

**American College of Radiology  
ACR Appropriateness Criteria®  
Chronic Knee Pain**

**Variant: 1 Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography knee	Usually Appropriate	⦿
US knee	Usually Not Appropriate	○
Radiography hip ipsilateral	Usually Not Appropriate	⦿⦿⦿
Image-guided aspiration knee	Usually Not Appropriate	Varies
MR arthrography knee	Usually Not Appropriate	○
MRI knee without and with IV contrast	Usually Not Appropriate	○
MRI knee without IV contrast	Usually Not Appropriate	○
CT arthrography knee	Usually Not Appropriate	⦿
CT knee with IV contrast	Usually Not Appropriate	⦿
CT knee without and with IV contrast	Usually Not Appropriate	⦿
CT knee without IV contrast	Usually Not Appropriate	⦿
Bone scan knee	Usually Not Appropriate	⦿⦿⦿

**Variant: 2 Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI knee without IV contrast	Usually Appropriate	○
US knee	May Be Appropriate (Disagreement)	○
Radiography hip ipsilateral	May Be Appropriate	⦿⦿⦿
Radiography lumbar spine	May Be Appropriate	⦿⦿⦿
Image-guided aspiration knee	May Be Appropriate	Varies
MR arthrography knee	May Be Appropriate	○
CT arthrography knee	May Be Appropriate	⦿
CT knee without IV contrast	May Be Appropriate	⦿
MRI knee without and with IV contrast	Usually Not Appropriate	○
CT knee with IV contrast	Usually Not Appropriate	⦿
CT knee without and with IV contrast	Usually Not Appropriate	⦿
Bone scan knee	Usually Not Appropriate	⦿⦿⦿

**Variant: 3 Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI knee without IV contrast	Usually Appropriate	○
MR arthrography knee	May Be Appropriate (Disagreement)	○
CT arthrography knee	May Be Appropriate	⦿
CT knee without IV contrast	May Be Appropriate	⦿

US knee	Usually Not Appropriate	O
Radiography hip ipsilateral	Usually Not Appropriate	☢☢☢
Image-guided aspiration knee	Usually Not Appropriate	Varies
MRI knee without and with IV contrast	Usually Not Appropriate	O
CT knee with IV contrast	Usually Not Appropriate	☢
CT knee without and with IV contrast	Usually Not Appropriate	☢
Bone scan knee	Usually Not Appropriate	☢☢☢

**Variant: 4 Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

Procedure	Appropriateness Category	Relative Radiation Level
Image-guided aspiration knee	May Be Appropriate (Disagreement)	Varies
MRI knee without IV contrast	May Be Appropriate	O
CT knee without IV contrast	May Be Appropriate	☢
US knee	Usually Not Appropriate	O
Radiography hip ipsilateral	Usually Not Appropriate	☢☢☢
MR arthrography knee	Usually Not Appropriate	O
MRI knee without and with IV contrast	Usually Not Appropriate	O
CT arthrography knee	Usually Not Appropriate	☢
CT knee with IV contrast	Usually Not Appropriate	☢
CT knee without and with IV contrast	Usually Not Appropriate	☢
Bone scan knee	Usually Not Appropriate	☢☢☢

**Variant: 5 Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI knee without IV contrast	Usually Appropriate	O
CT arthrography knee	May Be Appropriate	☢
CT knee without IV contrast	May Be Appropriate	☢
US knee	Usually Not Appropriate	O
Radiography hip ipsilateral	Usually Not Appropriate	☢☢☢
Image-guided aspiration knee	Usually Not Appropriate	Varies
MR arthrography knee	Usually Not Appropriate	O
MRI knee without and with IV contrast	Usually Not Appropriate	O
CT knee with IV contrast	Usually Not Appropriate	☢
CT knee without and with IV contrast	Usually Not Appropriate	☢
Bone scan knee	Usually Not Appropriate	☢☢☢

**Panel Members**

Michael G. Fox, MD, MBA<sup>a</sup>, Eric Y. Chang, MD<sup>b</sup>, Behrang Amini, MD, PhD<sup>c</sup>, Stephanie A. Bernard, MD<sup>d</sup>, Tetyana Gorbachova, MD<sup>e</sup>, Alice S. Ha, MD<sup>f</sup>, Ramesh S. Iyer, MD<sup>g</sup>, Kenneth S. Lee, MD, MBA<sup>h</sup>, Darlene F. Metter, MD<sup>i</sup>, Pekka A. Mooar, MD<sup>j</sup>, Nehal A. Shah, MD<sup>k</sup>, Adam D. Singer, MD<sup>l</sup>,

## Summary of Literature Review

### Introduction/Background

Chronic knee pain affects tens of millions of people in the United States annually, with the pain sometimes highly disabling and often negatively impacting the patient's quality of life. Chronic knee pain has numerous causes, and it can present with localized or diffuse symptoms. Osteoarthritis is the most common cause of chronic knee pain with the knee the most common lower extremity joint impacted by osteoarthritis [1].

Typically, radiography is the initial imaging study used to evaluate chronic pain in a native knee. When pain persists but the initial radiographs are normal or demonstrate a joint effusion, MRI is usually considered the next imaging study. However, the use of MRI may be premature and unnecessary in some patients, as it is estimated that approximately 20% of patients with chronic knee pain have had an MRI performed without recent (within the prior year) radiographs [2].

This document discusses 5 variants for imaging chronic pain in a native knee in patients  $\geq 5$  years of age. The variants discussed include: (1) initial examination; (2) initial radiograph is normal or demonstrates a joint effusion; (3) initial radiograph demonstrates osteochondritis dissecans (OCD), loose bodies or history of cartilage, or meniscal repair; (4) initial radiograph demonstrates osteoarthritis or chondrocalcinosis; and (5) initial radiograph demonstrates signs of prior (chronic) knee injury (ie, Second fracture, tibial spine avulsion, etc).

To evaluate knee pain associated with other conditions, please refer to the following ACR Appropriateness Criteria® topic on: "[Osteonecrosis of the Hip](#)" [3] for osteonecrosis, "[Acute Trauma to the Knee](#)" for acute knee injuries [4], "[Imaging After Total Knee Arthroplasty](#)" for patients with total knee arthroplasty [5], "[Soft-Tissue Masses](#)" for a patient with a suspected soft-tissue mass [6], "[Primary Bone Tumors](#)" for a patient with a suspected or known bone tumor [7], and "[Chronic Extremity Joint Pain-Suspected Inflammatory Arthritis](#)" for patient with suspected arthritis or synovitis [8].

