American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Avascular Necrosis (Osteonecrosis) of the Hip**

Variant 1: **Initial study when avascular necrosis is suspected clinically.**

Radiologic Procedure	Rating	Comments	RRL*
X-ray pelvis	9	For initial evaluation in patients at risk for AVN who present with hip pain.	☢☢
X-ray hips	9	Frogleg view is necessary to evaluate anterosuperior involvement of the femoral head.	☢☢☢
CT hips without contrast	1	Not useful for initial evaluation.	☢☢☢
Tc-99m bone scan with SPECT hips	1	Sensitive method for detecting AVN, but not indicated before radiographs.	☢☢☢
MRI hips with or without contrast	1	Most sensitive method for detecting AVN, but not indicated before radiographs.	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: **Avascular necrosis with femoral head collapse detected by radiographs of the painful hip: no surgery contemplated at this time.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hips without contrast	5	May be useful if knowledge of occult AVN in the opposite hip is needed.	O
Tc-99m bone scan with SPECT hips	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MRI is not available.	☢☢☢
CT hips without contrast	1	Provides no more information than conventional radiographs. Shows subchondral fractures earlier, but not needed.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 3: **Avascular necrosis with femoral head collapse by radiographs in the painful hip. Surgery contemplated.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hips without contrast	5	May be useful if knowledge of occult AVN in the opposite hip is needed or if surgical planning on either hip would be affected.	O
Tc-99m bone scan with SPECT hips	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MRI is not available.	☢☢☢
CT hips without contrast	1	Provides no more information than conventional radiographs. May be useful if planning osteotomy by defining anatomic localization of the AVN and the extent of bone deformity.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Clinical Condition: **Avascular Necrosis (Osteonecrosis) of the Hip**

Variant 4: **Radiograph shows mottled femoral head, suspicious but not definite for avascular necrosis in the painful hip(s). Further evaluation is needed.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hips without contrast	9	MRI provides definitive diagnosis when radiograph findings are equivocal.	O
Tc-99m bone scan with SPECT hips	6	If MRI is not available or is contraindicated.	☢☢☢
CT hips without contrast	6	If MRI is not available or is contraindicated. May show subchondral fracture not seen on MRI.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

Variant 5: **Avascular necrosis suspected clinically but radiographs are normal. Further evaluation needed.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hips without contrast	9	Most sensitive and specific method to establish or exclude AVN.	O
Tc-99m bone scan with SPECT hips	6	If MRI is not available or is contraindicated.	☢☢☢
CT hips without contrast	6	If MRI is not available or is contraindicated.	☢☢☢
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			***Relative Radiation Level**

AVASCULAR NECROSIS (OSTEONECROSIS) OF THE HIP

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Summary of Literature Review

Avascular necrosis (AVN) is a relatively common disease in which there is death of the cellular elements of bone or marrow. The femoral heads are the most commonly affected sites for clinically significant AVN. There are numerous predisposing causes, including dislocation of the hip, femoral neck fracture, corticosteroid usage, collagen vascular disease, and the hemoglobinopathies [1]. Femoral head AVN often affects young adults.

With collapse of the femoral head, disabling hip pain may result in the need for a hemiarthroplasty or total joint replacement in early adulthood. Nontraumatic AVN is often bilateral, which further increases the extent of disability.

There are no specific physical findings or laboratory tests that can reliably establish the diagnosis of AVN. Clinically suspected AVN can be confirmed only by diagnostic imaging or biopsy. Imaging methods that may assist in establishing the diagnosis include conventional radiography, computed tomography (CT), radionuclide bone scans, and magnetic resonance imaging (MRI). These methods vary considerably in their cost, diagnostic accuracy, and the information provided.

While the optimal treatment for femoral head AVN is debated, early diagnosis is important. First, establishing that AVN is the cause for a patient's hip pain allows exclusion of conditions such as infection, neoplasm, fracture or gluteal tendon tear [2,3]. Second, accurate diagnosis and staging of AVN are needed to assess the efficacy of treatment.

