American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Avascular Necrosis of the Hip**

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

Radiologic Procedure	Rating	Comments	RRL*
X-ray pelvis AP	9	Essential for initial evaluation in patients at risk for AVN who present with hip pain.	Min
X-ray hips frogleg lateral	9	Frogleg view is necessary to evaluate anterosuperior involvement of the femoral head.	Low
NUC bone scan targeted	1	Sensitive method for detection of AVN, but not indicated before radiographs.	Med
X-ray hips cross-table lateral	1	Poor detail due to overlapping soft tissues limits usefulness.	Low
MRI hip	1	Most sensitive method for detection of AVN, but not indicated before radiographs.	None
CT hip	1	Not useful for initial evaluation.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 2: **Avascular necrosis with femoral head collapse by radiographs in the painful hip: no surgery contemplated at this time.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without contrast	3	May be useful if knowledge of occult AVN in the opposite hip is needed.	None
CT hip axial and coronal and sagittal reformatted images	1	May be useful if planning osteotomy by defining anatomic localization of the AVN and the extent of bone deformity.	Med
NUC bone scan targeted	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MR is not available.	Med
NUC bone scan planar and SPECT	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MR is not available.	Med
CT hip axial images only	1	Provides no more information than conventional radiographs.	Med
MRI hip without and with contrast	1	Assessment of perfusion is not needed.	None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Avascular Necrosis of the Hip**

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

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without contrast	5	May be useful if knowledge of occult AVN in the opposite hip is needed.	None
CT hip axial and coronal and sagittal reformatted images	1	May be useful if planning osteotomy by defining anatomic localization of the AVN and the extent of bone deformity.	Med
NUC bone scan planar and SPECT	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MR is not available.	Med
MRI hip without and with contrast	1	Assessment of perfusion is not needed.	None
NUC bone scan targeted	1	May be useful if knowledge of occult AVN in the opposite hip is needed and MR is not available.	Med
CT hip axial images only	1	Provides no more information than conventional radiographs.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

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

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without contrast	9	MRI provides definitive diagnosis when radiograph findings are equivocal.	None
NUC bone scan planar and SPECT	1	Indicated if MRI is not available.	IP
CT hip axial and coronal and sagittal reformatted images	1	Less sensitive than bone scanning or MRI.	Med
MRI hip without and with contrast	1	Assessment of perfusion is not needed.	None
NUC bone scan targeted	1	Indicated if MRI is not available.	Med
CT hip axial images only	1	Less sensitive than bone scanning or MRI.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			***Relative Radiation Level**

Clinical Condition: **Avascular Necrosis of the Hip**

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

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without contrast	9	Most sensitive and specific method to establish or exclude AVN.	None
MRI hip without and with contrast	1	Assessment of perfusion is not needed.	None
NUC bone scan planar and SPECT	1	Might be indicated if MRI is not available or MR is negative and AVN is still suspected.	Med
NUC bone scan targeted	1	Might be indicated if MRI is not available or MR is negative and AVN is still suspected.	Med
CT hip axial images only	1	Not as sensitive as bone scan or MRI.	Med
CT hip axial and coronal and sagittal reformatted images	1	Not as sensitive as bone scan or MRI.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 6: **Displaced or nondisplaced femoral neck fracture on radiographs.**

Radiologic Procedure	Rating	Comments	RRL*
MRI hip without and with contrast	1	If MRI were to be proven to accurately predict the femoral heads that go on to collapse, evaluation of perfusion may be useful before surgery.	None
CT hip axial and coronal and sagittal reformatted images	1	Not needed for clinical management and not predictive of later AVN.	Med
NUC bone scan planar and SPECT	1	Not needed for clinical management and not predictive of later AVN.	Med
MRI hip without contrast	1	Not needed for clinical management and not predictive of later AVN.	None
CT hip axial images only	1	Not needed for clinical management and not predictive of later AVN.	Med
NUC bone scan targeted	1	Not needed for clinical management and not predictive of later AVN.	Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

AVASCULAR NECROSIS 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 [1]. 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 [1,2]. Femoral head AVN is a significant problem in healthcare because it often affects young adults [2,3]. With secondary collapse of the femoral head, disabling hip pain may result in the need for total joint replacement in early adulthood. For nontraumatic causes of AVN, the disease is often bilateral, which further increases the extent of disability.