### Special Imaging Considerations

Knee radiographs should include at least one frontal projection of one or both knees (anteroposterior, Rosenberg, or tunnel), a tangential patellar view, and a lateral view of the affected knee [2,9]. Standing radiographs more accurately reflect medial and lateral compartment cartilage loss than supine radiographs with the posteromedial and posterolateral joint compartments more accurately assessed using a weight-bearing flexion posteroanterior radiograph [9,10].

### Discussion of Procedures by Variant

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

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## **A. Radiography Knee**

Radiographs should be the initial imaging study for chronic knee pain. In elderly patients, the most common source of chronic knee pain is osteoarthritis. Conventional radiographic diagnosis of osteoarthritis includes joint space narrowing, osteophytes, subchondral cysts, and subarticular sclerosis [11]. Articular cartilage is evaluated indirectly on radiographs by joint space narrowing and changes in the subchondral bone [10]. When a severe varus or valgus deformity is present, significant cartilage loss in the apparently “wider” compartment may not be evident [11,12]. Conversely, joint space narrowing may be caused by meniscal extrusion or degeneration rather than cartilage loss [11].

Chronic knee pain is associated with the radiographic demonstration of osteophytes with the development of a “bone-on-bone” appearance or complete joint space loss on subsequent radiographs indicating disease progression and potentially indicating the need for arthroplasty [11-13].

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **B. Radiography Hip**

An ipsilateral hip radiograph is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **C. CT Knee**

CT is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **D. CT Arthrography Knee**

CT arthrography is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **E. MRI Knee**

MRI is usually not indicated as a first imaging examination. To avoid unnecessary MRI, assessment of current radiographs (within the prior year) is required [2].

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **F. MR Arthrography Knee**

MR arthrography is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **G. US Knee**

Ultrasound (US) is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

## **H. Bone Scan Knee**

Radionuclide bone scan is usually not indicated as a first imaging examination.

**Variant 1: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial imaging.**

#### **I. Image-Guided Aspiration Knee**

Joint aspiration is usually not indicated as a first imaging examination.

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **A. Radiography Hip**

In patients with chronic knee pain, referred pain from the hip must be considered, especially if the knee radiographs are unremarkable and there is clinical evidence or concern for hip pathology [14].

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **B. Radiography Lumbar Spine**

In patients with chronic knee pain, referred pain from the lower back must be considered, especially if the knee radiographs are unremarkable and there is clinical evidence or concern for lumbar spine pathology.

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **C. CT Knee**

CT without intravenous (IV) contrast may be indicated to evaluate the patellofemoral anatomy in the setting of chronic knee pain related to repetitive patellofemoral subluxation or maltracking [15]. CT can also be used to evaluate trochlear morphology and the tibial tubercle-trochlear groove distance. CT with IV contrast is usually not indicated when initial radiograph is negative or demonstrates a joint effusion.

CT without and with IV contrast is not routinely performed when initial radiographs are negative.

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **D. CT Arthrography Knee**

When an intra-articular abnormality is suspected, CT arthrography may be used instead of MRI to evaluate the menisci and articular cartilage [16].

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **E. MRI Knee**

When initial radiographs are normal or reveal a joint effusion but pain persists, the next indicated study is usually MRI without IV contrast, which is more sensitive than radiography [11].

MRI accurately depicts the extent of an effusion, presence of synovitis, and presence or rupture of a popliteal cyst [17]. Subchondral cysts, articular cartilage, and meniscal abnormalities are easily

detected on MRI [13,18,19]. However, meniscal tears are often incidental findings in older patients with the majority of people over 70 years of age having an asymptomatic meniscal tear, and the likelihood of a meniscal tear being present in either a painful or asymptomatic knee not significantly different in patients 45 to 55 years of age [20,21].

Bone marrow lesions (BML) are readily depicted on MRI as areas of increased edema-like signal in the subchondral bone. New or increasing BMLs are associated with increased knee pain, especially in males or patients with family history of osteoarthritis [22]. Conversely, decreasing BMLs are associated with reduced knee pain [23]. A systematic review of 22 articles concluded that both BMLs and synovitis/effusion may indicate the origin of knee pain in patients with osteoarthritis [24-26].

Subchondral insufficiency fractures, now recognized as the underlying cause of what was previously termed spontaneous osteonecrosis of the knee, most commonly involve the medial femoral condyle in middle-aged to elderly females. MRI can identify subchondral insufficiency fractures earlier than radiographs with radiographs often initially normal [27]. Radiographs may later reveal articular surface fragmentation, subchondral collapse, and progressive osteoarthritis sometimes requiring total knee arthroplasty [27]. Even when a subchondral insufficiency fracture is diagnosed on a conventional radiograph, MRI may be indicated if an additional injury is suspected clinically. MRI can also detect tibial stress fractures as discussed in the ACR Appropriateness Criteria® topic on "[Stress \(Fatigue/Insufficiency\) Fracture, Including Sacrum, Excluding Other Vertebrae](#)" [28].

Some patients with normal knee radiographs and anterior knee pain have abnormal cartilage on 3 T MRI using quantitative imaging [29]. In particular, patients 45 to 55 years of age with knee pain but normal radiographs exhibited elevated T2 mapping values on 3 T MRI [20].

Patellofemoral cartilage loss is also associated with chronic knee pain, with active knee pain correlated with BMLs [30,31]. Similar to CT, MRI can calculate various anatomic measurements associated with patellofemoral subluxation/dislocation and lateral patellofemoral friction syndrome [32-34]. Bone marrow edema in the classic location for patellofemoral dislocation/relocation injuries is also identified by MRI [15]. MRI may also differentiate patients with more severe patellofemoral osteoarthritis who may not benefit from supervised exercise therapy from patients with medial or lateral knee compartment arthritis who might benefit [35].

