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Provider Led Entity

CDI Quality Institute PLE
Knee Pain AUC
2019 Update

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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
KL	Kellgren Lawrence
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
OCD	Osteochondritis dissecans
OKR	Ottawa Knee Rule
ON	Osteonecrosis
PET	Positron emission tomography
PFS	Patellofemoral syndrome
PLE	Provider Led Entity
SPR	Society of Pediatric Radiology
SSR	Society of Skeletal Radiology
US	Ultrasound
VA	Department of Veterans Affairs

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

- **Green** – MRI without IV contrast
- **Yellow** – CT arthrography in patients who cannot undergo MRI
- **Yellow** – CT without IV contrast in patients with suspected tibial plateau fracture and negative or indeterminate radiographs, or to characterize a fracture detected on radiographs
- **Yellow** – MR arthrography in patients with previous meniscal repair and/or ACL reconstruction
- **Yellow** – CT angiography or MR angiography to evaluate for suspected vascular injury in patients with multiple ligament injuries and in patients with known or suspected dislocation
- **Red** – MRI without and with IV contrast, MRI with IV contrast, CT with IV contrast; CT 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:
Strong evidence supports that MRI can provide confirmation of ACL injury and assist in identifying concomitant knee pathology, such as other ligament, meniscal, or articular cartilage injury (Shea et al [*AAOS*] 2015; strength of recommendation: strong).

MRI is a valid and safe non-invasive diagnostic tool for diagnosing anterior cruciate ligament injury, with a high sensitivity and specificity (both 94%) (Meuffels et al 2012 [*Dutch Orthopaedic Association*]; Level 1 scientific evidence).

MRI has no additional value when physical examination has shown anterior-posterior or rotational instability of the knee, suggesting an anterior cruciate ligament injury. However, MRI is a reliable additional investigation to establish other intraarticular lesions (Meuffels et al 2012 [*Dutch Orthopaedic Association*]; Level 2 scientific evidence). *With respect to the above statements, the PLE expert panel thought that MRI is useful for surgical planning in patients undergoing ACL reconstruction to detect associated ligamentous injuries and/or meniscal tears* (PLE expert panel consensus opinion).

In patients with acute trauma to the knee – fall or twisting injury, no focal tenderness, no effusion, able to walk, first study, the *American College of Radiology* (Tuite et al [*ACR*] 2015) does not recommend any imaging.

In patients with acute trauma to the knee – fall or twisting injury, with one or more of the following: focal tenderness, effusion, inability to bear weight, first study, the *American College of Radiology* (Tuite

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et al [*ACR*] 2015) recommends x-ray knee (9) or MRI knee without IV contrast (5).

In patients with acute trauma to the knee – mechanism unknown, focal patellar tenderness, effusion, able to walk, the *American College of Radiology* (Tuite et al [*ACR*] 2015) recommends x-ray knee (9) or MRI knee without IV contrast (5).

In patients with acute trauma to the knee – fall or twisting injury with either no fracture or a Segond fracture seen on radiograph, suspect internal derangement, next study, the *American College of Radiology* (Tuite et al [*ACR*] 2015) recommends MRI knee without IV contrast (9), or CT knee without IV contrast (5).

In patients with acute trauma to the knee – fall or twisting injury with a tibial plateau fracture on a radiograph, with additional bone or soft-tissue injury suspected, next study, the *American College of Radiology* (Tuite et al [*ACR*] 2015) recommends CT knee without IV contrast (9), or MRI knee without IV contrast (7). *With respect to the above statement, the PLE expert panel consensus opinion was that thin section CT with multiplanar reconstructions would be useful to characterize tibial plateau fractures in consideration of operative reduction and internal fixation, while MRI would be useful to evaluate for associated meniscal tears, which can occur in a significant percentage of these patients.*

[In adults with acute knee injury] radiographs are indicated in the presence of one or more of the Ottawa Knee Rule (OKR) criteria. MRI is the modality of choice [if special investigations are indicated]. CT, US, or angiogram may be needed for additional information (Bussieres et al 2007; C level recommendation).

MRI is the gold standard for internal knee derangements such as meniscal and ligamentous injuries. Spiral CT arthrography may be indicated if MRI is unavailable (Bussieres et al 2007; C level recommendation).

The diagnosis of meniscal and cruciate ligament injuries to the knee can be made by MRI with a reasonable level of accuracy; however, many patients can be diagnosed without the need for this investigation. When there is an equivocal diagnosis, specialists may consider MRI to clarify the diagnosis and inform treatment decisions. MRI should generally be used ahead of diagnostic arthroscopy (Robb et al [*NZMA*] 2007; Grade C recommendation).

Computed tomography (CT) arthrogram may be useful to evaluate intra-articular abnormalities in patients who cannot undergo MRI. CT without contrast has very low sensitivity for internal knee derangements (PLE expert panel consensus opinion).

