American College of Radiology
ACR Appropriateness Criteria®
Acute Hip Pain-Suspected Fracture

Variant 1: **Acute hip pain. Fall or minor trauma. Suspect fracture. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography hip	Usually Appropriate	☢☢☢
Radiography pelvis	Usually Appropriate	☢☢
Radiography pelvis and hips	Usually Appropriate	☢☢☢
CT pelvis and hips with IV contrast	Usually Not Appropriate	☢☢☢
CT pelvis and hips without and with IV contrast	Usually Not Appropriate	☢☢☢☢
CT pelvis and hips without IV contrast	Usually Not Appropriate	☢☢☢
MRI pelvis and affected hip without and with IV contrast	Usually Not Appropriate	O
MRI pelvis and affected hip without IV contrast	Usually Not Appropriate	O
Bone scan hips	Usually Not Appropriate	☢☢☢
US hip	Usually Not Appropriate	O

Variant 2: **Acute hip pain. Fall or minor trauma. Negative radiographs. Suspect fracture. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI pelvis and affected hip without IV contrast	Usually Appropriate	O
CT pelvis and hips without IV contrast	Usually Appropriate	☢☢☢
CT pelvis and hips with IV contrast	Usually Not Appropriate	☢☢☢
CT pelvis and hips without and with IV contrast	Usually Not Appropriate	☢☢☢☢
MRI pelvis and affected hip without and with IV contrast	Usually Not Appropriate	O
Bone scan hips	Usually Not Appropriate	☢☢☢
US hip	Usually Not Appropriate	O

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Summary of Literature Review

Introduction/Background

Fractures of the proximal femur (commonly referred to as hip fractures) are a frequent source of morbidity and mortality in elderly osteoporotic patients [1]. Typically the result of a ground-level fall, fractures of this type result in approximately 300,000 hospitalizations per year and are nearly twice as common in women as in men [2,3]. As the United States population continues to age, the incidence of hip fractures and associated medical costs will continue to rise, predicted to reach $18 billion by 2025 [4]. Patients suffer a substantial decline in quality of life following a hip fracture [5] as well as a 1-year mortality rate of 22% for women and 33% for men [1]. Delays in diagnosis and treatment are associated with increased cost, complication rate, length of hospital stay, and short- and long-term mortality [6-13]. Therefore, rapid diagnosis and treatment of hip fractures is critical. Hip fractures cannot be reliably diagnosed or excluded on the basis of physical examination alone; therefore, imaging plays a key role in early and accurate diagnosis [14].

The biomechanics of proximal femoral and pelvic fractures that are a result of major trauma differs as these injuries may be seen in any age group, often with additional accompanying high-velocity injuries of the abdomen and pelvis. Motor vehicle–related trauma is the most common mechanism. Thorough evaluation of the hip may be superseded in these instances by the need for resuscitation and diagnosis and treatment of more urgent associated vascular or solid organ injuries. Imaging plays an important role not only in the diagnosis of high-velocity fractures but also in characterizing fracture mechanism and morphology for treatment planning purposes. However, imaging of high-velocity hip fractures occurs in the context of a broader trauma evaluation. A full discussion of the broader imaging workup of blunt trauma is beyond the scope of this paper and will be covered in the upcoming ACR Appropriateness Criteria® titled "Major Blunt Trauma" and will be made available on the ACR website when completed.

Treatment for both intra- and extracapsular proximal femoral fractures in the elderly is typically surgical fixation because of the risk of further fracture displacement and the dangers of prolonged immobilization in the elderly [15]. Joint replacement may be performed for displaced fractures of the femoral neck where the risk of femoral head avascular necrosis is high. Fractures from high-force trauma are also commonly treated with surgical fixation for stability to reduce the risk of post-traumatic osteoarthritis.

Discussion of Procedures by Variant

Variant 1: Acute hip pain. Fall or minor trauma. Suspect fracture. Initial imaging.

Radiography Hip

Radiography is the initial imaging modality of choice for assessment of acute hip pain with suspected fracture, with the more advanced imaging modalities reserved for instances of clinically suspected fracture in the setting of negative or equivocal radiographs. Radiographs are rapidly obtained and well tolerated by patients. When a fracture is demonstrated, frequently no more imaging is needed for treatment planning purposes [15-17]. Orthogonal views are considered standard and are most commonly an anteroposterior (AP) view with approximately 15° of internal rotation and a cross-table lateral view. Some authors have questioned the need for the cross-table lateral view for treatment planning when the AP view is clearly positive [18]. However, in the

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same study, Naqvi et al [18] did find that the cross-table lateral view changed treatment decisions in several patients and conceded that the cross-table lateral view remains valuable for improving overall sensitivity of radiographs, assessing femoral shaft extension, and assessing potentially pathologic fractures. The frog-leg view has been discouraged in patients with suspected fractures given concern that the required patient positioning will lead to further fracture displacement [15,17]. One small retrospective study evaluated the benefit of an oblique AP view with 30° of lateral tube angulation to better profile the femoral neck, but this led to only a small increase in sensitivity and, in some cases, resulted in obscuration of the femoral neck by the posterior wall of the acetabulum [19]. Thus, standard AP and cross-table lateral views have remained the mainstay for trauma assessment of the hip.

