapy and outpatient appointments. Median time to surgery and time off work was less in the MRI group. The MRI group also had less pain ($p < 0.05$), less activity limitation ($p = 0.04$) and better satisfaction ($p = 0.04$). The authors conclude that early MRI may facilitate faster diagnosis and management of internal derangement when compared to conventional treatment.

Low Level of Evidence

Sohn et al (2018) calculated the sensitivity, specificity, and accuracy of MRI in determining presence or absence of discoid lateral meniscus (DLM) for different tear types. MR imaging of 156 knees with arthroscopically confirmed lateral meniscus tears was analyzed: 78 knees in non-DLM group and 78 knees in DLM group on arthroscopy (reference standard). The presence of DLM on MRI was determined by an orthopedic surgeon and a radiologist, who were blinded to arthroscopic findings. Presence of DLM on MRI was determined by coronal and sagittal measurements, considering the tear pattern of lateral meniscus. Tear pattern was categorized into six types based on arthroscopic findings: horizontal, longitudinal, radial, combined radial, degenerative, and complex tear. Sensitivity for determining the presence of DLM was 58% for radial tear, 57% for combined radial tear, and 65% for longitudinal, with specificity of 100% for all groups. In the presence of radial or longitudinal tear, accuracy of MRI was significantly lower than having no radial and longitudinal tear ($p < 0.001$). The authors conclude that MRI was not successful in determining the presence or absence of DLM in radial tear, combined radial tear, and longitudinal tear.

Wylie et al (2017) conducted a retrospective study of 434 patients with minimal or no radiographic evidence of knee osteoarthritis to determine whether presenting signs and symptoms were predictive of knee pathology that was evident on MRI and could be treated with nonarthroplasty knee surgery or alter nonsurgical management. Record of patients showed that 281 (64.7%) had knee pathology on MRI. Evidence of ligamentous instability on physical exam had the highest association with positive MRI findings (OR, 9.98; 95% CI: 4.70-21.16). Significantly more surgeries were performed in patients with positive MRI results (71% vs. 14.4%, respectively; OR, 13.1; 95% CI: 7.8- 21.9. Analysis showed that male sex, history of acute injury, shorter symptom duration, subjective instability, mechanical symptoms, effusion, evidence of ligamentous instability on physical exam, and joint line tenderness had statistically significant association with positive MRI findings. The authors concluded that positive findings on knee MRI could be associated with a number of presenting signs and symptoms.

Ahn et al (2016) conducted a retrospective study to identify risk factors predicting false-negative MRI diagnosis for meniscal tear coincident with ACL injury. Records of consecutive patients (*n* = 249 meniscal tears: 159 medial, 90 lateral) who underwent arthroscopic ACL reconstruction were reviewed. Tears

were sorted into true-positive MRI (n = 136) and false-negative MRI (n = 113) groups. As time from injury (TFI) to MRI diagnosis increased, risk of false-negative MRI diagnosis decreased (OR, 0.859; (95% CI: 0.802-0.921). Meniscal tear location within the posterior one-third was a significant risk factor compared with tear within the anterior one-third (OR, 11.823; 95% CI: 2.272-61.519). Peripheral longitudinal tear pattern was also a significant risk factor (OR, 3.522; 95% CI: 1.256-9.878). The authors conclude that significant risk factors for false-negative MRI include short TFI to MRI diagnosis, meniscal tear location, and peripheral longitudinal tear pattern.

Kopka et al (2015) conducted a retrospective study of 611 patients with knee injuries (mean age = 38; range 14–81) to determine frequency and appropriateness of MRI utilization. Consecutive patients who had an MRI, and a randomly selected control group without MRI, were identified. MRI was classified on whether it was ordered by the Acute Knee Injury Clinic (AKIC) team or by an external clinician. Consensus-based "Indications for Urgent MRI in Acute Soft Tissue Knee Problems" were applied to both groups; MRI was considered appropriate if any of the indications were met. The overall MRI utilization rate was 23% (142/611). Of MRIs performed, 32% (46/142) met indications. About 94% (33/35) of the MRIs ordered by AKIC experts met indications, compared to 12% (13/107) of those ordered externally. Diagnoses were similar between groups. The authors conclude that application of guidelines by experts in knee evaluation can significantly reduce MRI utilization in patients with acute knee injuries without negatively impacting appropriate diagnosis and disposition.

Subhas et al (2014) conducted a prospective study to determine how frequently MRI changes (1) diagnosis, (2) diagnostic confidence, and (3) management. Six orthopedic specialists prospectively completed surveys when ordering knee MRI for 93 patients (mean age 43; range 14-82) with suspected internal derangement. MRI changed diagnosis in 29.3% and management in 25.3% of cases. Confidence in diagnoses after MRI increased, on average, by 10.6%. Change in diagnosis was significantly correlated with lateral joint line pain (*P* =.012) and tenderness (*P* =.006). The three most significant predictors for change in management were ligament pathology (*P* =.017), medial-sided pain/tenderness (*P* =.051), and age (*P* =.133). The authors conclude that MRI frequently changed diagnosis/management and improved diagnostic confidence in patients with internal derangement of the knee, even after evaluation by subspecialized physicians.

Nontraumatic knee pain persisting after an appropriate trial (> 4-6 weeks) of conservative care and no osteoarthritis or major abnormalities on radiographs:

- Green – **MRI knee without IV contrast**
- Yellow – **CT arthrography knee**
  [patient unable to undergo MRI]
- Yellow – **MR arthrography knee**
  [patient has had previous meniscal repair and/or ACL reconstruction]
- Yellow - **CT knee without IV contrast**
  [assess patellofemoral morphology for purposes of surgical planning]
- Red – **MRI knee with IV contrast**; **MRI knee without and with IV contrast**; **CT knee with IV contrast**; **CT knee without and with IV contrast**; **bone scan**; **SPECT**; **PET**; **PET/CT**

Level of Evidence: MRI without contrast: moderate-high; MR arthrography: moderate; CT without contrast, bone scan: very low; MRI without and with contrast, MRI with contrast, CT with contrast, CT without and with contrast, PET/CT: insufficient

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus summary:
In the event of knee pain, symptomatic medical treatment is advisable prior to treatment (Beaufils et al 2009: professional agreement). Typically, radiography (anterior-posterior views, Schuss, lateral, and patellofemoral 30°) is the initial imaging study to evaluate chronic knee pain (Fox et al [ACR] 2018; Beaufils et al 2009: professional agreement).

