

**American College of Radiology  
ACR Appropriateness Criteria®**

**Clinical Condition:**                      **Nontraumatic Knee Pain**

**Variant 1:**                                      **Child or adolescent: nonpatellofemoral symptoms. Mandatory minimal initial exam.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee AP and lateral	9		Min
CT knee postarthrography	1		Min
X-ray knee ipsolateral hip films (AP/frog leg lateral)	1		Min
INV aspiration/arthrography knee	1		IP
X-ray knee axial view	1		Min
MRI knee	1		None
NUC bone scan 3-phase lower extremity	1		Med
US knee	1		None
X-ray knee notch or tunnel view (standing or supine)	1		Min
CT knee	1		Min
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

**Variant 2:**                                      **Child or adult: patellofemoral (anterior) symptoms. Mandatory minimal initial exam.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee AP and lateral	9		Min
X-ray knee axial view	9		Min
MRI knee	1		None
NUC bone scan 3-phase area of interest	1		Med
CT knee postarthrography	1		Min
US knee	1		None
X-ray knee ipsolateral hip films (AP/frog leg lateral)	1		Min
X-ray knee notch or tunnel view (standing or supine)	1		Min
INV aspiration/arthrography knee	1		IP
CT knee	1		Min
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Nontraumatic Knee Pain****Variant 3:****Adult: nontrauma, nontumor, nonlocalized pain. Mandatory minimal initial exam.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray knee AP and lateral	9		Min
CT knee	1		Min
US knee	1		None
X-ray knee notch or tunnel view (standing or supine)	1		Min
INV aspiration/arthrography knee	1		IP
MRI knee	1		None
CT knee postarthrography	1		Min
NUC bone scan 3-phase area of interest	1		Med
X-ray knee axial view	No Consensus		Min
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 4:****Child or adolescent: nonpatellofemoral symptoms. Initial AP and lateral radiographs nondiagnostic (demonstrate normal findings or a joint effusion).**

Radiologic Procedure	Rating	Comments	RRL*
MRI knee	9	If additional study is needed.	None
NUC bone scan 3-phase lower extremity	1		Med
CT knee	1		Min
INV aspiration/arthrography knee	1		IP
CT knee postarthrography	1		Min
US knee	1		None
X-ray knee additional views	1	If hip exam is normal.	Min
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Nontraumatic Knee Pain****Variant 5:****Child or adult. Patellofemoral (anterior) symptoms. Initial AP, lateral, and axial radiographs nondiagnostic (demonstrate normal findings or a joint effusion).**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b>RRL*</b>
MRI knee	9	If additional imaging is necessary, and if internal derangement is suspected.	None
CT knee	1		Min
X-ray knee additional views	1		Min
US knee	1		None
CT knee postarthrography	1		Min
NUC bone scan 3-phase area of interest	1		Med
INV aspiration/arthrography knee	1		IP
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

**Variant 6:****Adult. Nontrauma, nontumor, nonlocalized pain. Initial AP and lateral radiographs nondiagnostic (demonstrate normal findings or a joint effusion).**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b>RRL*</b>
MRI knee	9	If additional studies are indicated, and if internal derangement is suspected.	None
CT knee postarthrography	1		Min
US knee	1		None
INV aspiration/arthrography knee	1		IP
X-ray knee additional views	1		Min
CT knee	1		Min
NUC bone scan 3-phase area of interest	1	Unless metastatic disease is a possibility.	Med
<b><u>Rating Scale:</u> 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Nontraumatic Knee Pain****Variant 7:**

**Child or adolescent. Nonpatellofemoral symptoms. Initial AP and lateral radiographs demonstrate osteochondral injuries (fracture/osteochondritis dissecans or a loose body).**

Radiologic Procedure	Rating	Comments	RRL*
US knee	1		None
INV aspiration/arthrography knee	1		IP
NUC bone scan 3-phase lower extremity	1		Med
X-ray knee additional views	1		Min
CT knee postarthrography	1	Indicated only if further studies are necessary and MR is contraindicated or cannot be performed.	Min
CT knee	1		Min
MRI knee	No Consensus	Panel agreed that MR is important to look for additional injury, status of articular surface, or suspected internal derangement and that treatment is dependent on additional information.	None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 8:**