Multiple studies have demonstrated that radiographs have limited sensitivity for fracture detection of the proximal femur, particularly in elderly osteoporotic patients [20-24]. All of these studies constitute retrospective series in which patients with negative radiographs but high clinical suspicion went on to receive a MRI scan at the discretion of the evaluating clinician. In one such study, 14% of patients with negative radiographs were found to have fractures of the hip or pelvis [23]. In this same study, Kirby et al [23] also reported 12% of patients with suspicious radiographs were found to have no fracture on MRI, illustrating limitations in the specificity of radiographs as well. Other studies have had more dramatic results, with Sankey et al [25] reporting 83 of 98 patients to have fractures after negative radiographs, 23 of whom required operative management. The variability is likely due to differing proportions of patients going on to MRI following negative radiographs in these retrospective studies. However, there is no accepted clinical decision rule to guide when patients with suspected hip fracture should have advanced imaging after negative radiographs. A new inability to bear weight is a clinically suspicious finding, although the sensitivity and specificity of this is unknown [20]. Allowing for variation between studies, the estimated prevalence of occult fracture after negative radiographs has been estimated at 4% to 10%, indicating the inability of negative radiographs alone to exclude fracture [21,26]. Risk factors for radiographically occult fracture in these studies included those age >65, low-force trauma, such as a ground-level fall, and female gender. These studies have almost exclusively included elderly patients. There is no relevant literature regarding the sensitivity and specificity of radiographs in the younger patient population, and clinicians are suggested to proceed with caution.

Radiography Pelvis

There is no specific literature regarding the use of an AP view of the pelvis alone for acute hip pain following low-force trauma. Previous literature regarding the accuracy of radiography has almost exclusively evaluated AP and cross-table lateral radiographs of the hip or the combined use of AP pelvis and hip radiographs. However, it is well established that patients with clinically suspected proximal femur fracture often have fractures of the pelvis, including the sacrum and pubic rami [21,27-30]. Therefore, it has been recommended that the radiographic series include the AP view of the pelvis along with the orthogonal views of the symptomatic hip [31]. The inclusion of a pelvis radiograph also allows for comparison of potential abnormalities to the contralateral asymptomatic side. Pelvis radiographs share the same limitations in sensitivity and specificity for fracture detection as hip radiographs, and a negative radiograph alone cannot exclude fracture.

Radiography Pelvis and Hip

As previously discussed, patients with clinically suspected proximal femur fracture often have fractures of the pelvis that include the sacrum and pubic rami [21,27-30]. Moreover, these pelvic fractures may occur in isolation or concomitant with a fracture of the proximal femur [28]. Therefore, it has been recommended that the radiographic series include both the AP view of the pelvis along with orthogonal views of the symptomatic hip [31]. The inclusion of a pelvis radiograph also allows for comparison of potential abnormalities to the contralateral asymptomatic side. For these reasons, an AP view of the pelvis with a cross-table lateral view of the symptomatic hip is the standard approach at many institutions, whereas some will include three views: an AP view of the pelvis, a separate AP view of the symptomatic hip, and the cross-table lateral view. There is no specific literature to compare these two approaches. Although they remain the mainstay for initial imaging, pelvis and hip radiographs share the same limitations in sensitivity and specificity for fracture detection, and negative radiographs alone cannot exclude fracture.

MRI Pelvis and Affected Hip

At least 90% of proximal femoral fractures will be identified on radiographs [21]. Therefore, MRI without intravenous (IV) contrast is reserved for second-line imaging in instances of negative radiographs with continued clinical suspicion for fracture rather than as a first-line modality.

The use of contrast-enhanced MRI has been explored as a technique to assess femoral head perfusion in cases of proximal femoral fracture [32,33], but this modality does not play a role in initial imaging assessment.

CT Pelvis and Hips
Although not as sensitive as MRI, noncontrast CT is also reserved as a problem-solving modality following radiography either to evaluate for radiographically occult fracture or to better depict fracture morphology for treatment planning purposes [34,35].