MRI
In cases of persistent knee pain without clinical improvement, MRI without IV contrast is recommended when initial radiographs are normal or the diagnosis is not well established, as it can better clarify the diagnosis and inform treatment decisions (Fox et al [ACR] 2018; Bussieres et al 2007: C level recommendation; Beaufils et al 2009: professional agreement; Robb et al [*NZMA*] 2007: grade C recommendation). MRI can assess the integrity of the medial patellofemoral ligament and medial patellar retinaculum, define the extent of cartilage injury, and identify loose bodies (Fox et al [*ACR*] 2018). MRI is also able to show chondromalacia and synovial plicae and accurately depict the extent of an effusion (Fox et al [ACR] 2018; Bussieres et al 2007: C level recommendation). Since MRI is more accurate than physical examination in identifying severe grades of chondromalacia patellae, it may be an appropriate screening tool prior to arthroscopy (Fox et al [*ACR*] 2018). MRI without and with IV contrast is not usually indicated for this clinical scenario (Fox et al [ACR] 2018).

CT arthrography
CT arthrography may be used instead of MRI to evaluate the menisci, articular cartilage, and presence of loose bodies, with sensitivity and specificity ranging from 86% to 100% (Fox et al [ACR] 2018; Bussieres et al 2007: C level recommendation; PLE expert panel consensus opinion). It may also be helpful to evaluate anterior knee pain if MRI is unavailable (Bussieres et al 2007: C level recommendation).

MR arthrography
MR arthrography is typically reserved for patients with known prior meniscal surgery, prior cartilage

repair procedures, chondral and osteochondral lesions, and suspected loose bodies (Fox et al [ACR] 2018; PLE expert panel consensus opinion). It may also be useful in patients with previous ACL reconstruction (PLE expert panel consensus opinion).

CT

In general, CT without contrast has very low sensitivity for internal knee derangements (PLE expert panel consensus opinion). However, its use may be indicated for patients with knee pain to evaluate patellofemoral anatomy related to repetitive patellofemoral subluxation or maltracking (Fox et al [ACR] 2018). Further, it can be helpful to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance, confirm prior osseous injury, loose bodies, or cartilage repair, or when MRI is not definitive (Fox et al [ACR] 2018).

Clinical notes:

- In patients with chronic knee pain, referred pain from the hip and/or lower back should be considered, especially if knee radiographs are unremarkable (Fox et al [ACR] 2018).
- Clinical features of anterior knee pain include insidious onset, aggravated with steps/incline/rising from chair, stiffness with rest or gliding, pseudolocking or giving way, tender patellar facets, positive apprehension tests, crepitation, and abnormal Q angle (Bussieres et al 2007).
- In the absence of other intra-articular disorders, there is currently consensus that anterior knee pain, which limits activities of daily living that demand knee flexion such as climbing and descending stairs, squatting or remaining seated, is defined as patellofemoral pain syndrome (PFPS) (Nunes et al 2013).
- Patellofemoral pain syndrome is common and often arises from malalignment of the patella in the femoral groove (e.g., due to asymmetric tension from the lateral and medial quadriceps (Katz et al 2021)).

Technical notes:

- Radiographs should include AP 15° flexed weight-bearing, lateral and tangential patellar views.
- T2 FSE sagittal oblique MRI sections should be obtained in patients with previous ACL reconstruction (PLE expert panel consensus opinion).
- Metal reduction technique should be used in patients with metallic instrumentation and knee arthroplasties (PLE expert panel consensus opinion).

Evidence update (2006–present):

Moderate Level of Evidence

Deshpande et al (2016) conducted a cross-sectional study of 84 patients (mean age = 64) with knee pain to examine the association between expert clinician impression of symptomatic meniscal tears and subsequent MRI. Patients were eligible if they were ≥ 45 years old, had not seen a surgeon within preceding year, and had not undergone knee surgery in past five years or total knee arthroplasty at any time. Surgeons rated their confidence that the patient's symptoms were due to meniscal tear and patient subsequently had MRI within 6 months. The prevalence of meniscal tear on MRI was 74%. Among subjects whose surgeon indicated high confidence that symptoms were due to meniscal tear, the prevalence was 80% (95 % CI: 63–90 %). Similarly, the prevalence was 87% (95 % CI: 62–96 %) among those whose surgeon had medium confidence and 64% (95 % CI: 48–77 %) among those whose surgeon had low confidence (p = 0.12). The authors conclude that a torn meniscus is often visible on imaging even when expert clinicians are confident on the basis of history and physical examination that a

patient's knee pain is not due to the torn meniscus.

Blyth et al (2015) conducted a prospective study to determine the diagnostic accuracy of the Thessaly test (alone or combined with other tests) and to determine if it can obviate need for MRI or arthroscopy in patients with suspected meniscal tear. Two cohorts of patients were recruited: patients with knee pathology (*n* = 292) and control group without pathology (*n* = 75). Participants were assessed by both a PCP and musculoskeletal clinician; each performed Thessaly test, McMurray's test, Apley's test, joint line tenderness test and took a standardized clinical history. The Thessaly test had a sensitivity of 0.66, a specificity of 0.39 and a diagnostic accuracy of 54% when utilized by PCPs. This compared with a sensitivity of 0.62, a specificity of 0.55 and diagnostic accuracy of 59% when used by musculoskeletal clinicians. The diagnostic accuracy of other tests when used by PCPs was 54% for McMurray's test, 53% for Apley's test, 54% for the joint line tenderness test and 55% for clinical history. The authors conclude that the Thessaly test is no better at diagnosing meniscal tears than other established physical tests, and neither the Thessaly test alone nor in combination with other physical tests could be reliably used by PCPs as an alternative for MRI scanning to diagnose meniscal tears.