Other etiologies of chronic anterolateral knee pain diagnosed on MRI include patellar tendinopathy, various fat pad impingement syndromes, Hoffa's disease, deep infrapatellar bursitis, iliotibial band syndrome, adhesive capsulitis, medial plicae, discoid meniscus, tumors, ganglion cysts, pigmented villonodular synovitis, osteophytes, and osteonecrosis [15,19,36-45].

MRI without and with IV contrast is not usually indicated when initial radiograph is negative or demonstrates a joint effusion. However, contrast-enhanced images may be more accurate in diagnosing other causes of chronic knee pain, such as Hoffa's disease, deep infrapatellar bursitis, patellofemoral friction syndrome, and adhesive capsulitis [15]. In particular, enhancing synovitis thicker than 2 mm in Hoffa's fat is correlated with peripatellar pain [46]. Contrast-enhanced MRI is also useful in quantifying the degree of synovitis and in evaluating conditions such as pigmented villonodular synovitis [17,42,47,48].

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **F. MR Arthrography Knee**

MR arthrography performed with an intra-articular injection of dilute gadolinium solution is typically not indicated as a second examination but rather reserved for patients with known prior meniscal surgery, chondral and osteochondral lesions, and suspected loose bodies [10].

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **G. US Knee**

US is not often useful as a screening test or a comprehensive examination. It may be appropriate to confirm a suspected effusion and to guide a potential aspiration [10]. US is as accurate in diagnosing a popliteal cyst and detecting cyst rupture when compared to MRI [10]. US is also useful in evaluating medial plicae and following patients with iliotibial band syndrome [17,44].

More recently, shear wave elastography has been used to evaluate female patients with patellofemoral pain by demonstrating reduced contraction ratio in the vastus medialis oblique but not the vastus lateralis muscles [49]. Finally, US can diagnose a cyst and determine the vascularity of a mass [37].

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **H. Bone Scan Knee**

Radionuclide bone scan is usually not indicated when initial radiograph is negative or demonstrates a joint effusion.

**Variant 2: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph negative or demonstrates joint effusion. Next imaging procedure.**

#### **I. Image-Guided Aspiration Knee**

If an aspiration for crystals or atypical/low-grade chronic infection is indicated, it can be facilitated by US or fluoroscopy [10].

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **A. Radiography Hip**

An ipsilateral hip radiograph is usually not indicated to evaluate patients with osteochondritis dissecans (OCD), loose bodies, or history of cartilage repair.

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **B. CT Knee**

CT without IV contrast may be indicated to evaluate patients with OCD or a history of cartilage repair, especially to confirm loose bodies or when MRI is not definitive.

CT with IV contrast is not usually indicated to evaluate patients with OCD, loose bodies, or history of cartilage repair.

CT without and with IV contrast is not usually indicated to evaluate patients with OCD, loose bodies, or history of cartilage repair.

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **C. CT Arthrography Knee**

CT arthrography may be used instead of MRI to evaluate the menisci, articular cartilage, and the presence of loose bodies [16].

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **D. MRI Knee**

In patients with OCD or subchondral insufficiency fracture 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 [41]. A hyperintense rim or cysts at the osteochondral fragment periphery on MRI are less specific for OCD fragment instability in children compared to adults; however, MRI is still useful to determine the best method of treatment [41,50]. Following cartilage repair, MRI can grade the repair site and even guide the retrograde drilling of the OCD lesion [51-54].

MRI with and without IV contrast is not usually indicated to evaluate patients with OCD, loose bodies, or history of cartilage repair because of the usual larger volume of joint fluid, the lesser degree of synovial invagination, and the longer time required to achieve steady state gadolinium in the joint compared to the shoulder [16].

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **E. MR Arthrography Knee**

MR arthrography is typically reserved for patients with known prior meniscal surgery, chondral and osteochondral lesions, prior cartilage repair procedures, or suspected loose bodies [10,16].

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

#### **F. US Knee**

US is not often useful as a screening test or a comprehensive examination. It may be appropriate to localize suspected loose bodies, especially if the loose bodies might be within a popliteal cyst, lateral recess, or suprapatellar recess.

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**



## **G. Bone Scan Knee**

Radionuclide bone scan is usually not indicated to evaluate patients with OCD, loose bodies, or history of cartilage repair.

**Variant 3: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates osteochondritis dissecans (OCD), loose bodies, or history of cartilage or meniscal repair. Next imaging procedure.**

## **H. Image-Guided Aspiration Knee**

Joint aspiration is usually not indicated to evaluate patients with OCD, loose bodies, or history of cartilage repair.

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

## **A. Radiography Hip**

An ipsilateral hip radiograph is usually not indicated to evaluate patients with osteoarthritis or chondrocalcinosis.

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

## **B. CT Knee**

Dual-energy CT without IV contrast may be indicated if gout or mixed crystal disease is a consideration. Otherwise, CT is not commonly used as a diagnostic test to evaluate patients with osteoarthritis or chondrocalcinosis. Limited CT without IV contrast can be used for surgical planning.

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

## **C. CT Arthrography Knee**

CT arthrography is not commonly utilized as a second test in patients with arthritis even though CT is the most accurate method for evaluating cartilage abnormalities extending to the articular surface that is due to the high spatial resolution between the contrast and the cartilage [11].

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

## **D. MRI Knee**

MRI without IV contrast is not usually indicated in patients for whom radiographs are diagnostic of osteoarthritis unless symptoms are not explained by the radiographic findings (eg, stress fractures) or the appropriate treatment option requires additional imaging [11,19].

Given the increased sensitivity of MRI for osteoarthritis, MRI may be indicated when more accurate or serial cartilage measurements are desired [10,55,56]. In patients >70 years of age, a higher

correlation with the “abnormal” knee being painful is present when structural abnormalities are unilateral on either radiographs or MRI. Since bilateral structural abnormalities can be present with primarily unilateral symptoms, the ability to discriminate painful from nonpainful knees is limited [57]. This persists even when using the MRI presence of synovitis or effusion and/or a Kellgren and Lawrence score of  $\geq 2$ ; findings were reported to be the best discriminators between painful and asymptomatic knees [19].

Patellofemoral cartilage loss is closely associated with chronic knee pain with active knee pain correlated with BMLs [56]. 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 [58].