Direct and indirect MR arthrography may be beneficial for various internal knee derangements and for imaging postoperative conditions (*ACR, SPR,* & *SSR* 2015).

In patients with suspected knee dislocation, the *American College of Radiology* (Tuite et al [*ACR*] 2015) recommends x-ray of the knee (9) or MRI without IV contrast (9) to evaluate the extent of damage to ligaments and other support structures. MR arteriography (7), CT arteriography (7) or arteriography (7) are useful to evaluate for associated vascular injury.

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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 requiring emergency care (Shea et al 2015 [*AAOS*]; work group consensus recommendation).
- The OKR is a valuable tool to guide the use of x-rays for excluding fractures in people with acute knee injuries in an emergency department setting (Robb et al [*NZMA*] 2017; Grade A recommendation; (*NICE* 2016).
- The OKR is that radiography series to exclude fracture are only required for acute knee injury in people with one or more of the following (Tuite et al 2015 [*ACR*]; Robb et al 2007 [*NZMA*]):
  - aged 55 or older
  - tenderness at the head of the fibula
  - isolated tenderness of the patella
  - inability to flex the knee to 90 degrees
  - inability to bear weight immediately following the injury
  - inability to walk four weight-bearing steps at examination
- In adults with acute knee injury and positive findings for the OKR, radiographs are indicated in the presence of one or more of the OKR criteria (A-level recommendation). If radiographs are negative but clinical signs are persistent, repeat films should be obtained 7-10 days after onset. Callus or deformity may become visible in the first month (Bussieres et al 2007).
- Adults with acute knee injury but negative findings for the OKR indicates that a fracture is very unlikely and routine radiographs are not routinely indicated (Bussieres et al 2007; B level recommendation).
- Patients excluded from the OKR include the following: referred with outside films; gross deformity; a palpable mass; < 18 years of age; pregnancy; isolated skin injury; a penetrating injury; unreliable physical exam secondary to multiple injuries; altered level of consciousness; neuropathy (paraplegia, diabetes) (Tuite et al [*ACR*] 2015; Bussieres et al 2007).
- Computed tomography (CT) with 3-D reconstruction has been compared to knee radiographs and shown to be more sensitive for fracture, 100% versus 83% for radiographs, and to reflect the severity of tibial plateau fractures more accurately (Tuite et al [ACR] 2015).
- Soft-tissue injuries are common in many patients with knee fractures (Tuite et al [*ACR*] 2015). Mustonen et al (2008) reported unstable meniscal tears in 36% of patients with tibial plateau fractures. 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.
- In patients with suspected dislocation of the knee, vascular injury can be seen in about 30% of patients. Physical signs of vascular injury include the absence of pulses, an abnormal ankle brachial index (ABI), asymmetric pulses, ischemia, an increasing hematoma and a bruit/thrill (Tuite et al [*ACR*] 2015).
- While angiography is considered the gold standard for vascular injury, CT angiography is being increasingly used because it is less invasive, has a high accuracy and a lower radiation dose (Tuite et al [*ACR*] 2015).
- Authors have reported 100% correlation between MR angiography and conventional angiography in patients with multiple ligament injuries and knee dislocations (Tuite et al [*ACR*] 2015).

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Technical notes:

- For patellar pain, radiographs should include patellar sunrise [tangential] views (Tuite et al [*ACR*] 2015).
- 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).

Evidence update (2008-present):

Clinical Exam

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 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 (moderate level of evidence).

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. Records of patients were reviewed, with 281 (64.7%) having 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 duration of symptoms, 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, and this information could aid physicians in deciding which patients should undergo knee MRIs (low level of evidence).

Kostov et al (2014) conducted a prospective study of 103 patients (mean age = 29.7; range 16-58) to compare findings from clinical exam, MRI, and arthroscopy in ACL injuries to assess diagnostic significance. The Lachman clinical exam showed 92% sensitivity, 100% specificity, 100% PPV, and 86% NPV for diagnosing ACL tears. The pivot shift clinical exam for ACL tears showed 62% sensitivity, 98% specificity, 98% PPV, and 67% NPV. MRI had 83% sensitivity, 88.4% specificity, 93% PPV, and 74.5% NPV. The authors conclude that when clinical diagnosis is in favor of ACL injuries, performing an MRI scan prior to arthroscopic examination is unlikely to be of significance. MRI scanning should not be used as a primary diagnostic tool in ACL injuries (low level of evidence). *The PLE expert panel agreed that MRI was useful in patients undergoing ACL reconstruction in order to evaluate for associated abnormalities (e.g., meniscal tears) in the medial and lateral compartments* (PLE expert panel consensus opinion).

MRI

Smith et al (2016) conducted a meta-analysis of 13 studies (n = 1,197 patients) to assess the evidence for

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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 (moderate level of evidence).

