

**American College of Radiology
ACR Appropriateness Criteria®
Acute Hip Pain**

Variant 1: **Adult. Acute hip pain, traumatic. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography hip	Usually Appropriate	⦿⦿⦿
US hip	Usually Not Appropriate	○
MRI hip without and with IV contrast	Usually Not Appropriate	○
MRI hip without IV contrast	Usually Not Appropriate	○
Bone scan hip	Usually Not Appropriate	⦿⦿⦿
CT hip with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 2: **Adult. Acute hip pain, traumatic. Suspect fracture. Radiographs negative or indeterminate. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI hip without IV contrast	Usually Appropriate	○
CT hip without IV contrast	Usually Appropriate	⦿⦿⦿
US hip	Usually Not Appropriate	○
MRI hip without and with IV contrast	Usually Not Appropriate	○
Bone scan hip	Usually Not Appropriate	⦿⦿⦿
CT hip with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without and with IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 3: **Adult. Acute hip pain, traumatic. Radiographs positive for hip fracture. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
CT hip without IV contrast	Usually Appropriate	⦿⦿⦿
MRI hip without IV contrast	May Be Appropriate	○
US hip	Usually Not Appropriate	○
MRI hip without and with IV contrast	Usually Not Appropriate	○
Bone scan hip	Usually Not Appropriate	⦿⦿⦿
CT hip with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without and with IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 4: Adult. Acute hip pain, traumatic. Post reduction of hip dislocation. Follow-up imaging.

Procedure	Appropriateness Category	Relative Radiation Level
Radiography hip	Usually Appropriate	⦿⦿⦿
CT hip without IV contrast	Usually Appropriate	⦿⦿⦿
US hip	Usually Not Appropriate	○
MRI hip without and with IV contrast	Usually Not Appropriate	○
MRI hip without IV contrast	Usually Not Appropriate	○
Bone scan hip	Usually Not Appropriate	⦿⦿⦿
CT hip with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without and with IV contrast	Usually Not Appropriate	⦿⦿⦿

Variant 5: Adult. Acute hip pain, traumatic. Suspect tendon, muscle, or ligament injury. Radiographs negative or indeterminate. Next imaging study.

Procedure	Appropriateness Category	Relative Radiation Level
MRI hip without IV contrast	Usually Appropriate	○
US hip	Usually Not Appropriate	○
MRI hip without and with IV contrast	Usually Not Appropriate	○
Bone scan hip	Usually Not Appropriate	⦿⦿⦿
CT hip with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without and with IV contrast	Usually Not Appropriate	⦿⦿⦿
CT hip without IV contrast	Usually Not Appropriate	⦿⦿⦿

ACUTE HIP PAIN

Expert Panel on Musculoskeletal Imaging: Roger J. Bartolotta, MD^a; Alice S. Ha, MD, MS^b; Cyrus P. Bateni, MD^c; Karen C. Chen, MD^d; Aleksey Dvorzhinskiy, MD^e; Jonathan Flug, MD, MBA^f; Christian S. Geannette, MD^g; A. Tuba Karagulle Kendi, MD^h; Olga Laur, MDⁱ; Robin B. Levenson, MD^j; Nadia Mujahid, MD^k; Sreelakshmi Panginikkod, MD^l; Gary M. Plant, MD^m; Benjamin E. Plotkin, MDⁿ; Richard D. Shih, MD^o; Daniel E. Wessell, MD, PhD.^p

Summary of Literature Review

Introduction/Background

Proximal femoral fractures (commonly known and henceforth referred to as hip fractures) occur in patients of all ages but are a particularly important source of morbidity and mortality in elderly patients with osteoporosis [1,2]. Over 300,000 people per year are hospitalized for hip fractures in the United States [2]. Delays in diagnosis and treatment of hip fractures are associated with increased costs, complication rates, hospital length-of-stay, and mortality [3-6]. In a retrospective study of 3,517 surgeries performed for hip fractures in patients >50 years of age, Nyholm et al [6] reported that a surgical delay of >12 hours significantly increased the adjusted risk of 30-day mortality (prior studies had used 48 hours as the significant timepoint for surgical delay in this clinical scenario). Imaging is essential in the timely and accurate diagnosis of hip fractures, particularly because hip fractures cannot be diagnosed or excluded definitively via physical examination alone.