MRI with and without IV contrast is indicated when performing semiquantitative assessment of knee osteoarthritis using various scoring systems to include cartilage, synovitis, ligaments, BMLs, and menisci [18]. In obese patients with osteoarthritis on contrast-enhanced images, increased perfusion in Hoffa’s fat is associated with more severe anterior knee pain [59].

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

#### **E. MR Arthrography Knee**

MR arthrography is usually not indicated to evaluate patients with osteoarthritis or chondrocalcinosis.

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

#### **F. US Knee**

US is not often useful as a screening test or a comprehensive examination. US can detect synovial pathology, effusions, and cortical erosive changes [11]. Power Doppler US can demonstrate increased synovial blood flow that is associated with knee pain and can demonstrate reduced blood flow, which correlates with reduced knee pain following joint injections [60]. US can also demonstrate meniscal extrusion, a finding that suggests an underlying meniscal tear, and, on occasion, chondrocalcinosis and peripheral meniscal tears [11].

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

#### **G. Bone Scan Knee**

Radionuclide bone scan is usually not indicated to evaluate patients with chronic knee pain given the low specificity and decreased anatomic resolution compared to CT or MRI [11]. However, it may help distinguish between bone and soft-tissue origins for pain as well as localize pain to one or more joints [11].

**Variant 4: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates degenerative changes or chondrocalcinosis. Next imaging procedure.**

#### **H. Image-Guided Aspiration Knee**

If an effusion is present, US- or fluoroscopically guided joint aspiration can be performed for

synovial fluid analysis if there is concern for crystal disease or infection. Corticosteroid injections can also be performed as they may result in a 1 to 2 week reduction in synovitis on MRI in two-thirds of patients. MRI also demonstrates a subsequent increase in the synovial volume in approximately 70% of patients that develop recurrent pain [61].

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

When associated with acute injury, recommendations are covered in the ACR Appropriateness Criteria® topic on "[Acute Trauma to the Knee](#)" [4].

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **A. Radiography Hip**

An ipsilateral hip radiograph is usually not indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **B. CT Knee**

CT without IV contrast may be indicated to evaluate the patellofemoral anatomy in the setting of chronic knee pain related to repetitive patellofemoral subluxation, which can be suggested by a small osseous fragment along the medial patellar margin on axial knee radiographs [15]. CT knee without IV contrast may also be useful to confirm a prior osseous injury.

CT with IV contrast is not usually indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

CT without and with IV contrast is not usually indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **C. CT Arthrography Knee**

CT arthrography may be used to evaluate the menisci, articular cartilage, and the presence of loose bodies with reported sensitivities and specificities ranging from 86% to 100% [16,62-64].

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **D. MRI Knee**

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 [41]. MRI is useful for evaluating Osgood-Schlatter or Sinding-Larsen-Johansson syndrome [41]. If the

radiograph suggests prior anterior cruciate ligament injury, MRI can effectively evaluate the menisci, but evaluation for associated cartilage lesions is less useful [65].

MRI without and with IV contrast is not usually indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **E. MR Arthrography Knee**

MR arthrography is usually not indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **F. US Knee**

US is usually not indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **G. Bone Scan Knee**

Radionuclide bone scan is usually not indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

**Variant 5: Adult or child greater than or equal to 5 years of age. Chronic knee pain. Initial knee radiograph demonstrates signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc.). Next imaging procedure.**

#### **H. Image-Guided Aspiration Knee**

Joint aspiration is usually not indicated to evaluate patients with signs of prior (chronic) osseous knee injury.

### **Summary of Highlights**

- **Variant 1:** Radiographs of the knee are usually appropriate for the initial imaging of chronic knee pain in patients greater than or equal to 5 years of age.
- **Variant 2:** MRI knee without IV contrast is usually appropriate in patients greater than or equal to 5 years of age with chronic knee pain when initial knee radiographs are normal or demonstrate a joint effusion.
- **Variant 3:** MRI knee without IV contrast is usually appropriate in patients greater than or equal to 5 years of age with chronic knee pain when initial knee radiographs demonstrate OCD, loose bodies, or history of cartilage or meniscal repair.
- **Variant 4:** (1) MRI knee without IV contrast or (2) knee aspiration or (3) CT knee without IV contrast may be appropriate in patients greater than or equal to 5 years of age with chronic knee pain when initial radiographs demonstrate degenerative changes or chondrocalcinosis. While MRI knee without IV contrast may be appropriate more often, knee aspiration and CT knee without IV contrast may be appropriate in specific instances detailed in the narrative.

On occasion, these examinations may complement each other with more than one being appropriate.

- **Variation 5:** MRI knee without IV contrast is usually appropriate in patients greater than or equal to 5 years of age with chronic knee pain when initial radiographs demonstrate signs of prior osseous injury (ie, Second fracture, tibial spine avulsion, etc).

## Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

For additional information on the Appropriateness Criteria methodology and other supporting documents, please go to the ACR website at <https://www.acr.org/Clinical-Resources/Clinical-Tools-and-Reference/Appropriateness-Criteria>.

## Appropriateness Category Names and Definitions
















Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as

compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document.

### Relative Radiation Level Designations

Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
0	0 mSv	0 mSv
	<0.1 mSv	<0.03 mSv
 	0.1-1 mSv	0.03-0.3 mSv
  	1-10 mSv	0.3-3 mSv
   	10-30 mSv	3-10 mSv
    	30-100 mSv	10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (e.g., region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as “Varies.”