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. 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 when interpreting results (moderate level of evidence).

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 (moderate level of evidence).

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 (low level of evidence).

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

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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 (low level of evidence).

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 (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 as reference standard. The presence of DLM on MRI was determined by orthopaedic 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 (low level of evidence).

Yeo et al (2018) evaluated diagnostic performance of MR imaging findings for diagnosis of a ramp lesion in patients with an ACL-deficient knee. Seventy-eight consecutive patients (mean age 33.7 years; 64 male) with arthroscopically proven ACL tear were retrospectively included. Presence of the following features on MR images were recorded: complete fluid filling between posterior horn of medial meniscus and capsule margin; edema affecting posterior capsule; irregularity of medial meniscus at posterior margin; fluid at periphery of medial meniscus; corner notch sign; and a vertical tear at medial meniscus. Findings at arthroscopy served as reference standard. Seven ramp lesions were noted on arthroscopy (9%). Findings of irregularity at posterior margin ($p = 0.001$) and complete fluid filling between posterior horn of medial meniscus and capsule margin ($p = 0.004$) on MR imaging were significantly associated with presence of a ramp lesion. With the irregularity at posterior margin, sensitivity was 86% and specificity was 79%. Complete fluid filling sign showed sensitivity of 57% and specificity of 92%. The authors conclude that irregularity at posterior margin and complete fluid filling were most sensitive findings for detecting a ramp lesion on MR imaging (low level of evidence).

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CT

Heffernan et al (2017) conducted a prospective study of 40 consecutive patients (mean age = 35.7 years; range 15-65) who underwent same-day MRI and MDCT of the knee to evaluate the accuracy of MDCT for assessing cruciate ligament tears and to determine its accuracy in the diagnosis of additional soft-tissue injuries. MDCT images were independently evaluated for integrity of the ACL and PCL, medial and lateral menisci, and medial and lateral collateral ligaments by two musculoskeletal radiologists, both blinded to clinical details and MRI findings. The sensitivity of MDCT for ACL tears was 87.5-100%, with specificity of 100%. The presence of one or more secondary signs of ACL tears on MDCT had a sensitivity of 50-87.5% with specificity of 100%. The sensitivity of MDCT for PCL tears was 0-25% with specificity of 100%. The sensitivity for meniscal tears was 9.1-23.1% with specificity of 96.3-100%. Interobserver agreement was very good for diagnosing ACL and meniscal tears and poor for PCL tears. The authors concluded that MDCT has very high sensitivity and specificity for ACL tears and a low sensitivity for other soft-tissue injuries of the knee. However, its high specificity indicates that apparent PCL, meniscal, and collateral ligament tears can reliably be treated as true-positive findings (low level of evidence).

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Nontraumatic knee pain persisting after an appropriate trial of conservative care and no major abnormalities (e.g., fracture, AVN, tumor, or moderate or severe osteoarthritis) on radiographs:

- **Green** – MRI without IV contrast
- **Yellow** – CT arthrography in patients who cannot undergo MRI
- **Yellow** – MR arthrography in patients with previous meniscal repair and/or ACL reconstruction
- **Orange** - CT without IV contrast, except when assessing patellofemoral morphology for surgical planning
- **Red** – MRI with IV contrast, MRI without and with IV contrast, CT with IV contrast, CT 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 patients with *chronic knee pain, initial knee radiograph negative or demonstrates joint effusion, next imaging procedure*, the *American College of Radiology* (Fox et al [*ACR*] 2018) recommends MRI knee without IV contrast (*usually appropriate*). Additionally, aspiration knee, CT arthrography knee, CT knee without contrast, ultrasound knee, or MR arthrography knee *may be appropriate*.

- MRI accurately depicts the extent of an effusion and presence of synovitis.
- CT without IV contrast may be indicated to evaluate the patellofemoral anatomy in knee pain related to repetitive patellofemoral subluxation or maltracking. It can also be used to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance.
- CT arthrography may be used instead of MRI when an intra-articular abnormality is suspected to evaluate the menisci and articular cartilage.
- MR arthrography knee may be reserved for patients with known prior meniscal surgery, chondral and osteochondral lesions, and suspected loose bodies.

In patients with *chronic knee pain, initial knee radiograph demonstrate osteochondritis dessicans, loose bodies, or history of cartilage or meniscal repair, next imaging procedure,* the *American College of Radiology* (Fox et al [*ACR*] 2018) recommends MRI knee without IV contrast (*usually appropriate*). Additionally, CT arthrography knee, CT knee without IV contrast, or MR arthrography knee *may be appropriate*.