**Child or adult. Patellofemoral (anterior) symptoms. Initial AP, lateral, and axial radiographs demonstrate degenerative joint disease and/or chondrocalcinosis.**

Radiologic Procedure	Rating	Comments	RRL*
CT knee	1		Min
INV aspiration/arthrography knee	1		IP
X-ray knee additional views	1		Min
CT knee postarthrography	1		Min
US knee	1		None
NUC bone scan 3-phase area of interest	1		Med
MRI knee	1	Unless treatment and/or surgery is dependent on findings.	None
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

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**Clinical Condition:****Nontraumatic Knee Pain****Variant 9:**

**Adult. Nontrauma, nontumor, nonlocalized pain. Initial AP and lateral radiographs demonstrate degenerative joint disease (uni- to tri- compartmental sclerosis, hypertrophic spurs, joint space narrowing, and/or subchondral cysts).**

Radiologic Procedure	Rating	Comments	RRL*
US knee	1		None
MRI knee	1	Consider for preoperative assessment.	None
CT knee postarthrography	1		Min
NUC bone scan 3-phase area of interest	1		Med
X-ray knee additional views	1	Standing if evaluation of TKA. Standing views in extension and flexion.	Min
CT knee	1		Min
INV aspiration/arthrography knee	1		IP
<b>Rating Scale:</b> 1=Least appropriate, 9=Most appropriate			<b>*Relative Radiation Level</b>

**Variant 10:**

**Adult. Nontrauma, nontumor, nonlocalized pain. Initial AP and lateral radiographs demonstrates inflammatory arthritis (diffuse tricompartmental joint space narrowing and large joint effusion).**

Radiologic Procedure	Rating	Comments	RRL*
NUC bone scan 3-phase area of interest	1		Med
US knee	1		None
X-ray knee additional views	1		Min
MRI knee	1	Unless preoperative assessment necessary.	None
CT knee postarthrography	1		Min
CT knee	1		Min
INV aspiration/arthrography knee	No Consensus	Aspiration for crystals may be indicated but can be done without arthrogram.	IP
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**Clinical Condition:****Nontraumatic Knee Pain****Variant 11:****Adult, nontrauma, nontumor, nonlocalized pain. Initial AP and lateral radiographs demonstrate avascular necrosis.**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b>RRL*</b>
CT knee postarthrography	1		Min
MRI knee	1		None
X-ray knee additional views	1		Min
INV aspiration/arthrography knee	1		IP
NUC bone scan 3-phase area of interest	1		Med
US knee	1		None
CT knee	1		Min
<b>Rating Scale: 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

**Variant 12:****Adult. Nontrauma, nontumor, nonlocalized pain. Initial AP and lateral radiographs demonstrate evidence of internal derangement (eg, Peligrini Stieda disease, joint compartment widening).**

<b>Radiologic Procedure</b>	<b>Rating</b>	<b>Comments</b>	<b>RRL*</b>
MRI knee	9		None
X-ray knee additional views	1		Min
INV aspiration/arthrography knee	1		IP
NUC bone scan 3-phase area of interest	1		Med
US knee	1		None
CT knee postarthrography	1		Min
CT knee	1		Min
<b>Rating Scale: 1=Least appropriate, 9=Most appropriate</b>			<b>*Relative Radiation Level</b>

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## NONTRAUMATIC KNEE PAIN

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### **Summary of Literature Review**

Nontraumatic knee pain in children, adolescents, and adults includes localized complaints such as anterior (patellofemoral) pain and diffuse nonlocalized symptoms. The consensus of the committee is that the initial imaging study for nontraumatic knee pain is anteroposterior (AP) and lateral radiograph. The AP view can be performed with the patient either standing or supine. The lateral view may be performed with the patient non weight bearing on his or her side with a vertical beam and the knee flexed 30 degrees. If symptoms are localized to the anterior (patellofemoral joint) aspect of the knee, a Merchant or axial (skyline) view of the patellofemoral joint is a mandatory part of the initial evaluation [1-3]. For patients with diffuse non-localized symptoms, there was no consensus regarding the usefulness of a Merchant or axial view as part of the initial examination.