### References

1. American College of Radiology. ACR Appropriateness Criteria®: Primary Bone Tumors. Available at: <https://acsearch.acr.org/docs/69421/Narrative/>.
2. Bencardino JT, Stone TJ, et al. ACR Appropriateness Criteria® Stress (Fatigue/Insufficiency) Fracture, Including Sacrum, Excluding Other Vertebrae. J Am Coll Radiol. 2017 May;14(5S):S1546-1440(17)30218-1.
3. Jacobson JA, Roberts CC, et al. ACR Appropriateness Criteria® Chronic Extremity Joint Pain-Suspected Inflammatory Arthritis. J Am Coll Radiol. 2017 May;14(5S):S1546-1440(17)30183-7.
4. Murphy LB, Moss S, Do BT, et al. Annual Incidence of Knee Symptoms and Four Knee Osteoarthritis Outcomes in the Johnston County Osteoarthritis Project. Arthritis Care Res (Hoboken). 2016 Jan;68(1):55-65.
5. George E, Tsipas S, Wozniak G, et al. MRI of the knee and shoulder performed before radiography. J Am Coll Radiol. 2014 Nov;11(11):S1546-1440(14)00278-6.
6. American College of Radiology. ACR Appropriateness Criteria®: Osteonecrosis of the Hip. Available at: <https://acsearch.acr.org/docs/69420/Narrative/>.
7. American College of Radiology. ACR Appropriateness Criteria®: Acute Trauma to the Knee. Available at: <https://acsearch.acr.org/docs/69419/Narrative/>.
8. Illingworth KD, El Bitar Y, Siewert K, Scaife SL, El-Amin S, Saleh KJ. Correlation of WOMAC and KOOS scores to tibiofemoral cartilage loss on plain radiography and 3 Tesla MRI: data from the osteoarthritis initiative. Knee Surg Sports Traumatol Arthrosc. 2014;22(7):1649-1658.
9. Wick MC, Kastlunger M, Weiss RJ. Clinical imaging assessments of knee osteoarthritis in the elderly: a mini-review. Gerontology. 2014;60(5):386-94.
10. Hayashi D, Roemer FW, Guermazi A. Imaging for osteoarthritis. Ann Phys Rehabil Med. 2016 Jun;59(3):S1877-0657(15)00584-9.

- 11.** Kinds MB, Marijnissen AC, Bijlsma JW, Boers M, Lafeber FP, Welsing PM. Quantitative radiographic features of early knee osteoarthritis: development over 5 years and relationship with symptoms in the CHECK cohort. *J Rheumatol*. 2013 Jan;40(1):58-65.
- 12.** Hayashi D, Xu L, Roemer FW, et al. Detection of osteophytes and subchondral cysts in the knee with use of tomosynthesis. *Radiology*. 2012 Apr;263(1):206-15.
- 13.** Haviv B, Bronak S, Thein R. The complexity of pain around the knee in patients with osteoarthritis. *Isr Med Assoc J*. 2013 Apr;15(4):178-81.
- 14.** Grando H, Chang EY, Chen KC, Chung CB. MR imaging of extrasynovial inflammation and impingement about the knee. *Magn Reson Imaging Clin N Am*. 2014 Nov;22(4):S1064-9689(14)00072-5.
- 15.** Kalke RJ, Di Primio GA, Schweitzer ME. MR and CT arthrography of the knee. *Semin Musculoskelet Radiol*. 2012 Feb;16(1):57-68.
- 16.** Krasnokutsky S, Belitskaya-Lévy I, Bencardino J, et al. Quantitative magnetic resonance imaging evidence of synovial proliferation is associated with radiographic severity of knee osteoarthritis. *Arthritis Rheum*. 2011 Oct;63(10):2983-91.
- 17.** Guermazi A, Roemer FW, Haugen IK, Crema MD, Hayashi D. MRI-based semiquantitative scoring of joint pathology in osteoarthritis. *Nat Rev Rheumatol*. 2013 Apr;9(4):236-51.
- 18.** Javaid MK, Kiran A, Guermazi A, et al. Individual magnetic resonance imaging and radiographic features of knee osteoarthritis in subjects with unilateral knee pain: the health, aging, and body composition study. *Arthritis Rheum*. 2012 Oct;64(10):3246-55.
- 19.** Baum T, Joseph GB, Arulanandan A, et al. Association of magnetic resonance imaging-based knee cartilage T2 measurements and focal knee lesions with knee pain: data from the Osteoarthritis Initiative. *Arthritis Care Res (Hoboken)*. 2012 Feb;64(2):248-55.
- 20.** Foong YC, Khan HI, Blizzard L, et al. The clinical significance, natural history and predictors of bone marrow lesion change over eight years. *Arthritis Res Ther*. 2014 Jul 14;16(4):R149.
- 21.** Driban JB, Price L, Lo GH, et al. Evaluation of bone marrow lesion volume as a knee osteoarthritis biomarker--longitudinal relationships with pain and structural changes: data from the Osteoarthritis Initiative. *Arthritis Res Ther*. 2013;15(5):R112.
- 22.** Baert IA, Staes F, Truijen S, et al. Weak associations between structural changes on MRI and symptoms, function and muscle strength in relation to knee osteoarthritis. *Knee Surg Sports Traumatol Arthrosc*. 2014 Sep;22(9):2013-25.
- 23.** Yusuf E, Kortekaas MC, Watt I, Huizinga TW, Kloppenburg M. Do knee abnormalities visualised on MRI explain knee pain in knee osteoarthritis? A systematic review. *Ann Rheum Dis*. 2011 Jan;70(1):60-7.
- 24.** Zhang Y, Nevitt M, Niu J, et al. Fluctuation of knee pain and changes in bone marrow lesions, effusions, and synovitis on magnetic resonance imaging. *Arthritis Rheum*. 2011 Mar;63(3):691-9.
- 25.** Plett SK, Hackney LA, Heilmeier U, et al. Femoral condyle insufficiency fractures: associated clinical and morphological findings and impact on outcome. *Skeletal Radiol*. 2015 Dec;44(12):1785-94.
- 26.** Hochman MG, Melenevsky YV, et al. ACR Appropriateness Criteria® Imaging After Total Knee Arthroplasty. *J Am Coll Radiol*. 2017 Nov;14(11S):S1546-1440(17)31091-8.