- MRI without IV contrast may be indicated if additional injury is suspected clinically or to clarify the status of the overlying articular cartilage.
- CT arthrography may be used instead of MRI to evaluate the menisci, articular cartilage, and presence of loose bodies.
- CT without IV contrast may be indicated to evaluate patients with osteochondritis dessicans or a history of cartilage repair, especially to confirm loose bodies or when MRI is not definitive.
- MR arthrography is typically reserved for patients with known prior meniscal surgery, chondral and osteochondral lesions, prior cartilage repair procedures, or suspected loose bodies.

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The assessment and management of nontraumatic degenerative meniscal lesions depend on the extent of cartilage damage. In the event of [knee pain], symptomatic medical treatment over six months is advisable. X-rays (anterior-posterior views, Schuss, lateral and patellofemoral 30°) should be carried out. When the patient does not respond to a complete course of medical treatment, MRI should be performed to evaluate the menisci, the subchondral bone, the synovium, and, to a lesser extent, the cartilage (Beaufils et al 2009; professional agreement).

If diagnosis is not well established from history, examination and radiographs or in the absence of clinical improvement, MRI is the gold standard for internal knee derangements such as meniscal and ligamentous injuries. Spiral CT arthrography [can be used] if MRI is unavailable (Bussieres et al 2007; C level recommendation).

Computed tomography (CT) arthrogram may be useful to evaluate intra-articular abnormalities in patients who cannot undergo MRI. CT without contrast has very low sensitivity for internal knee derangements (PLE expert panel consensus opinion).

MRI is the gold standard for internal knee derangements such as meniscal and ligamentous injuries. Spiral CT arthrography may be indicated if MRI is unavailable (Bussieres et al 2007; C level recommendation).

MR arthrography may be useful in patients with previous meniscal repair and/or previous ACL reconstruction (PLE expert panel consensus opinion).

The diagnosis of meniscal and cruciate ligament injuries to the knee can be made by MRI with a reasonable level of accuracy; however, many patients can be diagnosed without the need for this investigation. When there is an equivocal diagnosis, specialists may consider MRI to clarify the diagnosis and inform treatment decisions. MRI should generally be used ahead of diagnostic arthroscopy (Robb et al [*NZMA*] 2007; Grade C recommendation).

Clinical notes:

- Radiographs should be the initial imaging study for chronic knee pain (Fox et al [*ACR*] 2018).
- In adult patients with nontraumatic knee pain of < 4 weeks duration, radiographs are not initially indicated (Bussieres et al 2007; C level recommendation).

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):

Clinical Exam

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

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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 (moderate level of evidence).

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 (moderate level of evidence).

MRI

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 (moderate level of evidence).

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, MRA, and 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

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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 (moderate level of evidence).

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 (moderate level of evidence).

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Nontraumatic (chronic) knee pain with moderate to severe osteoarthritis on initial radiographs:

- **Green** – *
- **Yellow** – MRI without IV contrast in patients with new-onset severe pain, mechanical symptoms, a significant change in symptoms, or pain which is disproportionate to findings on repeat radiography
- **Yellow** – CT arthrography if the patient is unable to undergo MRI and there is new-onset severe pain, mechanical symptoms, a significant change in symptoms, or pain which is disproportionate to findings on repeat radiography
- **Yellow** – MR arthrography in patients with previous meniscal repair and/or ACL reconstruction and new-onset severe pain, mechanical symptoms, a significant change in symptoms, or pain which is disproportionate to findings on repeat radiography
- **Yellow** – MRI without IV contrast for surgical planning in patients considering patellofemoral arthroplasty or chondroplasty
- **Yellow** – CT arthrography for surgical planning in patients who are considering partial knee arthroplasty or chondroplasty and who are unable to undergo MRI
- **Yellow** – MR arthrography for surgical planning in patients with previous meniscal repair and/or ACL reconstruction who are considering partial knee arthroplasty or chondroplasty
- **Red** – MRI without and with IV contrast, MRI with IV contrast, CT with IV contrast, CT without IV contrast, CT without and with IV contrast, bone scan, SPECT, PET, PET/CT

* Advanced imaging is not recommended for the routine diagnosis, management or follow-up of osteoarthritis of the knee.

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:
Routine imaging in osteoarthritis follow-up is not recommended; however, imaging is recommended if there is unexpected rapid progression of symptoms or changes in clinical characteristics to determine if this relates to osteoarthritis or an additional diagnosis (Sakellariou et al [*EULAR*] 2017; level III-IV evidence; level of agreement: 8.8).

If imaging is needed, conventional radiography should be used before other modalities. To make additional diagnoses, soft tissues are best imaged by ultrasound or MRI and bone by CT or MRI (Sakellariou et al [*EULAR*] 2017; level III-IV evidence; level of agreement: 8.7).

If there is radiographic evidence for osteoarthritis and no mechanical symptoms or acute injury suggesting a concomitant internal derangement, MRI is not recommended as it may lead to an erroneous diagnosis and exaggerated patient expectations (*VA/DoD* 2014).