In elderly patients, the most common source of nontraumatic knee pain is degenerative osteoarthritis. Conventional radiographic diagnosis of degenerative joint disease includes joint space narrowing, osteophytes, subchondral cysts, and sclerosis bordering the joint. Articular cartilage is evaluated indirectly on conventional radiographs by joint space narrowing and changes in the subchondral bone [4]. 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 [5,6]. 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 [10-12]. A weight-bearing posterioranterior (PA) radiograph, obtained with knee flexion, has been reported to reflect the cartilage width of the posterior medial and lateral joint compartments more accurately than that a standing view obtained with the knee extended [13-15]. This view may be indicated in elderly patients with degenerative osteoarthritis when surgical intervention is being planned. Additional imaging studies are not indicated in patients for whom the conventional radiographs are diagnostic of degenerative joint disease unless treatment, or surgery, or both are dependent on additional findings such as internal knee derangement or when symptoms are not explained by the radiographic findings (eg, stress fractures).

Other nontraumatic causes of knee pain in adolescent and adult patients include internal knee derangement (meniscal and ligament tears), osteochondritis dissecans, transient osteoporosis, spontaneous osteonecrosis, chronic regional pain syndrome, stress fracture, and inflammatory arthritis. Chronic anterior lateral knee pain may also result from patella tendon—lateral femoral condyle friction syndrome or iliotibial band syndrome (friction syndrome) which can be confirmed/excluded by magnetic resonance imaging (MRI) [16]. In children with nontraumatic knee pain, referred pain from the hip must be entertained.

When initial conventional radiographs are nondiagnostic (normal findings or a joint effusion) and knee symptoms require further imaging, the next indicated study is an MRI exam. MRI is more sensitive than conventional radiographs and provides more specific information compared with radionuclide bone scan [17,18]. MRI of nontraumatic knee pain may document a joint effusion, communicating synovial cysts, proliferative changes of the synovial membrane, osteophytes, subchondral cysts, articular cartilage loss, meniscal and/or ligamentous tears and/or degeneration, bone marrow edema, fractures, and osteonecrosis [17-19].

MRI is useful to identify a subchondral insufficiency fracture as the initial injury from which localized osteonecrosis may result and which was otherwise identified as spontaneous osteonecrosis [20]. MRI can also detect osteonecrosis of the medial femoral condyle or of the medial tibial plateau associated with tibial stress fracture [21]. A suprapatellar joint effusion is readily detected on a routine lateral roentgenogram of the knee; however, the extent of a joint effusion, the presence of a communicating synovial (popliteal) cyst, or synovial proliferation are readily identified on MRI [19-26]. Subchondral cysts are easily detected on MRI because of the tomographic quality, multiplaner imaging capability, and the superb sensitivity to fluid- and fat-containing

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tissues [9,18,19]. 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 [27-32].

Magnetic resonance arthrography (MRA) performed with an intraarticular injection [33,34] or with an intravenous injection [35] of dilute gadolinium solution to enhance cartilage evaluation has been investigated, but noninvasive MRI has been reported accurate for cartilage abnormalities [32]. Patellofemoral cartilage loss has been reported to be closely associated with chronic knee pain symptoms [36].

MRI is very sensitive for detection of internal derangement, specifically meniscus and anterior cruciate ligament pathology [37-40], and a high prevalence of meniscal degeneration is associated with osteoarthritis [19,41]. Anterior cruciate ligament (ACL) tears and insufficiency are known to cause osteoarthritic changes in the knee [41].

Transient osteoporosis is characterized by self-limited pain and demonstrable osteopenia on radiographs within eight weeks after the onset of pain. Spontaneous osteonecrosis of the medial femoral condyle, 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 [42-44]. Bone marrow edema seen on MRI occurs in association with, or independent of, transient osteoporosis, osteonecrosis, and also in association with stress fractures; MRI is highly sensitive for detecting these abnormalities [42]. In patients with conventional radiograph diagnosis of an osteochondral injury such as osteochondritis dissecans or osteonecrosis, an MRI examination may be indicated if clinically additional injury is suspected or when it is necessary to determine the status of the articular cartilage over the area of abnormality. MRI is not indicated to confirm a stress fracture that is evident on the plain roentgenogram.