Hip fractures can be intracapsular (involving the femoral head and/or neck) or extracapsular (involving the basicervical, intertrochanteric, or subtrochanteric regions). Nondisplaced subcapital femoral neck fractures are typically treated with closed reduction percutaneous pinning, whereas displaced subcapital femoral neck fractures are typically treated with arthroplasty. True isolated greater trochanteric fractures are predominantly managed conservatively, but intertrochanteric fractures (including a subset of incomplete intertrochanteric fractures) are typically treated with internal fixation. Consequently, the imaging evaluation of fracture extent/alignment is integral in the appropriate management of hip fractures [7].

Hip dislocation and muscle/tendon injury are additional important etiologic considerations for the patient presenting with acute traumatic hip pain. Native hip dislocation in the nonosteoporotic patient most commonly results from high-energy injury, such as motor vehicle collision [8,9]. Please note that this narrative focuses on acute traumatic pain in the native hip. For postarthroplasty patients, please refer to the ACR Appropriateness Criteria[®] topic on “[Imaging After Total Hip Arthroplasty](#)” [10]. Labral tears are more likely to present clinically in the setting of chronic hip pain and are discussed in the ACR Appropriateness Criteria[®] topic on “[Chronic Hip Pain](#)” [11]. Stress (fatigue/insufficiency) fractures are fully detailed in the ACR Appropriateness Criteria[®] topic on “[Stress \(Fatigue/Insufficiency\) Fracture, Including Sacrum, Excluding Other Vertebrae](#)” [12]. Suspected osteomyelitis/septic arthritis is covered in the ACR Appropriateness Criteria[®] topic on “[Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection \(Excluding Spine and Diabetic Foot\)](#)” [13].

Initial Imaging Definition

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient’s care)

OR

^aPanel Vice-chair, Weill Cornell Medicine, New York, New York. ^bPanel Chair, University of California Los Angeles, Los Angeles, California. ^cUniversity of California Davis Health, Sacramento, California. ^dVA San Diego Healthcare System, San Diego, California. ^eOrthopedic Surgeon, Hospital for Special Surgery, New York, New York. ^fMayo Clinic Arizona, Phoenix, Arizona. ^gHospital for Special Surgery, New York, New York. ^hMayo Clinic, Rochester, Minnesota; Commission on Nuclear Medicine and Molecular Imaging. ⁱWeill Cornell Medicine, New York, New York. ^jBeth Israel Deaconess Medical Center, Boston, Massachusetts; Committee on Emergency Radiology-GSER. ^kBrown University Rhode Island Hospital, Providence, Rhode Island; American Geriatrics Society. ^lTufts University School of Medicine, Boston, Massachusetts; American College of Physicians. ^mMadras Medical Group, Madras, Oregon; American Academy of Family Physicians. ⁿUniversity of California Los Angeles, Los Angeles, California. ^oSchmidt College of Medicine, Florida Atlantic University, Boca Raton, Florida; American College of Emergency Physicians. ^pSpecialty Chair, Mayo Clinic, Jacksonville, Florida.

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- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

Discussion of Procedures by Variant

Variant 1: Adult. Acute hip pain, traumatic. Initial imaging.

The goal of imaging is to detect hip fracture and/or dislocation. This imaging information helps to initiate the appropriate treatment plan sooner, which can improve patient outcome by reducing length of immobility and possible risk of osteonecrosis. This imaging information benefits the patient by reducing potential delay in appropriate treatment and by hastening patient recovery.

Bone Scan Hip

There is no evidence to support the use of bone scan as the initial imaging study for the evaluation of acute traumatic hip pain.

CT Hip With IV Contrast

There is no evidence to support the use of CT with intravenous (IV) contrast as the initial imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without and With IV Contrast

There is no evidence to support the use of CT without and with IV contrast as the initial imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without IV Contrast

There is no evidence to support the use of CT without IV contrast as the initial imaging study for the evaluation of acute traumatic hip pain.

MRI Hip Without and With IV Contrast

There is no evidence to support the use of MRI without and with IV contrast as the initial imaging study for the evaluation of acute traumatic hip pain.

MRI Hip Without IV Contrast

There is no evidence to support the use of MRI without IV contrast as the initial imaging study for the evaluation of acute traumatic hip pain.