Radiography is the current “gold standard” for morphological assessment of knee osteoarthritis.

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[Advanced] imaging modalities (MRI, sonography and scintigraphy) are seldom indicated for diagnosis of osteoarthritis (Zhang et al [*EULAR*] 2010; level Ib-IIb evidence; strength of recommendation: 83).

Clinicians should not use magnetic resonance imaging (MRI) as an evaluative tool to diagnose, confirm, or manage the treatment of osteoarthritis…In patients with osteoarthritis who have concomitant signs and symptoms of loose body [e.g., locking], meniscal pathology or an injury with a sudden onset of pain and effusion, MRI may be indicated (*VA/DoD* 2014; Grade D recommendation).

MRI or 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 may be useful in patients with previous meniscal repair and/or previous ACL reconstruction (PLE expert panel consensus opinion).

In patients with *chronic knee pain, initial knee radiograph demonstrates degenerative changes or chondrocalcinosis, next imaging procedure*, the *American College of Radiology* (Fox et al [*ACR*] 2018) does not recommend any advanced imaging as *usually appropriate*. The ACR notes that MRI knee without IV contrast, aspiration knee, or CT knee without IV contrast *may be appropriate*.

- MRI without IV contrast is usually not indicated unless symptoms are not explained by the radiographic findings or the appropriate treatment option requires additional imaging.

Clinical notes:

- Radiography (both knees, weightbearing semiflexed PA view, plus a lateral and skyline view) is the current "gold standard" for morphological assessment of knee osteoarthritis. Classical features are focal joint space narrowing, osteophyte, subchondral bone sclerosis and subchondral "cysts" (Zhang et al [*EULAR*] 2010; level Ib-IIb evidence; strength of recommendation: 83; Fox et al [*ACR*] 2018).

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).
- 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):

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

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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 (low level of evidence).

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 (moderate level of evidence).

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 (low level of evidence).

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Patellofemoral (anterior knee) pain unresponsive to conservative management with non-diagnostic radiographs:

- **Green** – MRI without IV contrast
- **Yellow** – CT arthrography in patients who cannot undergo MRI
- **Yellow** – CT without IV contrast*
- **Yellow** – MR arthrography in patients with previous meniscal repair and/or ACL reconstruction
- **Red** – MRI without and with IV contrast, MRI with IV contrast, CT with IV contrast, CT without and with IV contrast, bone scan, SPECT, PET, PET/CT

*CT without contrast may be indicated in patients with anterior knee pain to evaluate patellofemoral anatomy or morphology

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

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus summary:
Special investigations for anterior knee pain include high field MRI for chondromalacia and synovial plicae; contrast CT arthrography [can be used] if MRI is unavailable (Bussieres et al 2007; C level recommendation).

MRI without IV contrast may be indicated when radiographs demonstrate a small osseous fragment along the medial patellar margin or if there is a clinical concern for prior or chronic patellar dislocation-relocation. 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).

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).

MR arthrography may be useful in patients with previous meniscal repair and/or previous ACL reconstruction (PLE expert panel consensus opinion).

In patients with *chronic knee pain, initial knee radiograph negative or demonstrates joint effusion, next imaging procedure*, the *American College of Radiology* (Fox et al [*ACR*] 2018) recommends MRI knee without IV contrast (*usually appropriate*). Additionally, aspiration knee, CT arthrography knee, CT knee without contrast, ultrasound knee, or MR arthrography knee *may be appropriate*.

- MRI accurately depicts the extent of an effusion and presence of synovitis.
- CT without IV contrast may be indicated to evaluate the patellofemoral anatomy in knee pain related to repetitive patellofemoral subluxation or maltracking. It can also be used to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance.
- CT arthrography may be used instead of MRI when an intra-articular abnormality is suspected to evaluate the menisci and articular cartilage.

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- MR arthrography knee may be reserved for patients with known prior meniscal surgery, chondral and osteochondral lesions, and suspected loose bodies.

Clinical notes:

- 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).

Evidence update (2006-present):

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 MRA 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 (low level of evidence).

Smith et al (2012) conducted a systematic review and meta-analysis of 27 studies (total n = 2,509) to assess diagnostic test accuracy of MRI, MRA, and CTA for detecting chondral lesions of patellofemoral and tibiofemoral joints. 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 MRA and CTA were superior in detecting patellofemoral joint chondral lesions compared with MRI. MRA reported 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 sensitivity of 0.74 (0.71–0.77) and 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: 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 of the need to replace the “gold-standard” arthroscopic investigation with any of these radiological investigations (moderate level of evidence).

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 PF 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

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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 PF compartment of the knee, using arthroscopy as the reference gold standard (moderate level of evidence).

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 (low level of evidence).