In patients with conventional radiograph evidence of inflammatory arthritis, the consensus of the panel is that an MRI is usually not indicated for the preoperative differentiation of pannus from effusion or for evaluation of erosion [26]. An aspiration for crystals may be indicated, but arthrographic confirmation is usually not necessary.

When intra-articular pathology 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 study such as postsurgical clamps, metal, a pacemaker, or electric

implants, a double-contrast arthrogram, possibly followed with computed tomography (CT), may be indicated.

A nuclear medicine bone scan is more sensitive than conventional radiographs for detecting bone changes and degenerative osteoarthritis; however, it is less specific than MRI [17]. A total body nuclear medicine bone scan may be indicated for evaluation of nontraumatic knee pain when there is the clinical suspicion or the possibility of multiple sites of involvement such as in suspected metastatic disease, infarcts, etc.

In summary, the mandatory initial examination for nontraumatic knee pain is an AP and lateral radiograph. In patients with anterior patellofemoral knee pain, an axial view should be included in the initial radiographic study. An MRI examination for nontraumatic knee pain is indicated when the pain is persistent and conventional radiographs are nondiagnostic or for which additional information is necessary before instituting treatment or surgical intervention. An MRI is not indicated before a physical examination or before routine conventional radiographs or when there is diagnostic conventional radiograph 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. A nuclear medicine bone scan may be indicated if there is a clinical need to confirm or exclude other sites of involvement (eg, suspicion of metastatic disease).

## References

1. 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* 1979; 144:16-26.
2. Newberg AH, Seligson D. The patellofemoral joint: 30°, 60°, and 90° views. *Radiology* 1980; 137(1 pt 1):57-61.
3. Merchant AC, Mercer RL, Jacobsen RH, Cool CR. Roentgenographic analysis of patellofemoral congruence. *J Bone Joint Surg* 1974; 56(7):1391-1396.
4. Hayes CW, Conway WF. Evaluation of articular cartilage: radiographic and cross-sectional imaging techniques. *Radio Graphics* 1992; 12(3):409-428.
5. Messieh SS, Fowler PJ, Munro T. Anteroposterior radiographs of the osteoarthritic knee. *J Bone Joint Surg [Br]* 1990; 72(4):639-640.
6. Brandt KD. Pain, synovitis, and articular cartilage changes in osteoarthritis. *Semin Arthritis Rheum* 1989; 18(4 suppl 2):77-80.
7. Fife RS, Brandt KD, Braunstein EM, et al. Relationship between arthroscopic evidence of cartilage damage and radiographic evidence of joint space narrowing in early osteoarthritis of the knee. *Arthritis Rheum* 1991; 34(4):377-382.
8. 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.
9. 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* 1991; 157(4):799-806.

