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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Nontraumatic Knee Pain**

Variant 1: **Child or adolescent: nonpatellofemoral symptoms. Initial examination.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9		☢
X-ray hip ipsilateral	1		☢ ☢ ☢
CT knee without IV contrast	1		☢ ☢
CT knee with IV contrast	1		☢ ☢
CT knee without and with IV contrast	1		☢ ☢
CT arthrography knee	1		☢ ☢
MRI knee without IV contrast	1		O
MRI knee without and with IV contrast	1		O
MR arthrography knee	1		O
US knee	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 2: **Child or adult: patellofemoral (anterior) symptoms. Initial examination.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9		☢
X-ray hip ipsilateral	1		☢ ☢ ☢
CT knee without IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT knee with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT knee without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢ ☢
CT arthrography knee	1	The RRL for the adult procedure is ☢ .	☢ ☢
MRI knee without IV contrast	1		O
MRI knee without and with IV contrast	1		O
MR arthrography knee	1		O
US knee	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Nontraumatic Knee Pain**

Variant 3: **Adult: nontrauma, nonlocalized pain. Initial examination.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee	9		☢
X-ray hip ipsilateral	1		☢☢☢
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
CT arthrography knee	1		☢
MRI knee without IV contrast	1		O
MRI knee without and with IV contrast	1		O
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 4: **Child or adolescent: nonpatellofemoral symptoms. Initial knee radiographs are negative or demonstrate a joint effusion.**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	9		O
MRI knee without and with IV contrast	3	Contrast may be helpful in the setting of unexplained synovitis and/or an unexplained prominent amount of joint fluid.	O
X-ray hip ipsilateral	2	Indicated if there is clinical evidence or concern for hip pathology causing referred pain to the knee.	☢☢☢
CT knee without IV contrast	1		☢☢
CT knee with IV contrast	1		☢☢
CT knee without and with IV contrast	1		☢☢
CT arthrography knee	1		☢☢
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Nontraumatic Knee Pain**

Variant 5: **Child or adult: patellofemoral (anterior) symptoms. Initial knee radiographs are negative or demonstrate a joint effusion.**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	9	If additional imaging is necessary and if internal derangement is suspected.	O
MRI knee without and with IV contrast	3	Contrast may be helpful in the setting of unexplained synovitis and/or an unexplained prominent amount of joint fluid.	O
X-ray hip ipsilateral	1		☢☢☢
CT knee without IV contrast	1	The RRL for the adult procedure is ☢ .	☢☢
CT knee with IV contrast	1	The RRL for the adult procedure is ☢ .	☢☢
CT knee without and with IV contrast	1	The RRL for the adult procedure is ☢ .	☢☢
CT arthrography knee	1	The RRL for the adult procedure is ☢ .	☢☢
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 6: **Adult: nontrauma, nonlocalized pain. Initial knee radiographs are negative or demonstrate a joint effusion.**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	9	If additional imaging is necessary and if internal derangement is suspected.	O
MRI knee without and with IV contrast	3	Contrast may be helpful in the setting of unexplained synovitis and/or an unexplained prominent amount of joint fluid.	O
X-ray hip ipsilateral	1		☢☢☢
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
CT arthrography knee	1		☢
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Nontraumatic Knee Pain**

Variant 7: **Child or adolescent: nonpatellofemoral symptoms. Initial knee radiographs demonstrate osteochondral injuries (fracture/osteochondritis dissecans or a loose body).**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	9		O
MR arthrography knee	6		O
CT arthrography knee	5	If MRI cannot be done.	☢ ☢
MRI knee without and with IV contrast	1		O
X-ray hip ipsilateral	1		☢ ☢ ☢
CT knee without IV contrast	1		☢ ☢
CT knee with IV contrast	1		☢ ☢
CT knee without and with IV contrast	1		☢ ☢
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Variant 8: **Adult: patellofemoral (anterior) symptoms. Initial knee radiographs demonstrate degenerative joint disease and/or chondrocalcinosis.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray hip ipsilateral	1		☢ ☢ ☢
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
CT arthrography knee	1		☢
MRI knee without IV contrast	1		O
MRI knee without and with IV contrast	1		O
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