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Patellofemoral (anterior knee) pain with patellofemoral osteoarthritis on radiographs:

- **Green** – *
- **Yellow** – MRI without contrast for surgical planning in patients considering patellofemoral arthroplasty or chondroplasty
- **Yellow** – CT arthrography for surgical planning in patients considering patellofemoral arthroplasty or chondroplasty who are unable to undergo MRI
- **Yellow** – CT without IV contrast**
- **Yellow** – MR arthrography in patients with previous meniscal repair and/or ACL reconstruction for surgical planning in patients considering patellofemoral arthroplasty or chondroplasty
- **Red** – MRI without and with IV contrast, MRI with IV contrast, CT without and with IV contrast, CT with IV contrast, bone scan, SPECT, PET, PET/CT

*Advanced imaging is not recommended for the routine diagnosis, management or follow-up of osteoarthritis of the knee.
**CT without contrast may be indicated in patients with anterior knee pain to evaluate patellofemoral anatomy or morphology

Level of Evidence: MRI without contrast: very low; MRI without and with contrast/arthrography, MRI with contrast, CT with contrast/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 with *chronic knee pain, initial knee radiograph demonstrates degenerative changes or chondrocalcinosis, next imaging procedure*, the *American College of Radiology* (Fox et al [*ACR*] 2018) does not recommend any advanced imaging as *usually appropriate*. The ACR notes that MRI knee without IV contrast, aspiration knee, or CT knee without IV contrast *may be appropriate*.

- MRI without IV contrast is usually not indicated unless symptoms are not explained by the radiographic findings or the appropriate treatment option requires additional imaging.
- CT without IV contrast may be indicated to evaluate the patellofemoral anatomy in knee pain related to repetitive patellofemoral subluxation or maltracking. It can also be used to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance.

MRI or CT arthrography may be useful in patients being considered for patellofemoral arthroplasty or chondroplasty in order to assess for degenerative changes and/or meniscal pathology in the medial and lateral tibiofemoral compartments (PLE expert panel consensus opinion).

MR arthrography may be useful in patients with previous meniscal repair and/or previous ACL reconstruction (PLE expert panel consensus opinion).

If there is radiographic evidence for osteoarthritis and no mechanical symptoms or acute injury suggesting a concomitant internal derangement, MRI is not recommended as it may lead to an erroneous diagnosis and exaggerated patient expectations (*VA/DoD* 2014).

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Clinical notes: none.

Evidence update (2006-present):
No additional relevant articles were identified.

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Clinical or radiological suspicion for avascular necrosis (osteonecrosis):

- **Green** – MRI knee without IV contrast
- **Yellow** – MRI knee with IV contrast after prior MRI without IV contrast reporting indeterminate findings of AVN
- **Yellow** – CT without IV contrast in patients who are unable to undergo MRI
- **Yellow** – Bone scan/SPECT when MRI is contraindicated or expected to be non-diagnostic
- **Red** – MRI without and with IV contrast, MR arthrography, CT with IV contrast, CT without and with IV contrast, CT arthrography, 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: none.

Guideline and PLE expert panel consensus summary:
MRI is useful when radiographs are normal, especially in high-risk patients. [Consider] bone scan or CT when MRI not available (Bussieres et al 2007; B level recommendation).

General indications for advanced imaging in extremity disorders – osteonecrosis: MRI (first choice). CT or nuclear medicine (second choice, determined on a case-by-case basis) (Bussieres et al 2007).

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).

Clinical notes:

- Avascular necrosis, or osteonecrosis, is a form of ischemic bone necrosis due to vascular insufficiency. It is often (60-75% of the time) associated with antecedent risk factors such as sickle cell disease, steroid use, alcoholism, or metabolic bone disease (Bussieres et al 2007).
- Radiographs should be the initial imaging study for chronic knee pain (Fox et al [*ACR*] 2018).
- MRI can identify subchondral insufficiency fractures earlier than radiographs with radiographs often initially normal (Fox et al [*ACR*] 2018).

Evidence update (2012-present):
No additional relevant articles were identified.

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Suspected stress or insufficiency reaction/fracture and negative or indeterminate radiographs:

- **Green** – MRI without IV contrast
- **Yellow** – Bone scan/SPECT in patients with equivocal MRI or for patients who are unable to undergo MRI
- **Yellow** – CT without IV contrast for diagnosis in patients with equivocal MRI findings, with increased uptake on bone scan if the patient is unable to undergo MRI, or to evaluate healing in patients with a known fracture
- **Red** – MRI with IV contrast, MRI without and with IV contrast, MR arthrography, CT with IV contrast, CT without and with IV contrast, CT arthrography, 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: none.