- 27.** Kransdorf MJ, Murphey MD, et al. ACR Appropriateness Criteria® Soft-Tissue Masses. *J Am Coll Radiol*. 2018 May;15(5S):S1546-1440(18)30337-5.
- 28.** Englund M, Guermazi A, Gale D, et al. Incidental meniscal findings on knee MRI in middle-aged and elderly persons. *N Engl J Med*. 2008 Sep 11;359(11):1108-15.
- 29.** Thuillier DU, Souza RB, Wu S, Luke A, Li X, Feeley BT. T1 $\rho$  imaging demonstrates early changes in the lateral patella in patients with patellofemoral pain and maltracking. *Am J Sports Med*. 2013 Aug;41(8):1813-8.
- 30.** Schiphof D, van Middelkoop M, de Klerk BM, et al. Crepitus is a first indication of patellofemoral osteoarthritis (and not of tibiofemoral osteoarthritis). *Osteoarthritis Cartilage*. 2014 May;22(5):S1063-4584(14)00048-X.
- 31.** Wang J, Antony B, Zhu Z, et al. Association of patellar bone marrow lesions with knee pain, patellar cartilage defect and patellar cartilage volume loss in older adults: a cohort study. *Osteoarthritis Cartilage*. 2015 Aug;23(8):S1063-4584(15)00062-X.
- 32.** Barbier-Brion B, Lerais JM, Aubry S, et al. Magnetic resonance imaging in patellar lateral femoral friction syndrome (PLFFS): prospective case-control study. *Diagn Interv Imaging*. 2012 Mar;93(3):e171-82.
- 33.** Monk AP, Doll HA, Gibbons CL, et al. The patho-anatomy of patellofemoral subluxation. *J Bone Joint Surg Br*. 2011 Oct;93(10):1341-7.
- 34.** Tuna BK, Semiz-Oysu A, Pekar B, Bukte Y, Hayirlioglu A. The association of patellofemoral joint morphology with chondromalacia patella: a quantitative MRI analysis. *Clin Imaging*. 2014;38(4):S0899-7071(14)00039-4.
- 35.** Knoop J, Dekker J, van der Leeden M, et al. Is the severity of knee osteoarthritis on magnetic resonance imaging associated with outcome of exercise therapy?. *Arthritis Care Res (Hoboken)*. 2014 Jan;66(1):63-8.
- 36.** Al-Hadithy N, Gikas P, Mahapatra AM, Dowd G. Review article: Plica syndrome of the knee. *J Orthop Surg (Hong Kong)*. 2011 Dec;19(3):354-8.
- 37.** Dean BJ, Reed DW, Matthews JJ, et al. The management of solitary tumours of Hoffa's fat pad. *Knee*. 2011 Mar;18(2):67-70.
- 38.** Hayashi D, Xu L, Guermazi A, et al. Prevalence of MRI-detected mediopatellar plica in subjects with knee pain and the association with MRI-detected patellofemoral cartilage damage and bone marrow lesions: data from the Joints On Glucosamine study. *BMC Musculoskelet Disord*. 2013 Oct 12;14():292.
- 39.** Jalgaonkar A, Dachepalli S, Farid M, Rao S. Angioleiomyoma of the knee: case series and an unusual cause of knee pain. *J Knee Surg*. 2011 Mar;24(1):33-7.
- 40.** Mao Y, Dong Q, Wang Y. Ganglion cysts of the cruciate ligaments: a series of 31 cases and review of the literature. *BMC Musculoskelet Disord*. 2012 Aug 03;13():137.
- 41.** Orth RC. The pediatric knee. *Pediatr Radiol*. 2013 Mar;43 Suppl 1():S90-8.
- 42.** Ottaviani S, Ayral X, Dougados M, Gossec L. Pigmented villonodular synovitis: a retrospective single-center study of 122 cases and review of the literature. *Semin Arthritis Rheum*. 2011 Jun;40(6):539-46.
- 43.** Skiadas V, Perdikakis E, Plotas A, Lahanis S. MR imaging of anterior knee pain: a pictorial



essay. *Knee Surg Sports Traumatol Arthrosc.* 2013 Feb;21(2):294-304.

44. Strauss EJ, Kim S, Calcei JG, Park D. Iliotibial band syndrome: evaluation and management. *J Am Acad Orthop Surg.* 2011 Dec;19(12):728-36.
45. Toppi J, Fairley J, Cicuttini FM, et al. Factors associated with magnetic resonance imaging defined patellar tendinopathy in community-based middle-aged women: a prospective cohort study. *BMC Musculoskelet Disord.* 2015 Aug 05;16():184.
46. Crema MD, Felson DT, Roemer FW, et al. Peripatellar synovitis: comparison between non-contrast-enhanced and contrast-enhanced MRI and association with pain. The MOST study. *Osteoarthritis Cartilage.* 2013 Mar;21(3):S1063-4584(12)01051-5.
47. Guermazi A, Roemer FW, Hayashi D, et al. Assessment of synovitis with contrast-enhanced MRI using a whole-joint semiquantitative scoring system in people with, or at high risk of, knee osteoarthritis: the MOST study. *Ann Rheum Dis.* 2011;70(5):805-811.
48. Wenham CY, Balamoody S, Grainger AJ, et al. The responsiveness of novel, dynamic, contrast-enhanced magnetic resonance measures of total knee synovitis after intra-articular corticosteroid for painful osteoarthritis. *Osteoarthritis Cartilage.* 2014;22(10):1614-1618.
49. Botanlioglu H, Kantarci F, Kaynak G, et al. Shear wave elastography properties of vastus lateralis and vastus medialis obliquus muscles in normal subjects and female patients with patellofemoral pain syndrome. *Skeletal Radiol.* 2013 May;42(5):659-66.
50. Kijowski R, Blankenbaker DG, Shinki K, Fine JP, Graf BK, De Smet AA. Juvenile versus adult osteochondritis dissecans of the knee: appropriate MR imaging criteria for instability. *Radiology.* 2008 Aug;248(2):571-8.
51. Gelber PE, Batista J, Millan-Billi A, et al. Magnetic resonance evaluation of TruFit® plugs for the treatment of osteochondral lesions of the knee shows the poor characteristics of the repair tissue. *Knee.* 2014 Aug;21(4):S0968-0160(14)00078-7.
52. Ojala R, Kerimaa P, Lakovaara M, et al. MRI-guided percutaneous retrograde drilling of osteochondritis dissecans of the knee. *Skeletal Radiol.* 2011;40(6):765-770.
53. Roemer FW, Guermazi A, Trattin S, et al. Whole joint MRI assessment of surgical cartilage repair of the knee: cartilage repair osteoarthritis knee score (CROAKS). *Osteoarthritis Cartilage.* 2014 Jun;22(6):S1063-4584(14)01018-8.
54. Stanish WD, McCormack R, Forriol F, et al. Novel scaffold-based BST-CarGel treatment results in superior cartilage repair compared with microfracture in a randomized controlled trial. *J Bone Joint Surg Am.* 2013 Sep 18;95(18):1640-50.
55. Eckstein F, Collins JE, Nevitt MC, et al. Brief Report: Cartilage Thickness Change as an Imaging Biomarker of Knee Osteoarthritis Progression: Data From the Foundation for the National Institutes of Health Osteoarthritis Biomarkers Consortium. *Arthritis Rheumatol.* 2015 Dec;67(12):3184-9.
56. Schiphof D, Oei EH, Hofman A, Waarsing JH, Weinans H, Bierma-Zeinstra SM. Sensitivity and associations with pain and body weight of an MRI definition of knee osteoarthritis compared with radiographic Kellgren and Lawrence criteria: a population-based study in middle-aged females. *Osteoarthritis Cartilage.* 2014 Mar;22(3):S1063-4584(14)00007-7.
57. Roemer FW, Jarraya M, Kwok CK, et al. Brief report: symmetry of radiographic and MRI-detected structural joint damage in persons with knee pain--the Joints on Glucosamine