Radiography Hip

Radiography is the initial imaging modality of choice in the evaluation of acute traumatic hip pain [2]. Standard posttraumatic hip radiographs should include an anteroposterior (AP) view with 15 degrees of internal hip rotation and a cross-table lateral view of the affected hip. Many institutions include an AP view of the pelvis for assessment of hip symmetry, either as part of the standard trauma evaluation or in conjunction with the dedicated hip series. The cross-table lateral view is favored over the frog-leg lateral view due to the potential risk for fracture displacement with frog-leg technique [14]. Radiographs are fast to obtain and can be performed portably in the trauma bay—this rapid method of diagnosis reduces the morbidity associated with acute hip fracture and/or dislocation without moving the patient [14].

Several publications describe possible additional radiographic views that can aid in fracture detection and classification [15-17], though none of these views has supplanted the standard AP and cross-table lateral views. For example, in a retrospective study of 78 consecutive hip fracture patients, Khurana et al [16] report that the addition of an internal rotation traction view can improve reader confidence and accuracy in the classification of intracapsular femoral neck fractures (displaced versus nondisplaced) and intertrochanteric fractures (stable versus unstable).

US Hip

There is no evidence to support the use of ultrasound (US) as the initial imaging study for the evaluation of acute traumatic hip pain.

Variant 2: Adult. Acute hip pain, traumatic. Suspect fracture. Radiographs negative or indeterminate. Next imaging study.

The goal of imaging is to detect radiographically occult fracture. This imaging information helps to initiate the appropriate treatment plan sooner, which can improve patient outcome by reducing length of immobility and

possible risk of osteonecrosis. This imaging information benefits the patient by reducing potential delay in appropriate treatment and by hastening patient recovery.

Bone Scan Hip

There is insufficient evidence to support the use of bone scan as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip With IV Contrast

There is no evidence to support the use of CT with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without and With IV Contrast

There is no evidence to support the use of CT without and with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without IV Contrast

Multiple studies over the past 2 decades have demonstrated the importance of cross-sectional imaging (CT and/or MRI) in revealing radiographically occult hip fractures in patients with acute traumatic hip pain [18-22]. Given the importance of rapid diagnosis in decreasing fracture-related morbidity, the relative speed in obtaining CT (versus MRI or bone scan) supports CT as the next imaging examination after negative radiographs when there is persistent clinical concern for hip fracture [18,19,21-24]. Patients with persistent clinical concern for hip fracture after a negative or equivocal CT will still need an MRI [18,19,21,23].

In a recent meta-analysis of 2,992 patients (35 studies) with clinically suspected hip fracture and using MRI as the reference standard, Haj-Mizraian et al [20] reported a frequency of surgical hip fracture in 39% of patients (1,110 of 2,835) with negative radiographs (moderate strength of evidence). The authors reported similar sensitivity for CT (79%) and bone scan (87%) in detecting radiographically occult hip fracture in this patient population ($P = .67$, noting low strength of evidence for this latter analysis). In a meta-analysis of 1,248 patients (13 studies) with clinically suspected hip fracture and negative radiographs, Kellock et al [21] reported a CT sensitivity of 94% and a specificity of 100% with 50 false-negative CT examinations in their study cohort. The studies in this latter meta-analysis used MRI or clinical follow-up as the reference standard (496 patients with hip fracture, 752 patients without hip fracture). A recent meta-analysis by Gatt et al [25] demonstrated that CT after negative radiographs found occult hip fractures in 24.1% and led to a change in management in 20% of cases. These authors also found that increasing the number of radiographic projections did not decrease the need for CT.

Dual-energy CT (with virtual noncalcium maps) can be helpful in evaluating fractures that predominantly involve cancellous/trabecular bone, such as nondisplaced intertrochanteric fractures. This technique enables CT detection of bone marrow edema, which previously required MRI to visualize [26]. For example, Kellock et al [27] reported that the addition of virtual noncalcium maps increased sensitivity for detection of nondisplaced hip fracture by 4% to 5% in their study population.

MRI Hip Without and With IV Contrast

There is no evidence to support the use of MRI without and with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

MRI Hip Without IV Contrast

Several meta-analyses recommend MRI after negative CT in patients with persistent clinical concern for CT-occult fracture given the morbidity and mortality associated with hip fractures [18,20-23]. In a recent retrospective study of 103 patients with clinically suspected but radiographically occult hip fracture, all patients underwent CT, and if the CT was negative, the patients then had MRI to exclude CT-occult fracture [19]. Although 49% of patients in this study were diagnosed with fracture by CT alone, 23% of the negative CT patients were found to have a fracture on MRI that necessitated surgery. The mean time from admission to diagnosis was 3 hours for the CT-only group and 40 hours for the CT plus MRI group.