There are no specific physical findings or laboratory tests to establish the diagnosis of AVN [3]. Clinically suspected AVN can be confirmed only by diagnostic imaging or biopsy. Imaging methods for definitive diagnosis include radiographs, conventional tomography, computed tomography (CT), radionuclide bone scans, and magnetic resonance imaging (MRI). These methods vary considerably in their cost, diagnostic accuracy, and the information provided. The importance of these methods for diagnosis of AVN is directly related to the influence of early diagnosis on patient outcome. Core decompression of an avascular femoral head has been proposed as a method to reduce the likelihood of subsequent femoral head collapse. This technique has shown good results in some series [4-8] but not in others [9,10]. A study of 18 patients with early AVN by radiographs found that core decompression was associated with a better outcome if the area of involvement measured by MRI was small [11-13]. Other techniques have been recommended for treatment of AVN of the femoral head, including free bone grafts, vascularized bone grafts, osteochondral allografts, osteotomy, and electrical stimulation [14]. More studies are needed to determine the long-term benefits of the many procedures that are used to treat AVN of the femoral head [15]. While the optimal treatment is still debated, early diagnosis and staging of AVN are important for two reasons. First, establishing that AVN is the cause for a patient's hip pain allows exclusion of conditions such as infection, neoplasm, or occult fracture that require early specific treatment [16]. Second, accurate diagnosis and staging of AVN will be essential in assessing the efficacy of any treatment developed in the future.

Radiographs are the least expensive and most widely available imaging technology. Radiographs should be obtained as the initial study in every patient suspected with AVN. In the presence of AVN, the radiograph findings may be normal, abnormal or nonspecific. Although the radiograph findings for AVN of the femoral head are well known, there are no studies that determine the diagnostic efficacy of individual radiographic views. Most authorities believe that both anteroposterior and frogleg lateral views are necessary because a subchondral fracture or cortical depression may be seen only on one of the two views [17]. Although anecdotal examples of the value of tomography have been presented, no study has been performed to determine the sensitivity or specificity of tomography for the diagnosis of AVN.

Computed tomography with multiplanar reconstruction is less sensitive than bone scanning and MRI in the diagnosis of AVN with an accuracy comparable [18,19] or superior [3,20,21] to that of radiographs. Its major role is in determining the severity of secondary degenerative joint disease or the extent of collapse of the femoral head [22]. This information is useful in surgical planning for either osteotomy or joint replacement [19,20]. In addition, CT has been shown to be more sensitive than radiography and MRI in the detection of subchondral fractures [23].

For the detection of radiographically occult AVN, radionuclide bone scanning and MRI are both sensitive methods [21,24-27]. However, MRI is preferred because it has greater sensitivity and a greater specificity than bone scanning [3,16,18,19,21,28-37]. The sensitivity for detection of AVN has ranged from 88%-100% for MRI and from 72%-87% for radionuclide bone scanning [10,21,28,30,33]. The addition of single-photon-emission computed tomography (SPECT) improves the accuracy of radionuclide imaging for the diagnosis of AVN, with MRI found to be more accurate than SPECT in one study [8]

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but SPECT more accurate than MRI in another [33,38]. One potential cause for incorrect diagnosis of AVN by MRI is transient osteoporosis, but attention to the MRI findings will usually allow differentiation of these two entities [39-42].

MRI has a second advantage over bone scanning, because the MRI findings of AVN are usually characteristic, which allows differentiation from other hip diseases [15]. There are occasional cases of AVN with normal radiographs in which either bone scanning or MRI may be falsely negative [3,25,28,43]. In these cases, both studies might be performed. Although MRI costs more than radionuclide bone scanning, a limited MRI examination may permit the diagnosis of AVN at a lower cost [44-46].