Karel et al (2015) conducted a meta-analysis of 11 RCTs (*n* = 2777 patients) to explore whether diagnostic imaging leads to better patient-reported outcomes in individuals with musculoskeletal disorders. Trials were eligible when: 1) a diagnostic imaging procedure was compared with any control group not getting or not receiving the results of imaging; 2) the population included individuals suffering from musculoskeletal disorders, and 3) if patient-reported outcomes were available. Primary outcome measures were pain and function. Results found a moderate level of evidence for no benefit of diagnostic imaging on all outcomes compared with controls. The authors conclude that the results strengthen the available evidence that routine referral to diagnostic imaging by general practitioners for patients with knee and low back pain yields little to no benefit. In non-traumatic knee complaints, diagnostic imaging should be used if conservative treatment fails.

Harris et al (2012) conducted a systematic review of 13 studies (total n = 596) to identify the sensitivity, specificity, and accuracy of MRI in diagnosis of patellofemoral chondral defects of the knee, using arthroscopy as the reference gold standard. For the patella and trochlea, the sensitivity of MRI to detect chondral pathology ranged from 0%-95% and 62%-100%, respectively. Within all studies performing direct comparison between patellar and trochlear defects, MRI was more sensitive in detection of patellar (87%) vs. trochlear (72%) defects. MRI was similarly specific for patellar (86%) and trochlear (89%) defects. MRI was similarly accurate for patellar (84%) and trochlear (83%) defects. Interobserver agreement was substantial to almost perfect for both patellar and trochlear defects. The authors concluded MRI is a highly sensitive, specific, and accurate noninvasive diagnostic modality for the detection of chondral defects in the patellofemoral compartment of the knee, using arthroscopy as the reference gold standard.

Smith et al (2012) conducted a systematic review and meta-analysis of 27 studies (total *n* = 2,509) to assess the diagnostic test accuracy of MRI, MR arthrography (MRA), and CT arthrography (CTA) for detecting chondral lesions of the patellofemoral and tibiofemoral joint. Overall, the specificity of radiological measurements was greater than their sensitivity for the detection of both patellofemoral and tibiofemoral joint lesions. The pooled meta-analysis indicated that MRA and CTA were superior in the detection of patellofemoral joint chondral lesions compared with MRI. MRA reported a pooled sensitivity of 0.70 (95% CI: 0.57–0.81) and specificity of 0.99 (0.97–1.00), CTA sensitivity was 0.80 (95% CI: 0.70–0.88) and specificity 0.99 (95% CI: 0.95–1.00), and MRI reported a sensitivity of 0.74 (0.71–0.77) and a specificity of 0.95 (0.94–0.95). Analysis indicated superior diagnostic test accuracy for detection of

tibiofemoral over patellofemoral joint lesions with the tibiofemoral joint reporting a sensitivity of 0.88 (95% CI: 0.86–0.89) and specificity of 0.82 (0.81–0.83), compared with 0.74 (95% CI: 0.71–0.77) and 0.95 (95% CI: 0.94–0.95) for patellofemoral joint sensitivity and specificity, respectively. Higher field strength MRI scanner and grade four lesions were more accurately detected compared with lower field strength and grade one lesions. There appeared no substantial difference in diagnostic accuracy between the interpretation from musculoskeletal and general radiologists when undertaking an MRI review of tibiofemoral and patellofemoral chondral lesions. Authors concluded that MRA, CTA and MRI can only be considered to be accurate for detecting the more advanced chondral lesions. The sensitivity for less-severe lesions is limited. There is little indication to replace the 'gold-standard' arthroscopic investigation with any of these radiological investigations.

Galea et al (2009) conducted a prospective study to evaluate the impact of preoperative MRI assessment of articular knee pathology on the clinical management of patients presenting with joint line pain. A preliminary study on 100 patients was performed to assess accuracy of specific MRI sequences, using arthroscopy as a gold standard. Next, 618 consecutive patients with knee symptoms presenting to two specialist knee surgeons were recruited. In the preliminary study, MRI sequences had an overall sensitivity of 83.2% and a specificity of 94.3% for detecting chondral lesions. In the second phase, 141 (22.8%) of the patients had altered clinical management subsequent to MRI. The authors suggest that preoperative MRI scanning identifies a group of patients who have more advanced degenerative joint disease than clinical assessment and radiographs may indicate.

Low Level of Evidence

Zhang et al (2013) conducted a meta-analysis of 40 studies (total n = 454; mean age range 33.7-49.5) to assess the diagnostic accuracy of MRI compared with arthroscopic findings in grading chondral defects. Studies with inadequate mapping of chondral defects and MR arthrography or contrast-enhanced MRI were excluded. The overall sensitivity, specificity, diagnostic odds ratio, positive likelihood ratio, and negative likelihood ratio were 75% (95% CI: 62%-84%), 94% (95% CI: 89%-97%), 47 (95% CI: 18-122), 12.5 (95% CI: 6.5-24.2), and 0.27 (95% CI: 0.17-0.42), respectively. There was substantial heterogeneity among the results. The authors conclude the results showed that MRI was effective in discriminating normal morphologic cartilage from disease but was less sensitive in detecting knee chondral lesions (> grade 1). The negative results of MRI should not prevent a diagnostic arthroscopy.