Though the association of ipsilateral femoral neck fracture with high-energy femoral shaft fracture is well documented in surgical literature, the femoral neck fracture may be occult on radiographs/CT and is prone to delay in diagnosis with reports that up to 57% of these fractures are not diagnosed until or after surgery for the femoral shaft fracture [28]. Inadequate fixation of the femoral neck fracture can result in unplanned reoperation, femoral head osteonecrosis, and/or nonunion. Rogers et al [28] reported the usefulness of an abbreviated MRI protocol (coronal T1 and coronal short tau inversion-recovery [STIR]) for patients with high-energy femoral shaft fracture—

MRI identified ipsilateral femoral neck fractures that were not visualized on CT in 12% of the patients in their study population.

Several other studies report the usefulness of an abbreviated MRI protocol in the emergency department setting with the primary goal of ruling in or ruling out hip fracture [29-31]. In a recent meta-analysis, Wilson et al [31] reported that a protocol consisting only of coronal T1-weighted and coronal STIR sequences is 100% sensitive for detecting radiographically occult hip fracture.

US Hip

There is insufficient evidence to support the use of US as the next imaging study for the evaluation of acute traumatic hip pain. There are 2 recent studies on the topic of point-of-care US performed by expert emergency sonographers that suggest potential usefulness for US in this setting [32,33], but more research on this topic would be necessary to validate more widespread use.

Variant 3: Adult. Acute hip pain, traumatic. Radiographs positive for hip fracture. Next imaging study.

The goal of imaging is to further characterize the fracture in order to guide appropriate treatment planning. This imaging information helps to initiate the appropriate treatment plan sooner, which can improve patient outcome by indicating the need for operative management. This imaging information benefits the patient by reducing potential delay in appropriate treatment and by hastening patient recovery.

Bone Scan Hip

There is no evidence to support the use of bone scan as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip With IV Contrast

There is no evidence to support the use of CT with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without and With IV Contrast

There is no evidence to support the use of CT without and with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

CT Hip Without IV Contrast

CT can be helpful in surgical decision-making for known femoral neck or trochanteric fractures. In a study of patients with nondisplaced femoral neck fractures, Zamora et al [34] reported that the addition of CT resulted in greater interobserver agreement with regard to surgical decision-making (arthroplasty versus closed reduction percutaneous pinning) and altered this decision in 21% of cases, with an odds ratio of 1.4 (95% confidence interval 0.62-3.2) for choosing arthroplasty if CT was performed. However, the authors report that CT did not affect interobserver agreement for Garden classification or posterior tilt evaluation. Hardy et al [35] evaluated the potential for 2 angles measured on CT (impaction angle in the coronal plane and posterior tilt angle in the axial plane) to predict secondary displacement of nondisplaced femoral neck fractures if treated nonsurgically. Their results support the femoral neck impaction angle on CT as a reproducible metric that can predict secondary displacement (odds ratio of 11.73 for impaction angles ≤ 135 degrees). Several studies also report the improved interobserver reliability of trochanteric fracture classification by CT as compared to radiographs [36-38]. These studies primarily use a 3-D CT adaptation of the 2018-revised AO Foundation/Orthopaedic Trauma Association classification.

MRI Hip Without and With IV Contrast

There is no evidence to support the use of MRI without and with IV contrast as the next imaging study for the evaluation of acute traumatic hip pain.

MRI Hip Without IV Contrast

When seemingly isolated fracture of the greater trochanter is visualized on radiographs or CT, it is important to consider the possibility that the fracture might reflect incomplete intertrochanteric fracture with occult fracture propagation into the intertrochanteric region (rather than true isolated greater trochanteric fracture) [20,39,40]. Although true isolated greater trochanteric fractures are often treated conservatively, a subset of incomplete intertrochanteric fractures warrant internal fixation due to their risk for progression to complete intertrochanteric fracture.