(JOG) Study. Osteoarthritis Cartilage. 2015 Aug;23(8):S1063-4584(15)00213-7.

58. Pihlajamäki HK, Kuikka PI, Leppänen VV, Kiuru MJ, Mattila VM. Reliability of clinical findings and magnetic resonance imaging for the diagnosis of chondromalacia patellae. *J Bone Joint Surg Am*. 2010 Apr;92(4):927-34.
59. Ballegaard C, Riis RG, Bliddal H, et al. Knee pain and inflammation in the infrapatellar fat pad estimated by conventional and dynamic contrast-enhanced magnetic resonance imaging in obese patients with osteoarthritis: a cross-sectional study. *Osteoarthritis Cartilage*. 2014 Jul;22(7):S1063-4584(14)01056-5.
60. Keen HI, Hensor EM, Wakefield RJ, Mease PJ, Bingham CO, Conaghan PG. Ultrasound assessment of response to intra-articular therapy in osteoarthritis of the knee. *Rheumatology (Oxford)*. 2015 Aug;54(8):1385-91.
61. O'Neill TW, Parkes MJ, Maricar N, et al. Synovial tissue volume: a treatment target in knee osteoarthritis (OA). *Ann Rheum Dis*. 2016 Jan;75(1):84-90.
62. De Filippo M, Bertellini A, Pogliacomi F, et al. Multidetector computed tomography arthrography of the knee: diagnostic accuracy and indications. *Eur J Radiol*. 2009 May;70(2):342-51.
63. Vande Berg BC, Lecouvet FE, Poilvache P, Dubuc JE, Maldague B, Malghem J. Anterior cruciate ligament tears and associated meniscal lesions: assessment at dual-detector spiral CT arthrography. *Radiology*. 2002 May;223(2):403-9.
64. Vande Berg BC, Lecouvet FE, Poilvache P, et al. Dual-detector spiral CT arthrography of the knee: accuracy for detection of meniscal abnormalities and unstable meniscal tears. *Radiology*. 2000 Sep;216(3):851-7.
65. Vlychou M, Hantes M, Michalitsis S, Tsezou A, Fezoulidis IV, Malizos K. Chronic anterior cruciate ligament tears and associated meniscal and traumatic cartilage lesions: evaluation with morphological sequences at 3.0 T. *Skeletal Radiol*. 2011 Jun;40(6):709-16.
66. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://edge.sitecorecloud.io/americancoldf5f-acrorgf92a-productioncb02-3650/media/ACR/Files/Clinical/Appropriateness-Criteria/ACR-Appropriateness-Criteria-Radiation-Dose-Assessment-Introduction.pdf>.
67. Eckstein F, Cotofana S, Wirth W, et al. Greater rates of cartilage loss in painful knees than in pain-free knees after adjustment for radiographic disease stage: data from the osteoarthritis initiative. *Arthritis Rheum*. 2011 Aug;63(8):2257-67.
68. Kinds MB, Marijnissen AC, Vincken KL, et al. Evaluation of separate quantitative radiographic features adds to the prediction of incident radiographic osteoarthritis in individuals with recent onset of knee pain: 5-year follow-up in the CHECK cohort. *Osteoarthritis Cartilage*. 2012 Jun;20(6):548-56.
69. Simpfendorfer C, Polster J. MRI of the Knee: What Do We Miss?. *Curr Radiol Rep* 2, 43 (2014). <https://doi.org/10.1007/s40134-014-0043-2>
70. Alaia EF, Samim M, Khodarahmi I, et al. Utility of MRI for Patients 45 Years Old and Older With Hip or Knee Pain: A Systematic Review. *AJR Am J Roentgenol*. 2024 Jun;222(6):e2430958.
71. Baker JC, Friedman MV, Rubin DA. Imaging the Postoperative Knee Meniscus: An Evidence-

Based Review. *AJR Am J Roentgenol*. 2018 Sep;211(3):519-527.