Radiographs are the least expensive and most widely available imaging technology. Radiographs should be obtained as the initial study in every patient suspected to have AVN. In the presence of AVN, the radiograph findings may be normal, abnormal, or nonspecific. Both anteroposterior and frogleg lateral views should be obtained because a subchondral fracture or cortical depression may be seen only on one of the two projections.

CT with multiplanar reconstruction has been reported to be less sensitive than bone scanning and MRI [4]. There have, however, been few studies comparing MRI to current-generation multidetector CT scanners. A recent report [5] using helical CT showed CT superior to MRI and radiography for detecting subchondral fractures of the femoral head in AVN. A major role for CT is in determining the severity of secondary degenerative joint disease or the extent of collapse of the femoral head. This information is useful in surgical planning for either osteotomy or joint replacement [6].

Prior to the routine availability of clinical MRI, radionuclide bone scanning was the mainstay for early diagnosis of AVN. More recently, MRI has largely replaced conventional radionuclide bone scanning because of its greater sensitivity (up to 100%, compared to 90% for radionuclide bone scanning) [7]. The addition of single-photon-emission computed tomography (SPECT) may improve the accuracy of radionuclide imaging for diagnosing AVN. In one report, SPECT was found to be more accurate than MRI for detecting early AVN after renal transplant [8]. If bone scanning is to be undertaken, it is suggested that the study be done using pinhole collimation, and SPECT with scatter correction and iterative reconstruction algorithms [9].

Recent studies report an improved specificity for MRI in detecting AVN. One potential cause for incorrect diagnosis of AVN by MRI is transient osteoporosis [10]. Attention to the specific MRI findings will usually allow differentiation of these two entities [11-13]. Although MRI costs more than radionuclide bone scanning, a limited MRI examination may permit the diagnosis of AVN at a lower cost [14,15]. To date, dynamic contrast-enhanced MRI has not proven to be clinically useful. Researchers studying Legg-Calve-Perthes disease have determined that while vascular and anatomic imaging can be correlated, only anatomical imaging is needed for evaluation [16].

Studies have found that the location and extent of involvement of the femoral head with AVN on MRI predicts subsequent bone collapse, with a worse prognosis in patients who have involvement of a large portion and/or the apex of the femoral head [17,18]. Additional

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literature suggests that core decompression should be performed only when the area of involvement as measured by MRI is small [19,20]. However, patients with a small area of involvement are more likely to have a good outcome even without intervention.

While most AVN is discovered during imaging for pain, asymptomatic AVN may be found in individuals who are imaged for a symptomatic contralateral hip or unrelated reasons [21,22].

Summary

- When a patient who is at risk for AVN develops hip pain, the initial examination should consist of an anteroposterior pelvis and frogleg lateral radiograph of the symptomatic hip.
- If the radiograph findings are definite for AVN, an MRI might be indicated if knowledge of asymptomatic AVN in the opposite hip is clinically important.
- If the radiograph findings are equivocal for AVN or are normal on the symptomatic side, then MRI is indicated to confirm the diagnosis of AVN and to exclude other potential causes for the patient's hip pain.
- In patients in whom MRI cannot be performed, a bone scan with SPECT imaging is a reasonable alternative for diagnosing radiographically occult AVN.
- Screening of a patient who is at high risk for AVN may be of value if prophylactic treatment of asymptomatic AVN is proven useful.

Anticipated Exceptions

Clinical factors will certainly play a role in determining the necessity of diagnostic imaging. If the patient at high risk for AVN has equivocal radiograph findings for AVN, those findings may be adequate for clinical management if the pain is mild and there are no laboratory or clinical findings to suggest underlying infection, tumor, or occult fracture. If the patient with hip pain and at risk for AVN has a normal radiograph, the radiograph alone may be adequate if the clinical findings suggest a condition such as bursitis. In the future, interventional treatment may be developed that significantly reduces the risk of femoral head collapse in the patient with early AVN. If so, screening of asymptomatic patients at high risk for AVN may become clinically appropriate.

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 NS (not specified).		

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Procedure Contrast Information
- Evidence Table

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