Clinical Condition: **Nontraumatic Knee Pain**

Variant 9: **Adult: Initial knee radiographs demonstrate inflammatory, crystalline, or degenerative joint disease (uni- to tri-compartmental sclerosis, hypertrophic spurs, joint space narrowing, and/or subchondral cysts).**

Radiologic Procedure	Rating	Comments	RRL*
X-ray hip ipsilateral	1		☢☢☢
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
CT arthrography knee	1		☢
MRI knee without IV contrast	1	Consider for preoperative assessment.	O
MRI knee without and with IV contrast	1		O
MR arthrography knee	1		O
US knee	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Variant 10: **Adult: Initial knee radiographs demonstrate avascular necrosis.**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	7	If needed for therapy.	O
MRI knee without and with IV contrast	1		O
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
CT arthrography knee	1		☢
MR arthrography knee	1		O
US knee	1		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition: **Nontraumatic Knee Pain**

Variant 11: **Adult: Initial knee radiographs demonstrate evidence of internal derangement (eg, Segond fracture, deep lateral femoral notch sign).**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee without IV contrast	9		O
CT arthrography knee	5	If MRI cannot be done.	☢
MRI knee without and with IV contrast	1		O
CT knee without IV contrast	1		☢
CT knee with IV contrast	1		☢
CT knee without and with IV contrast	1		☢
MR arthrography knee	1		O
US knee	1		O
Rating Scale: **1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate**			***Relative Radiation Level**

NONTRAUMATIC KNEE PAIN

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Summary of Literature Review

Background/Introduction

Nontraumatic knee pain in children, adolescents, and adults includes localized complaints such as anterior (parapatellar) pain and nonlocalized symptoms. The consensus of the committee is that the initial imaging study for nontraumatic knee pain should be radiography. When initial radiographs are nondiagnostic (normal findings or a joint effusion) and knee symptoms are suspicious for an internal derangement, the next indicated study is a magnetic resonance imaging (MRI) examination [1]. MRI is also indicated when the patient has persistent knee pain and normal radiographs. MRI is more sensitive than radiography and provides more specific information compared with radionuclide bone scan [2,3]. MRI of nontraumatic knee pain may document a joint effusion, communicating popliteal cysts, proliferative changes of the synovial membrane (such as, but not limited to lipoma arborescens, synovial chondromatosis, or synovitis of arthritis), osteophytes, subchondral cysts, articular cartilage loss, meniscal and/or ligamentous tears and/or degeneration, bone marrow edema (bearing in mind that actual edema is not a major constituent of this abnormal edema-like signal in the setting of osteoarthritis), fractures, and osteonecrosis [2-4].

Radiography

The consensus of the committee is that the initial imaging study for nontraumatic knee pain should be at least one frontal projection of one or both knees (anteroposterior [AP], Rosenberg, or tunnel), a lateral view of the affected knee, and tangential patellar view radiographs [5-7]. In patients with nontraumatic knee pain, referred pain from the hip must be considered, and hip radiographs may need to be obtained if there is clinical evidence or clinical concern for hip pathology.

In elderly patients, the most common source of nontraumatic knee pain is osteoarthritis. Conventional radiographic diagnosis of degenerative joint disease (osteoarthritis) includes joint space narrowing, osteophytes, subchondral cysts, and sclerosis bordering the joint. Articular cartilage is evaluated indirectly on radiographs by joint space narrowing and changes in the subchondral bone [8]. Routine radiographs are insensitive for assessing articular cartilage in the early stages of osteoarthritis, while in advanced disease, joint space narrowing on radiographs is usually an accurate assessment of cartilage loss [9-11]. Standing radiographs have been reported to more accurately reflect medial and lateral joint compartment cartilage loss than supine radiographs; however, in the presence of a severe varus or valgus deformity, significant cartilage loss in the compartment that appears wide (due to the alignment deformity) may not be evident [12,13]. A weight-bearing posteroanterior (PA) radiograph, obtained with knee flexion, has been reported to show the cartilage width of the posterior medial and lateral joint compartments more accurately than a standing view obtained with the knee extended [14]. The standing flexed view may be indicated in elderly patients with osteoarthritis when surgical intervention is being planned. Finally, one should bear in mind that a significant portion of the joint space narrowing may be due to meniscal extrusion or degeneration rather than hyaline cartilage loss in some patients [15]. Additional imaging studies are not indicated in patients for whom radiographs are diagnostic of degenerative joint disease unless treatment options