Guideline and PLE expert panel consensus summary:
In patients with *suspected stress (fatigue) fracture, excluding hip and vertebrae, negative radiographs, next imaging study*, the *American College of Radiology* (Bencardino et al [*ACR*] 2017*) recommends x-ray area of interest with repeat x-ray in 10-14 days (9), MRI area of interest without IV contrast (8), CT area of interest without IV contrast (5), or Tc-99m bone scan whole body with SPECT area of interest (5).

In patients with *suspected stress (fatigue) fracture, excluding hip and vertebrae, negative radiographs, immediate "need-to-know" diagnosis*, next imaging study, the *American College of Radiology* (Bencardino et al [*ACR*] 2017*) recommends MRI area of interest without IV contrast (9), CT area of interest without IV contrast (5), or Tc-99m bone scan whole body with SPECT area of interest (5).

In patients with *confirmed stress (fatigue) fracture, excluding vertebrae, follow-up imaging study for "return-to-play" evaluation*, the *American College of Radiology* (Bencardino et al [*ACR*] 2017*) recommends MRI area of interest without IV contrast (9). If symptoms persist after appropriate therapy, repeat imaging (radiographs, CT or MRI) may be useful to evaluate healing and return to activity (PLE expert panel consensus opinion).

In patients with *suspected stress (insufficiency) fracture of lower extremity*, excluding pelvis and hip, negative radiographs, next imaging study, the *American College of Radiology* (Bencardino et al [*ACR*] 2017*) recommends MRI lower extremity area of interest without IV contrast (9), x-ray lower extremity area of interest repeat in 10-14 days (7), CT lower extremity area of interest without IV contrast (5), or Tc-99m bone scan whole body with SPECT lower extremity area of interest (5).

In patients with follow-up imaging study for *characterizing nonspecific focal uptake on Tc-99m MDP bone scintigraphy, suspected to be a stress fracture*, the *American College of Radiology* (Bencardino et al [*ACR*] 2017*) recommends x-ray area of interest (9), MRI area of interest without IV contrast (8), MRI area of interest without and with IV contrast (5), or CT area of interest without IV contrast (5).

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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 *ACR* Guideline by Bencardino et al (2017) did not pass the AGREE II cutoff of 90. It was included, however, because of its direct relevance to the stress fracture 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).
- For suspected stress (fatigue or insufficiency) fracture, excluding the pelvis/hip and vertebrae, the ACR recommends radiography as the first imaging study (Bencardino et al [*ACR*] 2017).
- MRI can identify subchondral insufficiency fractures earlier than radiographs with radiographs often initially normal (Fox et al [*ACR*] 2018).

Evidence update (2006-present):
No additional relevant articles were identified.

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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 with or without IV contrast to evaluate for soft tissue gas or for a soft tissue foreign body
- **Yellow** - CT with or without IV contrast to evaluate patients with known or suspected chronic osteomyelitis
- **Yellow** - CT with or without IV contrast to evaluate patients who are unable to undergo MRI
- **Yellow** – Bone scan/SPECT or three-phase bone scan for suspected osteomyelitis for patients who are unable to undergo MRI or for whom MRI is indeterminate or nondiagnostic
- **Red** – MRI with IV contrast, MR arthrography, CT without and with IV contrast, CT arthrography, PET, PET/CT

*This guideline does not address the evaluation of suspected infection in patients with knee prostheses.

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: none.

Guideline and PLE expert panel consensus summary:
Magnetic resonance imaging is the modality of choice to evaluate osteomyelitis (Beaman et al [*ACR*] 2017, Coakley et al 2006; B recommendation).

In patients with soft-tissue or juxta-articular swelling, *suspected soft-tissue infection*, additional imaging following radiographs, the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends MRI area of interest without and with IV contrast (9), MRI area of interest without IV contrast (7), CT area of interest with IV contrast (6), or US area of interest (5).

In patients with soft-tissue or juxta-articular swelling with a *history of a puncture wound, suspected foreign body and negative radiographs*, the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends US area of interest (8), CT area of interest without IV contrast (7), MRI area of interest without and with IV contrast (7), CT area of interest with IV contrast (6), or MRI area of interest without IV contrast (6).

In patients with soft-tissue or juxta-articular swelling with *cellulitis and a skin lesion, injury, wound, ulcer, or blister, suspected osteomyelitis*, additional imaging following radiographs the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends MRI area of interest without and with IV contrast (9), MRI area of interest without IV contrast (7), CT area of interest with IV contrast (6), Labeled leukocyte scan and Tc-99m sulfur colloid marrow scan area of interest (6), Tc-99m 3-phase bone scan and labeled leukocyte scan area of interest (6), CT area of interest without IV contrast (5), or Tc-99m 3-phase bone scan area of interest (5).