Nunes et al (2013) conducted a systematic review of five studies (total *n* = 496) to investigate the diagnostic accuracy of clinical and functional tests used to diagnose patellofemoral pain syndrome (PFPS). The studies in this review analyzed 25 tests intending to accurately diagnose PFPS. Squatting was the most sensitive test (91%), with the lowest LR+ 1.8, LR- 0.2 and highest negative predictive value (74%). The vastus medialis coordination test had the best specificity among all tests (93%); the patellar tilt had the highest LR+ (5.4) and the active instability test had the highest PPV (100%). The authors concluded this review found no PFPS test with diagnostic consistency, which thus prohibits inferences about the best test to use.

Osteoarthritis of the knee on conventional radiography with <u>any</u> of the following:

- **New-onset severe pain**
- **Significant change in symptoms**
- **Pain that is disproportionate to findings on repeat radiography**
- **Pre-surgical planning is necessary:**

- **Green** – **MRI knee without IV contrast**
- **Yellow** – **CT arthrography knee**
  [patient unable to undergo MRI]
- **Yellow** – **MR arthrography knee**
  [patient has had previous meniscal repair and/or ACL reconstruction]
- **Yellow** – **CT knee without IV contrast**
  [evaluate for purposes of surgical planning]
- **Red** – **MRI knee without and with IV contrast**; **MRI knee with IV contrast**; **CT knee with IV contrast**; **CT knee without and with IV contrast**; **bone scan**; **SPECT**; **PET**; **PET/CT**

<u>Level of Evidence:</u> MRI without contrast: moderate-high; MR arthrography: moderate; CT without contrast, bone scan: very low; MRI without and with contrast, MRI with contrast, CT with contrast, CT without and with contrast, PET/CT: insufficient

<u>Notes concerning applicability and/or patient preferences</u>: none.

<u>Guideline and PLE expert panel consensus summary:</u>
Routine imaging for osteoarthritis is not recommended; however, imaging may be recommended if there is an unexpected rapid progression of symptoms or changes in clinical characteristics (Sakellariou et al [*EULAR*] 2017: level III-IV evidence, level of agreement: 8.8). Conventional radiography is the standard for morphological assessment of knee osteoarthritis, and should be used before other modalities (Sakellariou et al [EULAR] 2017; Zhang et al [EULAR] 2010). Advanced imaging modalities are seldom indicated for diagnosis of osteoarthritis (Zhang et al [*EULAR*] 2010; level Ib-IIb evidence; strength of recommendation: 83). If there is radiographic evidence for osteoarthritis and no mechanical symptoms or acute injury suggesting a concomitant internal derangement, MRI is not recommended as an evaluative tool to diagnose, confirm, or manage treatment (*VA/DoD* 2014: grade D recommendation).

MRI
MRI without IV contrast may be indicated when symptoms are not explained by the radiographic findings or the appropriate treatment option requires additional imaging (Fox et al [ACR] 2018). For example, in patients with osteoarthritis who have concomitant signs and symptoms of loose body/locking, meniscal pathology or an injury with a sudden onset of pain and effusion, MRI may be necessary (*VA/DoD* 2014; Grade D recommendation). MRI can also better differentiate patients with more severe patellofemoral osteoarthritis who may not benefit from exercise therapy from those with medial or lateral knee compartment arthritis who may benefit from exercise therapy (Fox et al [ACR] 2018).

CT arthrography
If MRI is not available, CT arthrography may be useful in patients being considered for partial knee arthroplasty or chondroplasty in order to assess for degenerative changes and/or meniscal pathology in the patellofemoral and/or contralateral tibiofemoral compartments (PLE expert panel consensus opinion).

MR arthrography
MR arthrography is usually not indicated to evaluate patients with osteoarthritis (Fox et al [ACR] 2018), but may be helpful in patients with previous meniscal repair and/or ACL reconstruction (PLE expert panel consensus opinion).

CT
CT without IV contrast may be indicated to evaluate the patellofemoral anatomy in knee pain related to repetitive patellofemoral subluxation or maltracking (Fox et al [ACR] 2018). It can also be used to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance [Fox et al [ACR] 2018).

Clinical notes:

- Osteoarthritis is the most common cause of chronic knee pain in elderly patients (Fox et al [ACR] 2018).
- Patients with osteoarthritis typically present with pain and stiffness in the affected joint(s), with stiffness worse in the morning or on arising after prolonged sitting (Katz et al 2021).
- Classical features of knee osteoarthritis on radiographs are focal joint space narrowing, osteophyte, subchondral bone sclerosis and subchondral "cysts" (Katz et al 2021; Zhang et al [*EULAR*] 2010; Fox et al [*ACR*] 2018).
- Prior joint trauma, such as anterior cruciate ligament rupture, increases risk, accounting for about 12% of knee osteoarthritis cases (Katz et al 2021).
- Clinicians must distinguish symptomatic osteoarthritis from other entities that can cause knee pain, including inflammatory arthritis, infection and crystalline arthritis, and soft tissue lesions such as bursitis, tendinitis, and meniscal tear (Katz et al 2021).
- Osteophytes on knee radiographs are both sensitive (91%) and fairly specific (83%) for osteoarthritis (Katz et al 2021).
- Ultrasound can visualize joint effusion, osteophytes, and other features, but is not as accurate as MRI in assessing joint space narrowing (Katz et al 2021).
- Individuals with retropatellar pain may have patellofemoral osteoarthritis, which can exist in isolation or in the presence of tibiofemoral osteoarthritis (Katz et al 2021).
- Because the patellofemoral joint is loaded when the knee is bent, patellofemoral osteoarthritis is especially painful when patients ascend and descend stairs or get into and out of cars (Katz et al 2021).