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depend on additional imaging findings, or when symptoms are not explained by the radiographic findings (eg, stress fractures) [16].

Other nontraumatic causes of knee pain in adult patients include internal knee derangement (meniscal and ligament tears), stress fracture, subchondral insufficiency fracture, inflammatory arthritis, transient osteoporosis, and chronic regional pain syndrome. Meniscal tears are highly prevalent in symptomatic knee osteoarthritis [17]; however, meniscal tears are also common incidental findings in middle-aged to older adults, with a majority of people over the age of 70 having an asymptomatic meniscal tear [18]. Chronic anterolateral knee pain may also result from patellar tendon–lateral femoral condyle friction syndrome or iliotibial band syndrome (friction syndrome), both of which can be confirmed or excluded by MRI [19,20].

Magnetic Resonance Imaging

When initial radiographs are nondiagnostic (normal findings or a joint effusion) and knee symptoms are suspicious for an internal derangement, the next indicated study is an MRI examination [1]. MRI is also indicated when the patient has persistent knee pain and normal radiographs. MRI is more sensitive than radiography and provides more specific information compared with radionuclide bone scan [2,3]. MRI of nontraumatic knee pain may document a joint effusion, communicating popliteal cysts, proliferative changes of the synovial membrane (such as, but not limited to lipoma arborescens, synovial chondromatosis, or synovitis associated with arthritis), osteophytes, subchondral cysts, articular cartilage loss, meniscal and/or ligamentous tears and/or degeneration, extensor mechanism disorders, bone marrow edema (bearing in mind that actual edema is not a major constituent of this abnormal edema-like signal in the setting of osteoarthritis), fractures, and osteonecrosis [2-4].

A suprapatellar joint effusion is readily detected on a lateral radiograph of the knee; however, the extent of a joint effusion, the presence of a communicating synovial (popliteal) cyst, or synovitis is readily identified on MRI [4,21-27]. Subchondral cysts are easily detected on MRI because of its tomographic quality, multiplaner imaging capability, and superb sensitivity to fluid- and fat-containing tissues [3,4,28]. Cartilage pathology, both articular and meniscal, can be evaluated directly on MRI, and demonstration depends on the location of the abnormality and the pulse sequences used [29-33].

Magnetic resonance arthrography performed with an intra-articular injection of dilute gadolinium solution [34,35] or with an intravenous injection [36] of gadolinium contrast to improve cartilage evaluation has been investigated; however, noncontrast MRI (at both 1.5 T and 3.0 T) has been reported as being accurate for cartilage abnormalities [29,33,37].

Patellofemoral cartilage loss has been reported to be closely associated with chronic knee pain symptoms [38]. MRI has been reported to be more accurate than physical examination for identifying more severe (grades II-IV) lesions of chondromalacia patellae, and may be an appropriate screening tool before arthroscopy [39].

Transient osteoporosis is characterized by self-limited pain and radiographically demonstrable osteopenia. The osteopenia typically develops within 8 weeks after the onset of pain.

MRI is useful to identify a subchondral insufficiency fracture as the initial injury from which localized osteonecrosis may result and which, in the past, was termed spontaneous osteonecrosis [24]. MRI can also detect osteonecrosis of the medial tibial plateau associated with tibial stress fractures [21]. Subchondral insufficiency fracture — most commonly involving the medial femoral condyle, and most often found in middle-aged and elderly females — may have normal radiographs for months, followed by subchondral collapse, fragmentation of the articular cartilage, and progressive osteoarthritis [21,24,40].