There is no relevant literature to support the use of contrast-enhanced CT as an initial imaging modality in instances of acute hip pain following low-force trauma.

There is no relevant literature to support the use of multiphase CT as an initial imaging modality in instances of acute hip pain following low-force trauma.

US Hip
Although there has been limited investigation into the use of ultrasound (US) for hip fracture detection, US does not play a role as the initial imaging in this setting [36].

Bone Scan Hips
There is no relevant literature to support the use of a nuclear medicine bone scan as an initial imaging modality in instances of acute hip pain following low-force trauma.

Variant 2: Acute hip pain. Fall or minor trauma. Negative radiographs. Suspect fracture. Next imaging study.

MRI Pelvis and Affected Hip
There is considerable literature regarding the use of noncontrast MRI for the detection of radiographically occult proximal femoral fractures. An early study by Quinn et al [37] found MRI to be 100% accurate for fracture detection in patients with indeterminate radiographs using clinical outcomes as the gold standard. A subsequent study by Pandey et al [38] found no missed fractures in 10 of 33 patients with negative MRIs, all of whom were followed clinically for at least 6 months. A 2008 study showed 99% sensitivity of MRI, both for proximal femoral fractures and fractures of the pelvis [39]. With multiple studies indicating near 100% sensitivity for proximal femoral fracture, it has been suggested that a negative MRI may allow for confident discharge from the emergency department and reduce the number of cautionary admissions [23,29]. Conversely, rapid diagnosis of surgical fractures reduces delay to treatment with associated improved outcomes [10].

Several additional studies have also shown high diagnostic accuracy for diagnosis of both pelvis fractures and soft-tissue injuries in addition to fractures of the proximal femur [28,30,39]. This versatility is important as many series have shown a high incidence of extrafemoral trauma in patients with acute hip pain and negative radiographs. For example, in the study by Ohishi et al [30], of 113 patients, 38% had fractures of the proximal femur and 33% had fractures of the pelvis. In another retrospective series, Dominguez et al [21] found pelvic fractures to be more common than proximal femur fractures in this patient population, emphasizing the importance of accuracy in the assessment of extrafemoral trauma. Although many of these pelvic fractures and soft-tissue injuries may not be treated surgically, correct diagnosis allows for appropriate conservative treatment, including protected weight-bearing, pain control, deep vein thrombosis prophylaxis, and skilled rehabilitation.

In addition to its increased sensitivity for fracture detection, MRI has been shown to be useful in characterizing fracture morphology. Seemingly isolated fractures of the greater trochanter diagnosed on radiography frequently have intertrochanteric extension when evaluated with MRI [22]. In a classic study of 30 patients, Schultz et al [40] demonstrated the use of MRI to accurately depict the extent of the fracture line in these radiographically occult intertrochanteric fractures. There is an increasing trend to treat incomplete intertrochanteric fractures conservatively. For example, in a small series of 8 patients, Alam et al [41] found that of the 5 patients treated conservatively, none went on to complete their fracture. Several authors have suggested that with its ability to depict fracture morphology with accuracy, MRI may have a continued role to play in directing treatment [22,40].

Specific scanning protocols have emphasized either speed or comprehensiveness. A 2003 study of 93 cases found 100% sensitivity for the coronal short tau inversion-recovery (STIR) sequence alone [42], and a more recent study found 99% sensitivity of the coronal STIR sequence with increasing confidence and specificity with the addition of a coronal T1 sequence [43]. Given the increasing throughput pressures in the emergency department and the

difficulty of older patients in tolerating long scan times, there continues to be interest in developing rapid and accurate MRI protocols.

With the diagnostic accuracy of noncontrast MRI approaching 100%, there has been little need to explore the addition of IV gadolinium contrast solely for the purposes of fracture detection. Rather, the interest has been in the use of dynamic MRI to evaluate femoral head perfusion for prognostic purpose to estimate the risks of impaired perfusion, such as osteonecrosis and nonunion. In one study of 36 patients, impaired femoral head perfusion was more common in patients with displaced fractures, although there was considerable overlap of perfusion pattern and fracture type [44]. The accuracy of predicting successful osseous union was 75% based on fracture morphology and improved incrementally to 89% on the basis of perfusion dynamics. Only 2 of 16 patients with nondisplaced fractures had osteonecrosis. A study from 2009 had similar results with 90% accuracy for prediction of successful fracture union on the basis of femoral head perfusion [45]. However, the study identified only 1 patient with a nondisplaced fracture with impaired femoral head perfusion and did not specify whether this patient went on to osteonecrosis, nor was the accuracy of predicting osteonecrosis on the basis of femoral head perfusion compared to that of the well-established Garden classification system. Given these findings, it is not clear if contrast-enhanced MRI offers significant advantages in the evaluation of the fractured hip compared to existing classification systems.