Technical notes:

- Consideration of radiographic views is important for optimizing detection of OA; in particular for the knee, weightbearing and patellofemoral views are recommended (Sakellariou et al [*EULAR*] 2017; level III evidence; level of agreement: 9.4). Knee radiographs should be performed with the patient standing to reveal the extent of joint space narrowing of the tibiofemoral joint (Katz et al 2021).
- Additional radiographic views (45° oblique views) may be useful if signs and symptoms do not correlate with standard views (Bussieres et al 2007).

- With respect to radiographic views, the 45^{o} flexion PA view is more sensitive for medial and lateral tibiofemoral joint space narrowing than is the standing AP view (Duncan et al 2015). Using the amount of joint space narrowing as a guide for the amount of osteoarthritis can help to both rule in and rule out the presence of severe osteoarthritis (Duncan et al 2015).

Evidence update (2008-present):

Moderate Level of Evidence

Culvenor et al (2019), in a systematic review and meta-analysis, examined the prevalence of MRI features of osteoarthritis in asymptomatic uninjured knees. A total of 63 studies were included (5,397 knees of 4,751 adults). Two reviewers independently assessed risk of bias, and summary estimates were calculated using random-effects meta-analysis. The overall pooled prevalence of cartilage defects was 24% (9% CI 15%-34%) and meniscal tears was 10% (95% CI 7%-13%), with significantly higher prevalence with age. The overall pooled estimate of bone marrow lesions and osteophytes was 18% (95% CI 12%-24%) and 25% (95% CI 14%-38%), respectively, with prevalence of osteophytes (but not bone marrow lesions) increasing with age. The authors conclude that the prevalence of knee osteoarthritis features on MRI in otherwise healthy, asymptomatic, uninjured knees is high.

Hare et al (2017) conducted a multi-center cross-sectional study of 199 patients (mean age = 48; range 35-65) to determine whether symptoms commonly considered to be related to meniscus injury were associated with early radiographic signs of knee osteoarthritis (OA). Patients had MRI-verified degenerative medial meniscal tear, $\geq$ two months' duration of knee pain and no previous significant trauma. Early radiographic signs of OA were associated with increased risk of self-reported swelling (OR 2.4, 95% CI: 1.2–4.9), catching (OR 2.3, 95% CI: 1.2– 4.3), and stiffness later in the day (OR 2.3, 95% CI: 1.1–5.0). At least monthly knee pain, pain during stair walking and when twisting on the knee, and lack of confidence in knee was present in at least 80% of the patients. The authors conclude that patients with a degenerative medial meniscus tear reported symptoms commonly associated with knee OA. Frequent pain, lack of confidence in the knee, and clicking did not distinguish those with a meniscal tear alone from those with early radiographic knee OA.

Low Level of Evidence

Zarringam et al (2021), in a systematic review, examined the added value of SPECT/CT in the diagnostic algorithm of knee osteoarthritis. A total of 9 studies were included in the review. Results from the review not that the use of SPECT/CT might objectify some clinical knee osteoarthritis symptoms, and could correlate with findings on plain radiography and MRI. There is some evidence that SPECT-CT gives additional information compared with these imaging modalities; however, superiority is not proven. The uptake on SPECT could predict intraoperative macroscopic findings; yet, the clinical relevance remains unclear. The authors conclude that there is no strong evidence that SPECT/CT should play a role in the diagnosis and decision-making process of knee osteoarthritis, and more clinical studies are better needed to define its role in this area.

Nguyen et al (2018) prospectively evaluated prognostic and diagnostic values of ^{18}F-FDG PET for identification and classification of osteoarthritis (OA) of shoulder, hip, and knee joints in 65 patients. 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, acromioclavicular (AC), and glenohumeral (GH) joints. Scout PET/CT images were evaluated for OA using the Kellgren and Lawrence (K/L) system. Patients were followed-up for 5 years to determine progression of OA on basis of follow-up imaging or surgical intervention. SUV of knee (r=0.309, P=0.0003), hip (r=0.260, P=0.0027), AC (r=0.186, P=0.0313), and GH (r=0.191, P=0.0271) joints

correlated with WOMAC overall scores. SUV of knee (r=0.410, P<0.0001), hip (r=0.203, P=0.0199), and AC (r=0.364, P<0.0001) joints correlated with K/L scores. The area under the receiver operating characteristic curves for SUV were 0.734 (knee), 0.678 (hip), 0.661 (AC), and 0.544 (GH) for symptomatic OA detection. Compared with K/L score [hazard ratio (HR)=0.798, P=0.5324], age (HR=0.992, P=0.8978), and WOMAC overall score (HR=1.089, P=0.1265), only SUV (HR=5.653, P=0.0229) was an independent predictor of OA progression in the knees. The authors conclude that ^{18}F-FDG PET/CT may be helpful with localization of painful abnormalities in inflamed joint regions, which could potentially be used to direct individualized treatment in moderate and severe OA.

Carotti et al (2017) conducted a cross-sectional study to investigate associations between structural findings on MRI (bone marrow lesions [BMLs], synovitis, cartilage defects, meniscal lesions), radiograph examination (Kellgren and Lawrence [KL] grade), and psychological aspects with pain in 149 patients (mean age = 70) with symptomatic knee osteoarthritis (KOA). Knee radiographs were acquired and scored according to K/L grade. MRI was performed, with presence of the following alterations collected: BMLs, infrapatellar fat pad (IFP) synovitis, chondral defects, and meniscal tears. BMLs were detected in 38.3%, cartilage defects in 91.9%, IFP synovitis in 37.5%, and meniscal lesions in 34.9%. Knee pain was significantly associated with volume of BMLs (p = 0.0001), IFP synovitis (p = 0.0036), and SF-36 MCS scores (p = 0.0001). The authors conclude that in KOA patients, MRI features, such as larger BMLs, IFP synovitis, and high psychological distress, are associated with greater knee pain.