In a meta-analysis of 2,992 patients (35 studies) with clinically suspected hip fracture and using MRI as the reference standard, Haj-Mirzaian et al [20] reported a frequency of surgically managed hip fracture in 92% of

patients with seemingly isolated greater trochanteric fractures on radiographs (134 of 157 patients). In a retrospective study of 146 patients who underwent MRI after identification of seemingly isolated greater trochanteric fracture on radiographs or CT, Walsh et al [40] examined if the orientation/degree of intertrochanteric fracture extension on MRI correlated with the decision to undergo conservative versus surgical management. The authors stratified patients into 1 of 5 categories based on fracture morphology on MRI: horizontal isolated greater trochanteric fracture, vertical fracture along the lateral femoral cortex, intertrochanteric fracture extending <50% in the mid coronal plane, intertrochanteric fracture extending >50% in the mid coronal plane but not contacting medial cortex, and intertrochanteric fracture contacting medial cortex. They reported that intertrochanteric fracture extension >50% in the mid coronal plane (ie, the latter 2 categories above) was a highly statistically significant predictor of surgical management in their study cohort ($P < .0001$), but they acknowledge that 31.9% of the surgical fractures in their study traversed <50% of the mid coronal plane [40]. In a retrospective review of 15 incomplete intertrochanteric fractures that traversed less than or close to 50% of the mid coronal plane on initial MRI (one of these fractures traversed 60% whereas the others traversed <50%), all 15 fractures healed on follow-up radiographs without fracture displacement or need for surgical intervention [41].

US Hip

There is no evidence to support the use of US as the next imaging study for the evaluation of acute traumatic hip pain.

Variant 4: Adult. Acute hip pain, traumatic. Post reduction of hip dislocation. Follow-up imaging.

The goals of imaging are to confirm successful reduction of native hip dislocation and to detect possible associated fracture(s). This imaging information helps to initiate the appropriate treatment plan sooner, which can improve patient outcome by reducing length of immobility and potential risk of recurrent dislocation. This imaging information benefits the patient by reducing potential delay in appropriate treatment and by hastening patient recovery.

Bone Scan Hip

There is no evidence to support the use of bone scan as follow-up imaging after reduction of hip dislocation.

CT Hip With IV Contrast

There is no evidence to support the use of CT with IV contrast as follow-up imaging after reduction of hip dislocation.

CT Hip Without and With IV Contrast

There is no evidence to support the use of CT without and with IV contrast as follow-up imaging after reduction of hip dislocation.

CT Hip Without IV Contrast

Postreduction CT may be considered to evaluate for joint congruence, intraarticular fragments, and to characterize associated acetabular fracture, noting that CT has better detection/evaluation of these findings than radiographs [8]. Postreduction hip CT is particularly indicated for radiographically visible (larger) fractures of the posterior acetabular wall to further characterize the fracture and determine if surgical management will be necessary to prevent repeat hip dislocation. Additionally, any patient who fails closed reduction should undergo CT to evaluate for entrapped fracture fragment(s) within the hip joint as the source of failed reduction.

In a study correlating CT, MRI, and arthroscopy after traumatic hip dislocation, Mandell et al [42] reported that although CT had a sensitivity of 87.3% for detecting intraarticular fracture fragments, 43.3% of patients with negative preoperative CT had intraarticular fracture fragments at arthroscopy. Mullis and Dahners [43] evaluated the arthroscopic detection of small intraarticular fracture fragments or small (nonsurgical) acetabular wall fracture that were not identified on radiographs or CT—they reported that intraarticular fragments were found in 78% of patients who had negative radiographs and CT.

MRI Hip Without and With IV Contrast

There is no evidence to support the use of MRI without and with IV contrast as follow-up imaging after reduction of hip dislocation.

MRI Hip Without IV Contrast

There is insufficient evidence to support the use of MRI in the acute postreduction setting.

Radiography Hip

Hip radiographs (AP and cross-table lateral views) are the mainstay of postreduction imaging after hip dislocation and should be obtained in all patients who do not undergo immediate postreduction CT. Prompt concentric reduction of hip dislocation and timely confirmation of successful reduction via imaging are essential to prevent femoral head osteonecrosis and other potential complications [44].

US Hip

There is no evidence to support the use of US as follow-up imaging after reduction of hip dislocation.

Variant 5: Adult. Acute hip pain, traumatic. Suspect tendon, muscle, or ligament injury. Radiographs negative or indeterminate. Next imaging study.

The goal of imaging is to detect acute myotendinous injury as the source of acute hip pain. This imaging information helps to initiate the appropriate treatment plan sooner, which can improve patient outcome by reducing length of immobility. This imaging information benefits the patient by reducing potential delay in appropriate treatment and by hastening patient recovery.