72. Basha MAA, Eldib DB, Aly SA, et al. Diagnostic accuracy of ultrasonography in the assessment of anterior knee pain. *Insights Imaging*. 2020 Oct 01;11(1):107.
73. Riddle DL, Jiranek WA. Knee osteoarthritis radiographic progression and associations with pain and function prior to knee arthroplasty: a multicenter comparative cohort study. *Osteoarthritis Cartilage*. 2015 Mar;23(3):S1063-4584(14)01385-5.
74. Muraki S, Akune T, En-Yo Y, et al. Joint space narrowing, body mass index, and knee pain: the ROAD study (OAC1839R1). *Osteoarthritis Cartilage*. 2015 Jun;23(6):S1063-4584(15)00024-2.
75. Galván-Tejada JI, Celaya-Padilla JM, Treviño V, Tamez-Peña JG. Multivariate Radiological-Based Models for the Prediction of Future Knee Pain: Data from the OAI. *Comput Math Methods Med*. 2015;2015():794141.
76. Dai Z, Li J, Yang Z, et al. Patellar Tendon-Trochlear Groove Angle Measured on a Single Computed Tomography Slice of the Distal Femoral Trochlear Groove Is a Reliable Measurement for the Evaluation of Patellar Instability. *Arthroscopy*. 2023 May;39(5):S0749-8063(22)00765-4.
77. Marchand RC, Bhowmik-Stoker M, Chen Z, Mont MA. Clinical Outcomes After Computed Tomography-Based Total Knee Arthroplasty: A Surgeon's First 1,000 Cases. *Surg Technol Int*. 2022 May 19;40():391-395.
78. Yablon CM, Pai D, Dong Q, Jacobson JA. Magnetic resonance imaging of the extensor mechanism. *Magn Reson Imaging Clin N Am*. 2014 Nov;22(4):S1064-9689(14)00065-8.
79. Delorme JP, Jibri Z. The association of patellar tendinosis with patellar maltracking and Hoffa's fat pad impingement: A case-control MRI study. *Clin Imaging*. 2021 Aug;76():S0899-7071(21)00172-8.
80. Docking SI, Ooi CC, Connell D. Tendinopathy: Is Imaging Telling Us the Entire Story?. *J Orthop Sports Phys Ther*. 2015 Nov;45(11):842-52.
81. Esfandiarpour F, Lebrun CM, Dhillon S, Boulanger P. In-vivo patellar tracking in individuals with patellofemoral pain and healthy individuals. *J Orthop Res*. 2018 Feb 28;().
82. Faruch-Bilfeld M, Lapegue F, Chiavassa H, Sans N. Imaging of meniscus and ligament injuries of the knee. *Diagn Interv Imaging*. 2016;97(7-8):S2211-5684(16)30152-8.
83. Gondim Teixeira PA, Balaj C, Marie B, et al. Linear signal hyperintensity adjacent to the subchondral bone plate at the knee on T2-weighted fat-saturated sequences: imaging aspects and association with structural lesions. *Skeletal Radiol*. 2014 Nov;43(11):1589-98.
84. Jibri Z, Jamieson P, Rakhra KS, Sampaio ML, Dervin G. Patellar maltracking: an update on the diagnosis and treatment strategies. *Insights Imaging*. 2019 Jun 14;10(1):65.
85. Kandemirli GC, Basaran M, Kandemirli S, Inceoglu LA. Assessment of knee osteoarthritis by ultrasonography and its association with knee pain. *J Back Musculoskelet Rehabil*. 2020;33(4):711-717.
86. Lee W, Kim HS, Kim SJ, et al. CT arthrography and virtual arthroscopy in the diagnosis of the anterior cruciate ligament and meniscal abnormalities of the knee joint. *Korean J Radiol*. 2004;5(1):47-54.

87. Macri EM, Felson DT, Zhang Y, et al. Patellofemoral morphology and alignment: reference values and dose-response patterns for the relation to MRI features of patellofemoral osteoarthritis. *Osteoarthritis Cartilage*. 2017 Oct;25(10):S1063-4584(17)31052-X.
88. Mathieu L, Bouchard A, Marchaland JP, et al. Knee MR-arthrography in assessment of meniscal and chondral lesions. *Orthop Traumatol Surg Res*. 2009 Feb;95(1):40-7.
89. Nishida Y, Nishino T, Tanaka K, Onishi S, Kanamori A, Yamazaki M. An Objective Measure of Patellar Tendon Thickness Based on Ultrasonography and MRI in University Athletes. *J Clin Med*. 2021 Sep 10;10(18):4092.
90. Nizak R, Bekkers J, de Jong PA, Witkamp T, Luijkx T, Saris D. Osteochondral lesion depth on MRI can help predict the need for a sandwich procedure. *Eur J Radiol*. 2017 May;90():S0720-048X(17)30107-9.
91. Ochi J, Nozaki T, Nimura A, Yamaguchi T, Kitamura N. Subchondral insufficiency fracture of the knee: review of current concepts and radiological differential diagnoses. *Jpn J Radiol*. 2022 May;40(5):443-457.
92. Prakash J, Seon JK, Woo SH, Jin C, Song EK. Comparison of Radiological Parameters between Normal and Patellar Dislocation Groups in Korean Population: A Rotational Profile CT-Based Study. *Knee Surg Relat Res*. 2016 Dec 01;28(4):302-311.
93. Sarmanova A, Hall M, Fernandes GS, et al. Association between ultrasound-detected synovitis and knee pain: a population-based case-control study with both cross-sectional and follow-up data. *Arthritis Res Ther*. 2017 Dec 19;19(1):281.
94. Schueda MA, Astur DC, Bier RS, Bier DS, Astur N, Cohen M. Use of computed tomography to determine the risk of patellar dislocation in 921 patients with patellar instability. *Open Access J Sports Med*. 2015;6():55-62.
95. Tscholl PM, Biedert RM, Wanivenhaus F, Fucentese SF. Patellar tendinopathy with intratendinous alteration on MRI may be related to patellofemoral dysplasia. *Scand J Med Sci Sports*. 2018 Apr;28(4):1443-1450.

## Disclaimer

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.

<sup>a</sup>Mayo Clinic Arizona, Phoenix, Arizona. <sup>b</sup>Panel Chair, VA San Diego Healthcare System, San Diego, California. <sup>c</sup>The University of Texas MD Anderson Cancer Center, Houston, Texas. <sup>d</sup>Penn State Milton S. Hershey Medical Center, Hershey, Pennsylvania. <sup>e</sup>Albert Einstein College of Medicine, Philadelphia, Pennsylvania. <sup>f</sup>University of Washington, Seattle, Washington. <sup>g</sup>Seattle Children's Hospital, Seattle, Washington. <sup>h</sup>University of Wisconsin Hospital & Clinics, Madison, Wisconsin. <sup>i</sup>UT Health San Antonio, San Antonio, Texas; Commission on Nuclear Medicine and Molecular Imaging. <sup>j</sup>Temple University Hospital, Philadelphia, Pennsylvania; American Academy of Orthopaedic Surgeons. <sup>k</sup>Brigham & Women's Hospital, Boston, Massachusetts. <sup>l</sup>Emory University School of Medicine, Atlanta, Georgia. <sup>m</sup>Brigham & Women's Hospital & Harvard Medical School, Boston, Massachusetts. <sup>n</sup>University of Arizona, Tucson, Arizona. <sup>o</sup>University of Rochester School of Medicine and Dentistry, Rochester, New York; American College of Rheumatology. <sup>p</sup>Northwestern Memorial Hospital, Chicago, Illinois; American College of Physicians. <sup>q</sup>Specialty Chair, Mayo Clinic, Phoenix, Arizona.