Bone marrow edema seen on MRI occurs in association with, or independent of, transient osteoporosis, subchondral insufficiency fractures, and stress fractures; MRI is highly sensitive for detecting these abnormalities [40]. In adult patients with conventional radiograph diagnosis of an osteochondral injury such as osteochondritis dissecans or subchondral insufficiency fracture, an MRI examination may be indicated if an additional injury is suspected clinically or when it is necessary to determine the status of the articular cartilage over the area of abnormality. In the child or adolescent with radiographic evidence of osteochondritis dissecans, an MRI is indicated to determine the best method of treatment [41-43]. Finally, MRI is not indicated to confirm a stress fracture that is evident on the radiographic study.

In patients with radiographic evidence of inflammatory arthritis of the knee, the consensus of the panel is that a knee MRI is usually not indicated for preoperative differentiation of pannus from effusion or for evaluation of erosion. An aspiration for crystals may be indicated; however, the use of medical imaging (such as fluoroscopic guidance, ultrasound [US] guidance, or arthrographic confirmation) may not be necessary.

Computed Tomography Arthrography

When an intra-articular abnormality is suspected in a patient with claustrophobia, with a large body habitus, or who cannot for some reason tolerate an MRI examination, or when there is contraindication to an MRI, a computed tomography (CT) arthrogram may be used instead of the MRI to evaluate the cruciate ligaments, menisci, and articular cartilage [44,45]. CT without intra-articular contrast has very low sensitivity for internal knee derangements.

Ultrasound

In a patient with nontraumatic knee pain that is felt to be arising from a popliteal cyst, US is an effective imaging method for confirming or ruling out a popliteal cyst. It has been shown to be as accurate as MRI and can be less time-consuming to perform [46]. In diagnosing a popliteal cyst by US, it is important to visualize the neck of the cyst between the semimembranosis tendon and medial head of the gastrocnemius muscle.

Summary

- The initial imaging examination for nontraumatic knee pain is radiography.
- An MRI examination for nontraumatic knee pain is indicated when the pain is persistent and conventional radiographs are nondiagnostic or when additional information is necessary before instituting treatment.
- An MRI is not indicated before a physical examination or routine conventional radiographs, or when there is diagnostic radiographic evidence of severe degenerative joint diseases, inflammatory arthritis, stress fracture, osteonecrosis, or reflex sympathetic dystrophy, for which additional imaging is not going to alter the treatment plan.

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, both because of 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 to 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**
O	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 (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies".		

Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to www.acr.org/ac.