Clinical or radiological suspicion for avascular necrosis (osteonecrosis):

- Green – **MRI knee without IV contrast**
- Yellow – **MRI knee with IV contrast**
  [previous findings on MRI without IV contrast are non-diagnostic]
- Yellow – **CT knee without IV contrast**
  [patient unable to undergo MRI]
- Yellow – **Bone scan/SPECT** or **Bone scan/SPECT/CT**
  [patient unable to undergo MRI; previous findings on MRI without IV contrast are non-diagnostic]
- Red – **MRI knee without and with IV contrast**; **MR arthrography knee**; **CT knee with IV contrast**; **CT knee without and with IV contrast**; **CT arthrography knee**; **PET**; **PET/CT**

Level of Evidence: MRI without contrast: moderate; CT without contrast, bone scan: low; MRI without and with contrast, MRI with contrast, MR arthrography, CT with contrast, CT without and with contrast, CT with contrast, PET/CT: insufficient

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 summary:
Radiographs should be the initial imaging study for chronic knee pain (Fox et al [*ACR*] 2018). MRI is useful when radiographs are normal, especially in high-risk patients, and should be the first choice for advanced imaging of suspected osteonecrosis of the extremities (Bussieres et al 2007: B level recommendation). MRI can identify subchondral insufficiency fractures earlier than radiographs with radiographs often initially normal (Fox et al [*ACR*] 2018). In patients with subchondral insufficiency fracture (now recognized as the underlying cause of what was previously termed spontaneous osteonecrosis of the knee) on radiographs, MRI without IV contrast may be indicated if an additional injury is suspected clinically, or to clarify the status of the overlying articular cartilage (Fox et al [*ACR*] 2018). Bone scan or CT can be considered on a case-by-case basis for suspected osteonecrosis of the extremities when MRI is not available (Bussieres et al 2007: B level recommendation).

Clinical notes:

- Avascular necrosis, or osteonecrosis, is a form of ischemic bone necrosis due to vascular insufficiency. It is often (60-75%) associated with antecedent risk factors such as sickle cell disease, steroid use, alcoholism, or metabolic bone disease (Bussieres et al 2007).

Evidence update (2012-present):
No articles identified in the 2022 update that have impact on the guideline summary and recommendations listed above.

Suspected stress or insufficiency reaction/fracture and negative or non-diagnostic radiographs:

- Green – **MRI knee without IV contrast**
- Yellow – **CT knee without IV contrast**
  [previous findings on MRI without IV contrast are non-diagnostic; or patient unable to undergo MRI; or further characterize or evaluate healing of known fracture]
- Yellow – **Bone scan/SPECT** or **Bone scan/SPECT/CT**
  [patient unable to undergo MRI; previous findings on MRI without IV contrast are non-diagnostic]
- Red – **MRI knee with IV contrast**; **MRI knee without and with IV contrast; MR arthrography knee**; **CT knee with IV contrast**; **CT knee without and with IV contrast**; **CT arthrography knee; PET**; **PET/CT**

Level of Evidence: MRI without contrast: moderate-high; CT without contrast: low; Bone scan: very low; MRI without and with contrast, MRI with contrast, MR arthrography, CT with contrast, CT without and with contrast, PET/CT: insufficient

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 summary:
Radiographs
Radiographs in at least two planes should be obtained as the initial imaging study in every patient suspected of having a stress fracture (Bencardino et al [ACR] 2017*). While early radiographic findings are typically nonspecific, more specific findings tend to develop over time (Bencardino et al [ACR] 2017). Because of this, repeat radiographs after 10 or more days may be appropriate, depending on the location of pain and relative risk of potential complications (Bencardino et al [ACR] 2017).

MRI
The clinical literature favors MRI as the advanced imaging procedure of choice for early diagnosis of stress fractures, outperforming bone scintigraphy, and CT (Bencardino et al [ACR] 2017). With superb contrast resolution and multiplanar imaging capability, MRI is highly accurate to evaluate for the presence of radiographically occult fractures (Taljanovic et al [ACR] 2020). MRI is extremely sensitive and demonstrates stress abnormalities as early as bone scintigraphy and with as much sensitivity (Bencardino et al [ACR] 2017). In patients with subchondral insufficiency fracture (now recognized as the underlying cause of what was previously termed spontaneous osteonecrosis of the knee) on radiographs, MRI without IV contrast may be indicated if an additional injury is suspected clinically or to clarify the status of the overlying articular cartilage (Fox et al [*ACR*] 2018). The use of intravenous contrast is not necessary for diagnosis (Bencardino et al [ACR] 2017).

CT
While not typically used as a primary imaging tool, CT may be appropriate for the evaluation of suspected radiographically occult knee fractures when other imaging modalities are equivocal (Taljanovic et al [ACR] 2020; Bencardino et al [ACR] 2017). Although superior to radiography, it is less

sensitive than nuclear scintigraphy or MRI (Bencardino et al [ACR] 2017). The use of intravenous contrast is not helpful for this patient population (Bencardino et al [ACR] 2017).

Bone scan
Bone scan with SPECT or SPECT/CT is generally not the first imaging study to evaluate for radiographically occult fractures (Taljanovic et al [ACR] 2020). Previously acknowledged as the standard advanced imaging modality for stress-induced injuries, its use has largely been replaced by MRI (Bencardino et al [ACR] 2017). However, bone scan can show stress fracture earlier than radiographs in many instances, and differentiates between osseous and soft tissue injury (Bencardino et al [ACR] 2017). Bone scan with SPECT is more accurate in diagnosing stress injuries than planar bone scan (Bencardino et al [ACR] 2017).

MR arthrography
MR arthrography is not routinely used as the initial imaging study, following negative radiographs, for evaluating suspected occult knee fractures (Taljanovic et al [ACR] 2020).

*This guideline did not pass the AGREE II cutoff score, but was included for its direct relevance to this clinical scenario.