The indications for which diagnostic modalities to use vary depending on the clinical situation. In the typical patient presenting with hip pain, there have been no studies to indicate that MRI should be used routinely to detect occult AVN. Because of the large number of patients who have bursitis or osteoarthritis, it would not be cost effective to obtain an MRI on every patient presenting with hip pain.

A less clear situation is when the patient is being treated with high-dose corticosteroids. These patients are at a high risk for development of AVN, and MRI is commonly recommended if they develop hip pain [31,47,48]. There have also been studies evaluating MRI or radionuclide bone scanning in patients without hip pain who are at high risk for AVN [49,50]. Patients who are on corticosteroids for renal transplants were found to have a high incidence of AVN despite the absence of hip pain. MRI shows typical changes of AVN in 6%-22% of these asymptomatic patients [44,51,52]. In a well controlled prospective study of 104 patients who had renal transplants, 14 patients developed MRI evidence of AVN [52]. Four of these patients subsequently developed pain with collapse of the femoral heads and ultimately required hip arthroplasty. The other 10 patients remained asymptomatic; the MRI returned to normal in five patients. Similarly, in a prospective study of 23 patients on corticosteroids for systemic lupus erythematosus, MRI findings of AVN were noted in 12 (52%) of the 23 patients; three patients subsequently developed hip pain [16]. In another study of patients with systemic lupus erythematosis, 24 asymptomatic hips where found to have AVN on MRI with only four hips showing worsening on follow-up MRI [12]. It is clear that MRI can detect AVN in these high-risk, asymptomatic patients. Because of the variability in development of later symptoms, the difficulty has been in deciding in which patient's early intervention may be useful [51]. Several studies have found that the extent of involvement of the femoral head on MRI predicts subsequent bone collapse [49,50,53-55]. These studies would suggest that early intervention should be considered in patients who have involvement of a large portion of the apex of the femoral head. Certainly, future studies evaluating treatment of AVN to prevent collapse should include pretreatment MRI evaluation of the extent of disease [3]. The current literature suggests that core decompression should be performed only when the area of involvement as measured by MRI is small [11,12]. However, patients with a small area of involvement are more likely to have a good outcome even without intervention.

A second clinical consideration is the risk of developing AVN in patients who have acute femoral neck fractures. Most patients with minimally displaced femoral neck fractures are treated empirically with internal fixation. With markedly displaced fractures, femoral head replacement is usually performed because of the increased risk of fracture nonunion and avascular necrosis. There may be a role for diagnostic imaging in determining which femoral heads are avascular after fracture. If the femoral head is still vascularized, internal fixation might be an alternative to femoral head replacement. If the head were avascular, femoral head replacement could be done immediately. Neither conventional MRI [56] nor radionuclide bone scanning is effective in evaluating the vascular perfusion of the femoral head in the 48-hour period after development of ischemia. However, MRI after gadolinium injection accurately assessed femoral head vascularity both in a dog model of acute AVN [56] and in a study of 13 humans with acute femoral neck fractures [57]. This assessment should be confirmed in a controlled study before it can be routinely recommended. Serial MRI after fixation of femoral neck fractures was shown to be useful in the prediction of development of AVN, but this has been noted in only one study [58].

In summary, the following guidelines are proposed. When a patient who is at high risk for avascular necrosis 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 avascular necrosis, an MRI might be indicated only if knowledge of asymptomatic AVN in the opposite hip is clinically important [59]. If the radiograph findings are equivocal for AVN or are normal in the symptomatic hip, then MRI is necessary to confirm the diagnosis of avascular necrosis and to exclude other 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 the diagnosis of radiographically occult AVN. Screening of the patient who is at high risk for AVN may be of value only if prophylactic treatment of asymptomatic AVN is proven useful. The use of MRI with gadolinium enhancement is

currently of unproven value in managing patients with acute hip fractures.

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.

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