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10. Leach RE, Gregg T, Siber FJ. Weight-bearing radiography in osteoarthritis of the knee. *Radiology* 1970; 97(2):265-268.
11. Altman RD, Fries JF, Bloch DA, et al. Radiographic assessment of progression in osteoarthritis. *Arthritis Rheum* 1987; 30(11):1214-1225.
12. Marklund T, Myrnes R. Radiographic determination of cartilage height in the knee joint. *Acta Orthop Scand* 1974; 45(5):752-755.
13. Resnick D, Vint V. The "tunnel" view in assessment of cartilage loss in osteoarthritis of the knee. *Radiology* 1980; 137(2):547-548.
14. Homblad EC. Postero-anterior x-ray view of knee in flexion. *JAMA* 1937; 109(15):1196-1197.
15. Rosenberg TD, Paulos LE, Parker RD, et al. The forty-five-degree posteroanterior flexion weight-bearing radiograph of the knee. *J Bone Joint Surg* 1988; 70(10):1479-1482.
16. Chung CB, Skaf A, Roger B, et al. Patellar tendon-lateral femoral condyle friction syndrome: MR imaging in 42 patients. *Skeletal Radiol* 2001; 30(12):694-697.
17. McAlindon TE, Watt I, McCrae F, et al. Magnetic resonance imaging in osteoarthritis of the knee: correlation with radiographic and scintigraphic findings. *Ann Rheum Dis* 1991; 50(10):14-19.
18. Reiser MF, Vahlensieck M, Schüller H. Imaging of the knee joint with emphasis on magnetic resonance imaging. *Eur Radiol* 1992; 2:87-94.
19. 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.
20. Yamamoto T, Bullough P. Spontaneous osteonecrosis of the knee: The result of subchondral insufficiency fracture. *J Bone Joint Surg Am* 2000; 82(6):858-866.
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. *Revue du Rhumatisme* 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. Beltran J, Caudill JL, Herman LA, et al. Rheumatoid arthritis: MR imaging manifestations. *Radiology* 1987; 165(1):153-157.
24. Reiser MF, Naegela M. Inflammatory joint disease: static and dynamic gadolinium-enhanced MR imaging. *J Magn Reson Imaging* 1993; 3(1):307-310.
25. Terrier F, Hricak H, Revel D, et al. Magnetic resonance imaging and spectroscopy of the periarticular inflammatory soft-tissue changes in the experimental arthritis of the rat. *Invest Radiol* 1985; 20(8):813-823.
26. Yulish BS, Liebermann JM, Newman AJ, et al. Juvenile rheumatoid arthritis: assessment with MR imaging. *Radiology* 1987; 164(3):763-766.
27. König 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.
28. Reiser MF, Bongartz G, Erlemann R, et al. Magnetic resonance in cartilaginous lesions of the knee joint with three-dimensional gradient-echo imaging. *Skeletal Radiol* 1988; 17(3):465-471.
29. Spritzer CE, Vogler JB, Martinez S, et al. MR imaging of the knee: preliminary results with a 3DFT GRASS pulse sequence. *AJR* 1988; 150(3):597-603.
30. Reiser MF, Bongartz G, Erlemann R, et al. Magnetic resonance in cartilaginous lesions of the knee joint with three-dimensional gradient-echo imaging. *Skeletal Radiol* 1988; 17(7):465-471.
31. Ghelman BG, Hodge JC. Imaging of the patellofemoral joint. *Orthop Clin North Am* 1992; 23(4):523-543.
32. Boegard TL, Rudling O, Peterson IF, Jonsson K. Magnetic resonance imaging of the knee in chronic knee pain. *Osteoarthritis Cartilage* 2001; 9(5):473-480.
33. Hajek PC, Baker LL, Sartoris DJ, et al. MR arthrography: anatomic-pathologic investigation. *Radiology* 1987; 163(1):141-147.
34. Engel A. Magnetic resonance knee arthrography: enhanced contrast by gadolinium complex in the rabbit and in humans. *Acta Orthop Scand Suppl* 1990; 61(240):5-25.
35. Winalski CS, Wiessman BN, Aliabadi P, et al. Enhancement of joint fluid with intravenously administered gadopentetate dimeglumine: technique, rationale, and implications. *Radiology* 1993; 187(1):179-185.
36. Hunter DJ, Sambrook PN. The association of cartilage volume with knee pain. *Osteoarthritis and Cartilage* 2003; 11(10):725-729.
37. De Smet AA, Norris MA, Yandow DR, et al. Diagnosis of meniscal tears of the knee with MR imaging: effect on observer variation and sample size on sensitivity and specificity. *AJR* 1993; 160(3):555-559.
38. Crues JV III, Mink J, Levy TL, et al. Meniscal tears of the knee: accuracy of MR imaging. *Radiology* 1987; 164(2):445-448.
39. Mink JH, Levy T, Crues JV III. Tears of the anterior cruciate ligament and menisci of the knee: MR imaging evaluation. *Radiology* 1988; 167(3):769-774.
40. Lee JK, Yao L, Phelps CT, et al. Anterior cruciate ligament tears: MR imaging compared with arthroscopy and clinical test. *Radiology* 1988; 166(3):861-864.
41. Kannus P, Järvinen M. Posttraumatic anterior cruciate ligament insufficiency as a cause of osteoarthritis in a knee joint. *Clin Rheumatol* 1989; 8(2):251-260.
42. 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.
43. Ahlbäck S, Bauer GC, Bohne WH. Spontaneous osteonecrosis of the knee. *Arthritis Rheum* 1968; 11(6): 705-733.
44. Lotke PA, Ecker ML. Current concepts review: osteonecrosis of the knee. *J Bone Joint Surg* 1988; 70(3):470-473.

An 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 exams 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.