CT Pelvis and Hips

CT has advantages over MRI in terms of speed as well as use in patients with significant confusion. There has been considerable investigation into the accuracy of noncontrast CT for detection of radiographically occult proximal femoral fractures, although these studies have been invariably retrospective in nature, have used inconsistent methodology, and at times produced conflicting results. In one study of 199 patients, CT was negative for fracture in 93 patients, and none were found to have undiscovered fractures at 4-month clinical follow-ups [34]. Another similar study with 68 patients found no missed fractures in 27 patients with negative CT scans, although it was not clear if clinical follow-up was as comprehensive [46]. However, a number of other studies have demonstrated potential limitations in the sensitivity of CT. For example, Haubro et al [26] found a sensitivity for CT of 87% compared with 100% for MRI, with CT missing 6 of 15 fractures. Another larger study of 129 cases compared MRI and CT for the diagnosis of both proximal femoral and pelvic fractures and found a sensitivity of 99% for MRI and 69% for CT using clinical outcomes and follow-up imaging as the gold standard [39]. This same study by Cabarrus et al [39] also found MRI to be substantially better at detecting soft-tissue abnormalities with 99% sensitivity for MRI and 13% sensitivity edema, and the differences in sensitivity for more significant injuries, such as hematoma or tendon avulsion, may be somewhat less. Several other similar studies comparing CT and MRI have also shown decreased sensitivity of CT with potential for missed fractures as well as changes in diagnosis and management when MRI is obtained after CT [24,47,48].

There is no relevant data to support the use of contrast-enhanced CT solely for the purpose of fracture detection following negative radiographs. However, if contrast-enhanced CT examination of the abdomen and pelvis is performed because of suspicion of concurrent intra-abdominal trauma, bone algorithm reconstruction of the pelvis and hips may be performed rather than performing a separate examination.

There is no relevant data to support the use of multiphase CT for the detection of fractures of the pelvis and proximal femur.

Dual-energy CT is a more recent technology that has the ability to produce virtual noncalcium images for the detection of bone marrow edema. Although the technology holds promise, diagnostic accuracy does not yet approach that of MRI, with an initial study by Reddy et al [49] demonstrating a sensitivity of 90% and specificity of 40% for nondisplaced femoral neck fractures. However, this may be a modality of emerging importance as technology improves.

US Hip

The use of US for evaluation of the acutely painful hip has been evaluated in a single study of 10 patients with hip fractures [36]. Although US was able to identify trauma-related changes, such as joint effusion, with 100% sensitivity, specificity for fracture reached only 65%. The authors acknowledged that performance might further decrease for examinations performed by sonographers and radiologists not experienced with musculoskeletal US. For this document, it is assumed the procedure is performed and interpreted by an expert. Given the inability of US to comprehensively evaluate the bones and soft tissues of the pelvis, there is not enough evidence to support the role of US in the workup of radiographically occult hip fracture.

Bone Scan Hips

Prior to the advent of MRI, a bone scan was the preferred test for radiographically occult proximal femoral fractures. However, as early as 1993, Rizzo et al [50] demonstrated MRI to be at least as accurate as bone scans and with substantially decreased time to diagnosis. A later study by Rubin et al [51] comparing bone scans and MRI demonstrated improved sensitivity and specificity of MRI relative to bone scans. Moreover, the bone scan group averaged an additional day to surgery.

Bone scintigraphy is a time-consuming process. Bone scans may be falsely negative for up to 72 hours from the time of injury, and false-positive scans are likewise common, related to osteoarthritis, soft-tissue injury, or any other process that may increase bone turnover [50]. It has been postulated that performing single-photon emission computed tomography may combine the sensitivity of bone scintigraphy with the spatial accuracy of CT, but there are no data to support this view. In current practice, the role of bone scans as a secondary line of imaging in patients with contraindications to MRI has largely been usurped by CT.

Summary of Recommendations

- **Variant 1:** Radiographs of the hip, radiographs of the pelvis, or radiographs of the pelvis and hips is usually appropriate for the initial imaging of the hip with acute pain, fall or minor trauma, and suspected fracture.
- **Variant 2:** MRI pelvis and affected hip without IV contrast or CT pelvis and hips without IV contrast is usually appropriate as the next imaging study for the evaluation of acute hip pain from a fall or minor trauma with negative radiographs and suspected fracture.

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 go to www.acr.org/ac.

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 [52].

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".		

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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.