Clinical notes:

- Stress fractures occur in two varieties: 1) fatigue fractures resulting from repetitive submaximal stress on normal bone, resulting in a region of accelerated bone remodeling, and 2) insufficiency fractures due to normal activity on bones that are deficient in microstructure and/or mineralization (Bencardino et al [*ACR*] 2017).
- At the microscopic level, repetitive overloading leads to increased osteoclastic activity that exceeds the rate of osteoblastic new bone formation, resulting in bone weakening, stress injury, and possible fracture (Bencardino et al [ACR] 2017).

Evidence update (2006-present):
No articles identified in the 2022 update that have impact on the guideline summary and recommendations listed above.

Clinical or radiological suspicion for septic arthritis, osteomyelitis and/or periarticular abscess:

- Green – **MRI knee without IV contrast** or **MRI without and with IV contrast**
- Yellow – **CT knee with IV contrast** or **CT knee without IV contrast**
  [evaluate for soft tissue gas, foreign body, or chronic osteomyelitis; or patient unable to undergo MRI]
- Yellow – **Multiphase bone scan (with or without SPECT or SPECT/CT) or White Blood Cell (WBC) scan (with or without SPECT or SPECT/CT)**
  [patient unable to undergo MRI; previous findings on MRI without IV contrast are non-diagnostic]
- Red – **MRI knee with IV contrast**; **MR arthrography knee**; **CT knee without and with IV contrast**; **CT arthrography knee**; **PET**; **PET/CT**

Level of Evidence: CT without contrast: moderate; MRI without contrast, MRI without and with contrast, MRI with contrast, bone scan: low; CT with contrast: very low; MR arthrography, CT without and with contrast, CT arthrography, PET/CT: insufficient

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 summary:
Radiographs
Radiographs are the recommended first study for patients with suspected osteomyelitis, septic arthritis or soft-tissue infection (Beaman et al [ACR] 2017; Coakley et al 2006: C recommendation). Although often not diagnostic in acute osteomyelitis, they may show chondrocalcinosis, provide anatomic evaluation of the affected site, depict changes of chronic osteomyelitis, reveal gas or foreign bodies, and suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor (Beaman et al [*ACR*] 2017; Coakley et al 2006).

MRI
Magnetic resonance imaging is sensitive in detecting suspected bone and extremity soft tissue infections, and should be used as the advanced imaging modality of choice (Beaman et al [*ACR*] 2017; Bussieres et al 2007; Coakley et al 2006: B recommendation). MRI has a 100% negative predictive value for excluding osteomyelitis; a normal marrow signal reliably excludes infection (Beaman et al [ACR] 2017). The absence of a joint effusion and synovial hyperplasia effectively excludes septic arthritis (PLE expert panel consensus opinion). While the use of MRI without and with IV contrast is preferred, MRI without IV contrast is an alternative if contrast is contraindicated (Beaman et al [ACR] 2017).

CT
CT is particularly sensitive to soft tissue gas (that can signal necrotizing fasciitis) and foreign bodies, and is in fact superior to MRI for diagnosing these conditions (Beaman et al [ACR] 2017). The addition of IV contrast is useful to evaluate soft tissue, while CT without contrast is preferred for assessment of a radiopaque foreign body (Beaman et al [ACR] 2017).

Bone scan

Nuclear medicine examinations may be useful in situations where MRI is contraindicated, infection is multifocal, or when the infection is associated with chronic bone alterations from trauma or surgery (Beaman et al [*ACR*] 2017). Bone scans, highly sensitive but lacking specificity, can become positive as early as one or two days after the onset of clinical symptoms (Beaman et al [ACR] 2017; Bussieres et al 2007). A 3-phase bone scan aids in distinguishing cellulitis from osteomyelitis (Beaman et al [ACR] 2017). A WBC scan may also be appropriate for suspicion of osteomyelitis (Beaman et al [ACR] 2017). The addition of single-photon emission CT (SPECT) or SPECT/CT improves the accuracy of radionuclide scintigraphy, facilitating the differentiation between bone and soft-tissue infection (Beaman et al [*ACR*] 2017).

FDG-PET
Currently, there is no evidence supporting the use of FDG-PET in the evaluation of septic arthritis, as FDG also accumulates in inflammatory arthritis (Beaman et al [*ACR*] 2017).

Clinical notes:

- Imaging plays a key role in characterizing soft tissue and osseous infections by identifying the location, evaluating the extent of involvement, and detecting complications (Beaman et al [ACR] 2017).
- Patients with a short history of a hot, swollen, and tender joint(s) with restriction of movement should be regarded as having septic arthritis until proven otherwise (Coakley et al 2006).
- In patients with new knee pain and a new joint effusion or swelling following an injection procedure in the knee, the white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) should be measured (PLE expert panel consensus opinion).
- In patients with suspected joint infection, joint aspiration is recommended for diagnosis. Ultrasound can be used to confirm the presence of a joint effusion. Fluoroscopy or ultrasound may be used to guide diagnostic joint aspirations (Beaman et al [ACR] 2017; PLE expert panel consensus opinion).

Evidence update (2016-present):
No articles identified in the 2022 update that have impact on the guideline summary and recommendations listed above.

Suspected intraarticular pathology associated with a Baker's (popliteal) cyst*:

- Green – **MRI knee without IV contrast**
- Yellow – **CT arthrography knee**
  [patient unable to undergo MRI]
- Yellow – **MR arthrography knee**
  [patient has had previous meniscal repair and/or ACL reconstruction]
- Red – **MRI knee without and with IV contrast**; **MRI knee with IV contrast**; **CT knee without and with IV contrast**; **CT knee without contrast**; **CT knee with IV contrast**; **PET**; **PET/CT**; **SPECT**; **bone scan**

*Ultrasound is recommended for the initial evaluation of a suspected popliteal cyst (Fox et al [ACR] 2018).