References

1. Vincken PW, ter Braak AP, van Erkel AR, et al. MR imaging: effectiveness and costs at triage of patients with nonacute knee symptoms. *Radiology.* 2007;242(1):85-93.
2. McAlindon TE, Watt I, McCrae F, Goddard P, Dieppe PA. Magnetic resonance imaging in osteoarthritis of the knee: correlation with radiographic and scintigraphic findings. *Ann Rheum Dis.* 1991;50(1):14-19.
3. Reiser MF, Vahlensieck M, Schuller H. Imaging of the knee joint with emphasis on magnetic resonance imaging. *Eur Radiol.* 1992;2:87-94.
4. Sabiston CP, Adams ME, Li DK. Magnetic resonance imaging of osteoarthritis: correlation with gross pathology using an experimental model. *J Orthop Res.* 1987;5(2):164-172.
5. Laurin CA, Dussault R, Levesque HP. The tangential x-ray investigation of the patellofemoral joint: x-ray technique, diagnostic criteria and their interpretation. *Clin Orthop Relat Res.* 1979(144):16-26.
6. Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg Am.* 1974;56(7):1391-1396.
7. Newberg AH, Seligson D. The patellofemoral joint: 30 degrees, 60 degrees, and 90 degrees views. *Radiology.* 1980;137(1 Pt 1):57-61.
8. Hayes CW, Conway WF. Evaluation of articular cartilage: radiographic and cross-sectional imaging techniques. *Radiographics.* 1992;12(3):409-428.
9. Brandt KD, Fife RS, Braunstein EM, Katz B. Radiographic grading of the severity of knee osteoarthritis: relation of the Kellgren and Lawrence grade to a grade based on joint space narrowing, and correlation with arthroscopic evidence of articular cartilage degeneration. *Arthritis Rheum.* 1991;34(11):1381-1386.
10. Kijowski R, Blankenbaker D, Stanton P, Fine J, De Smet A. Arthroscopic validation of radiographic grading scales of osteoarthritis of the tibiofemoral joint. *AJR Am J Roentgenol.* 2006;187(3):794-799.
11. Messieh SS, Fowler PJ, Munro T. Anteroposterior radiographs of the osteoarthritic knee. *J Bone Joint Surg Br.* 1990;72(4):639-640.
12. Altman RD, Fries JF, Bloch DA, et al. Radiographic assessment of progression in osteoarthritis. *Arthritis Rheum.* 1987;30(11):1214-1225.
13. Leach RE, Gregg T, Siber FJ. Weight-bearing radiography in osteoarthritis of the knee. *Radiology.* 1970;97(2):265-268.
14. Rosenberg TD, Paulos LE, Parker RD, Coward DB, Scott SM. The forty-five-degree posteroanterior flexion weight-bearing radiograph of the knee. *J Bone Joint Surg Am.* 1988;70(10):1479-1483.
15. Hunter DJ, Zhang YQ, Tu X, et al. Change in joint space width: hyaline articular cartilage loss or alteration in meniscus? *Arthritis Rheum.* 2006;54(8):2488-2495.
16. Lo GH, McAlindon TE, Niu J, et al. Bone marrow lesions and joint effusion are strongly and independently associated with weight-bearing pain in knee osteoarthritis: data from the osteoarthritis initiative. *Osteoarthritis Cartilage.* 2009;17(12):1562-1569.
17. Lo GH, Hunter DJ, Nevitt M, Lynch J, McAlindon TE. Strong association of MRI meniscal derangement and bone marrow lesions in knee osteoarthritis: data from the osteoarthritis initiative. *Osteoarthritis Cartilage.* 2009;17(6):743-747.
18. 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;359(11):1108-1115.
19. Chung CB, Skaf A, Roger B, Campos J, Stump X, Resnick D. Patellar tendon-lateral femoral condyle friction syndrome: MR imaging in 42 patients. *Skeletal Radiol.* 2001;30(12):694-697.
20. Vasilevska V, Szeimies U, Stabler A. Magnetic resonance imaging signs of iliotibial band friction in patients with isolated medial compartment osteoarthritis of the knee. *Skeletal Radiol.* 2009;38(9):871-875.
21. Le Gars L, Savy JM, Orcel P, et al. Osteonecrosis-like syndrome of the medial tibial plateau can be due to a stress fracture. MR findings in 13 patients. *Rev Rhum Engl Ed.* 1999;66(6):323-330.
22. Shanley DJ, Auber AE, Watabe JT, Buckner AB. Pigmented villonodular synovitis of the knee demonstrated on bone scan. Correlation with US, CT, and MRI. *Clin Nucl Med.* 1992;17(11):901-902.
23. Terrier F, Hricak H, Revel D, et al. Magnetic resonance imaging and spectroscopy of the periarticular inflammatory soft-tissue changes in experimental arthritis of the rat. *Invest Radiol.* 1985;20(8):813-823.