In patients with soft-tissue or juxta-articular swelling with a *history of prior surgery, suspected*

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osteomyelitis or septic arthritis, additional imaging following radiographs, the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends aspiration area of interest if concern for septic arthritis (9), MRI area of interest without and with IV contrast (9), MRI area of interest without IV contrast (7), CT area of interest with IV contrast (6), CT area of interest without IV contrast (5), or labeled leukocyte scan and Tc-99m sulfur colloid marrow scan area of interest (5).

In patients with pain and swelling or cellulitis with *previous nonarthroplasty hardware*, suspected osteomyelitis or septic arthritis, additional imaging following radiographs, the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends aspiration area of interest if concern for septic arthritis (9), MRI area of interest without and with IV contrast (9), MRI area of interest without IV contrast (8), CT area of interest with IV contrast (7), labeled leukocyte scan and Tc-99m sulfur colloid marrow scan area of interest (5), or CT area of interest without IV contrast (5).

In patients with *draining sinus* (not associated with a joint prosthesis), suspected osteomyelitis, additional imaging following radiographs, the *American College of Radiology* (Beaman et al [*ACR*] 2017) recommends MRI area of interest without and with IV contrast (9), MRI area of interest without IV contrast (7), CT area of interest with IV contrast (6), or CT area of interest without IV contrast (6).

In patients with clinical examination suggesting *crepitus, suspected soft-tissue gas*, first study, the American College of Radiology (Beaman et al [*ACR*] 2017) recommends x-ray area of interest (9), CT area of interest with IV contrast (5), or CT area of interest without IV contrast (5).

Clinical notes:

- 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; B recommendation).
- In patients with a suspected joint infection, the white blood cell count, erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) should be measured (Coakley et al 2006; B recommendation).
- 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).
- Radiographs are the recommended first study in patients with suspected osteomyelitis, septic arthritis or soft-tissue infection. They are well suited for the detection of radiodense foreign bodies (Beaman et al [*ACR*] 2017).
- Although often not diagnostic in acute osteomyelitis, [radiographs] provide anatomic evaluation of the affected site, depict changes of chronic osteomyelitis, can reveal gas or foreign bodies, and can suggest alternative diagnoses such as neuropathic arthropathy, fracture, or tumor, which influence subsequent imaging selection and interpretation (Beaman et al [*ACR*] 2017).
- Magnetic resonance imaging (MRI) is the modality of choice for suspected bone and extremity soft-tissue infections. 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).
- CT is particularly sensitive to soft-tissue gas (that can signal necrotizing fasciitis) and foreign bodies. CT in fact is superior to MRI for the diagnosis of sequestra, foreign bodies and gas (Beaman et al [ACR] 2017).

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- 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).
- Nuclear medicine examinations may be useful in cases where MRI is contraindicated, infection is multifocal, or when the infection is associated with orthopedic hardware or chronic bone alterations from trauma or surgery (Beaman et al [*ACR*] 2017).
- Skeletal scintigraphy is highly sensitive but lacks specificity. Bone scans can become positive as early as one–two days after the onset of clinical symptoms. A 3- or 4-phase bone scan aids in distinguishing cellulitis from osteomyelitis. 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).
- Currently, there is no evidence supporting a role for FDG-PET in the evaluation of septic arthritis since FDG also accumulates in inflammatory arthritis (Beaman et al [*ACR*] 2017).

<u>Evidence update (2016-present)</u>:
No additional relevant articles were identified.

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Baker's (popliteal) cyst with or without abnormalities on radiographs:

- **Green** –*
- **Yellow** – MRI without IV contrast to evaluate for associated intraarticular pathology
- **Yellow** – CT arthrography to evaluate for associated intraarticular pathology for patients who are unable to undergo MRI
- **Yellow** – MR arthrography to evaluate for associated intraarticular pathology in patients with previous meniscal repair and/or ACL reconstruction
- **Red** – MRI without and with IV contrast, MRI with IV contrast, CT without and with IV contrast, CT without contrast, CT with IV contrast, PET, PET/CT, SPECT, bone scan

*Ultrasound is recommended for the initial evaluation of a suspected popliteal cyst.

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:
MRI and US may be useful in the evaluation of bursitis/tendinitis/strain/tendinosis (Bussieres et al 2007/Level D recommendation).

MRI accurately depicts the presence or rupture of a popliteal cyst (Fox et al [*ACR*] 2018).

Radiographs are useful to evaluate for osteoarthritis and MRI (or MR/CT arthrography) for intraarticular pathology in patients with symptomatic semimembranosus/medial gastrocnemius bursal (Baker's) cysts (PLE expert panel consensus opinion).

Advanced imaging should be considered to evaluate patients with atypical popliteal cysts. 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. 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).

Clinical notes:

- 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 US guidance (Bussieres et al 2007).

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Evidence update (2006-present):
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 (low level of evidence).

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 (low level of evidence).

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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
- 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):	Posting Date:	Approved By:
07/09/2019	n/a	07/16/2019	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**

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