Level of Evidence: Ultrasound: very low; MRI without and with contrast, MRI without contrast, MRI with contrast, MR arthrography, CT without and with contrast, CT without contrast, CT with contrast, PET/CT, bone scan: insufficient

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus summary:
In patients presenting with symptomatic semimembranosus or medical gastrocnemius bursal (Baker's) cysts, conventional radiography is useful to evaluate for osteoarthritis, while MRI (or MR/CT arthrography) can be used for intraarticular pathology or otherwise atypical cases (PLE expert panel consensus opinion). MRI accurately depicts the presence or rupture of a popliteal cyst (Fox et al [*ACR*] 2018) and, if ultrasound is non-diagnostic or not available, may be useful in the evaluation of associated bursitis, tendinitis, strain, or tendinosis (Bussieres et al 2007: level D recommendation; PLE expert panel consensus opinion).

Clinical notes:

- On physical examination of persons with osteoarthritis, those with effusions may have popliteal or Baker cysts, which are extensions of the synovial swelling that can be palpated in the posterior aspect of the knee (Katz et al 2021).
- Bursal cysts should localize to the semimembranosus-medial gastrocnemius space or should extend deep to the semimembranosus tendon or MCL. Ganglion cysts should arise from the joint capsule, cruciate ligaments or periarticular tendons. Meniscal cysts should arise from or be contiguous with the meniscocapsular attachment (PLE expert panel consensus opinion).
- Cysts with solid components and cysts who do not meet these criteria should be evaluated for possible malignancy (e.g., monophasic synovial cell sarcoma, peripheral nerve sheath tumors, cystic metastases or myxomatous tumors) which can mimic a benign cyst (PLE expert panel consensus opinion).
- Ultrasonography has proved useful and simple for detecting Baker's cyst, which may be treated by aspiration or monitored over time (Picerno et al 2014). Ultrasound is as accurate in diagnosing a popliteal cyst and detecting cyst rupture when compared to MRI (Fox et al [*ACR*] 2018).

- Aspiration and injection of a popliteal cyst and corticosteroid injection can be done under ultrasound guidance (Bussieres et al 2007).

Evidence update (2006-present):

Low Level of Evidence

A literature review by Herman & Marzo (2014) discussed the anatomy and etiology of popliteal cysts, including the common clinical presentations, differential diagnoses, and guidance for proper diagnostic imaging. Radiographs are simple and readily available, but provide limited information; they may help in identifying associated articular disorders, such as loose bodies in the cyst or general findings of osteoarthritis and inflammatory arthritis. Ultrasound (US) has quickly become a popular replacement for arthrography in imaging for the presence of popliteal cysts. It is readily available, relatively inexpensive, and noninvasive, involves no exposure to radiation and allows assessment of the cyst. However, it is not sensitive to intraarticular lesions, and so further imaging is needed to confirm the presence of an associated internal derangement. MRI is considered the gold standard in visualizing and characterizing masses about the knee. An MRI can confirm the cystic, unilocular nature of the benign popliteal cyst; evaluate its relationship to anatomic structures in the joint and surrounding tissue; and delineate associated intra-articular pathologies. Ultrasound is the reasonable choice for quickly assessing a potential popliteal cyst. However, MRI follow-up may be necessary to confirm the cyst and diagnose coexistent knee joint pathology. Overall, US and MRI have proven to be consistent and accurate in the confirmation of popliteal cysts, with MRI becoming the modern imaging modality of choice.

Picerno et al (2014) conducted a retrospective study to investigate the prevalence of Baker's cyst (BC) in patients with knee pain, and to assess the correlation between BC and severity of osteophytes and joint effusion. A total of 399 patients (mean age = 56.2; range 18- 89) with knee pain were included. Of these, 293 patients (73.43%) showed US signs of osteophytosis of the knee, 251 (62.9%) joint effusion and 102 (25.56%) BC. A total of 99 (33.8%) patients with osteophytosis also had BC. Only three patients had BC without US signs of osteoarthritis (OA). Logistic regression showed a positive correlation between presence of BC and severity of OA, and between BC and degree of effusion. Specifically, the Odds Ratio for presence of BC increased by about 1.42 (CI 95%: 1.03-1.96) for each grade in the OA severity score, whereas for each grade in the degree of joint effusion the Odds Ratio increased by about 1.82 (CI 95%: 1.29-2.57). The authors found a 25.8% prevalence of BC in patients with knee pain and suggest a positive association between BC and OA of the knee (with an increasing trend between prevalence and severity of osteoarthritis) and between BC and presence and degree of joint effusion. These data support that all patients with osteoarthritis of the knee, especially advanced disease with joint effusion, should undergo ultrasonographic screening for BC.

Guideline exclusions:

Ultrasound is not considered advanced imaging by the Centers for Medicare & Medicaid Services (CMS) or by statute; the appropriate applications of ultrasound are not addressed directly in this document. Other exclusions include:

- Inflammatory arthritis other than septic arthritis
- Evaluation of suspected infection in patients with knee prostheses.
- Crystal deposition disease
- Metabolic bone disease
- Primary synovial abnormalities, such as pigmented villonodular synovitis (PVNS) or osteochondromatosis
- Osteochondritis dissecans
- Suspected osteoid osteoma
- Incidental bone lesions
- Primary bony or soft tissue neoplasm
- Complications of partial and total knee arthroplasties
- Major/high velocity trauma
- Pediatric patients
- Pregnant patients.

AUC Revision History:

Revision Date:	New AUC Clinical Scenario(s):	Approved By:
05/22/2018	Initial Document Development	CDI Quality Institute's Multidisciplinary Committee
07/09/2019	n/a	CDI Quality Institute's Multidisciplinary Committee

02/22/2022	n/a	RAYUS Quality Institute's Multidisciplinary Committee

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

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02/22/2022

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