24. Yamamoto T, Bullough PG. Spontaneous osteonecrosis of the knee: the result of subchondral insufficiency fracture. *J Bone Joint Surg Am.* 2000;82(6):858-866.
25. Yulish BS, Montanez J, Goodfellow DB, Bryan PJ, Mulopulos GP, Modic MT. Chondromalacia patellae: assessment with MR imaging. *Radiology.* 1987;164(3):763-766.
26. Machado PM, Koevoets R, Bombardier C, van der Heijde DM. The value of magnetic resonance imaging and ultrasound in undifferentiated arthritis: a systematic review. *J Rheumatol Suppl.* 2011;87:31-37.
27. Sugimoto H, Takeda A, Hyodoh K. Early-stage rheumatoid arthritis: prospective study of the effectiveness of MR imaging for diagnosis. *Radiology.* 2000;216(2):569-575.
28. Chan WP, Lang P, Stevens MP, et al. Osteoarthritis of the knee: comparison of radiography, CT, and MR imaging to assess extent and severity. *AJR Am J Roentgenol.* 1991;157(4):799-806.
29. Boegard TL, Rudling O, Petersson IF, Jonsson K. Magnetic resonance imaging of the knee in chronic knee pain. A 2-year follow-up. *Osteoarthritis Cartilage.* 2001;9(5):473-480.
30. Ghelman B, Hodge JC. Imaging of the patellofemoral joint. *Orthop Clin North Am.* 1992;23(4):523-543.
31. Konig H, Sauter R, Deimling M, Vogt M. Cartilage disorders: comparison of spin-echo, CHESS, and FLASH sequence MR images. *Radiology.* 1987;164(3):753-758.
32. Spritzer CE, Vogler JB, Martinez S, et al. MR imaging of the knee: preliminary results with a 3DFT GRASS pulse sequence. *AJR Am J Roentgenol.* 1988;150(3):597-603.
33. Chen CA, Lu W, John CT, et al. Multiecho IDEAL gradient-echo water-fat separation for rapid assessment of cartilage volume at 1.5 T: initial experience. *Radiology.* 2009;252(2):561-567.
34. Engel A. Magnetic resonance knee arthrography. Enhanced contrast by gadolinium complex in the rabbit and in humans. *Acta Orthop Scand Suppl.* 1990;240:1-57.
35. Vande Berg BC, Lecouvet FE, Poilvache P, et al. Assessment of knee cartilage in cadavers with dual-detector spiral CT arthrography and MR imaging. *Radiology.* 2002;222(2):430-436.
36. Winalski CS, Aliabadi P, Wright RJ, Shortkroff S, Sledge CB, Weissman BN. Enhancement of joint fluid with intravenously administered gadopentetate dimeglumine: technique, rationale, and implications. *Radiology.* 1993;187(1):179-185.
37. Kijowski R, Blankenbaker DG, Davis KW, Shinki K, Kaplan LD, De Smet AA. Comparison of 1.5- and 3.0-T MR imaging for evaluating the articular cartilage of the knee joint. *Radiology.* 2009;250(3):839-848.
38. Hunter DJ, March L, Sambrook PN. The association of cartilage volume with knee pain. *Osteoarthritis Cartilage.* 2003;11(10):725-729.
39. Pihlajamaki HK, Kuikka PI, Leppanen 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;92(4):927-934.
40. Hayes CW, Conway WF, Daniel WW. MR imaging of bone marrow edema pattern: transient osteoporosis, transient bone marrow edema syndrome, or osteonecrosis. *Radiographics.* 1993;13(5):1001-1011; discussion 1012.
41. O'Connor MA, Palaniappan M, Khan N, Bruce CE. Osteochondritis dissecans of the knee in children. A comparison of MRI and arthroscopic findings. *J Bone Joint Surg Br.* 2002;84(2):258-262.
42. Pill SG, Ganley TJ, Milam RA, Lou JE, Meyer JS, Flynn JM. Role of magnetic resonance imaging and clinical criteria in predicting successful nonoperative treatment of osteochondritis dissecans in children. *J Pediatr Orthop.* 2003;23(1):102-108.
43. 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;248(2):571-578.
44. Vande Berg BC, Lecouvet FE, Maldague B, Malghem J. MR appearance of cartilage defects of the knee: preliminary results of a spiral CT arthrography-guided analysis. *Eur Radiol.* 2004;14(2):208-214.
45. 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;223(2):403-409.
46. Ward EE, Jacobson JA, Fessell DP, Hayes CW, van Holsbeeck M. Sonographic detection of Baker's cysts: comparison with MR imaging. *AJR Am J Roentgenol.* 2001;176(2):373-380.

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.