Bone Scan Hip

There is no evidence to support the use of bone scan as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury.

CT Hip With IV Contrast

There is no evidence to support the use of CT with IV contrast as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury.

CT Hip Without and With IV Contrast

There is no evidence to support the use of CT without and with IV contrast as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury.

CT Hip Without IV Contrast

There is no evidence to support the use of CT without IV contrast as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury.

MRI Hip Without and With IV Contrast

There is no evidence to support the use of MRI without and with IV contrast as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury.

MRI Hip Without IV Contrast

MRI is the next useful imaging examination to evaluate for tendon, muscle, or ligament injury about the hip. The usefulness of MRI in diagnosing gluteus medius tendon avulsion/tear was first reported in radiology literature in the late 1990s around the same time that orthopedic literature began to focus on the gluteus minimus/medius tendons as the functional “rotator cuff of the hip” [45]. A 2004 retrospective analysis reported that MRI had sensitivity of 93%, specificity of 92%, and accuracy of 91% in the detection of gluteus minimus/medius tendon tear [46]. More recent retrospective reviews and meta-analyses have reported more modest MRI accuracy, though still acknowledging that MRI remains the mainstay of evaluating gluteus minimus/medius tendinopathy [47-50]. Of note, most of these studies included patients with chronic greater trochanteric pain syndrome and were not limited to patients with acute tendon injury. For example, a meta-analysis of 5 MRI studies with intraoperative correlation reported sensitivity range of 33% to 100% and specificity range of 92% to 100% for MRI in detecting gluteus minimus/medius tendon tears [51].

Hamstring injuries are common in athletes and are among the most common reason that athletes miss time from sports [52]. Though most muscle belly hamstring injuries do not require MRI in the acute setting, MRI evaluation is particularly useful in acute proximal hamstring tendon avulsions with successful outcomes reported for repairs of both partial and complete tendon avulsions [53]. In a retrospective study comparing US and MRI for proximal hamstring avulsion injuries, Koulouris and Connell [54] reported that MRI detected 100% of these injuries, whereas US detected only 58.3%. Several more recent publications on the topic of hamstring injuries describe the usefulness of MRI in classifying the location, extent, degree (partial versus complete), and chronicity [52,55,56].

Two recent review articles describe the usefulness of MRI in the evaluation of iliofemoral ligament and ligamentum teres injury, respectively [57,58].

US Hip

There is insufficient evidence to support the use of US as the next imaging study for the evaluation of suspected tendon, muscle, or ligament injury. There is a paucity of studies that specifically evaluate the usefulness of US for the detection of acute gluteus tendon tear—most sonographic studies to date include patients with chronic greater trochanteric pain syndrome. For example, a study of patients with chronic greater trochanteric pain syndrome reported a sensitivity of 79% for US in the detection of gluteus minimus/medius tendon tear [59].

A review article by Lungu et al [56] describes US of myotendinous injuries about the hip but the authors report that it has limited use in return-to-play decisions with MRI playing a more important role. In a retrospective study comparing US and MRI for proximal hamstring avulsion injuries, Koulouris and Connell [54] reported that MRI detected 100% of these injuries, whereas US detected only 58.3%.

There are no publications on the topic of iliofemoral ligament evaluation via US and the ligamentum teres cannot be evaluated sonographically because of its depth within the hip joint.

Summary of Highlights

This is a summary of the key recommendations from the variant tables. Refer to the complete narrative document for more information.

- **Variant 1:** Hip radiographs (AP and lateral views) are usually appropriate for the initial imaging of acute hip pain.
- **Variant 2:** If there is persistent concern for hip fracture after negative or indeterminate radiographs, then noncontrast CT is usually appropriate as the first-line examination in this scenario, but patients with persistent clinical concern for hip fracture after negative or equivocal CT will still need noncontrast MRI.
- **Variant 3:** After a positive radiograph for hip fracture, noncontrast CT is usually appropriate when further characterization of fracture alignment is needed for surgical decision-making. Noncontrast MRI may be appropriate to identify incomplete intertrochanteric fracture extension, which cannot be reliably distinguished from isolated greater trochanteric fracture on radiographs and CT.
- **Variant 4:** After reduction of hip dislocation, repeat radiographs (AP and lateral views) should be obtained to confirm successful hip relocation. In patients with associated large posterior acetabular wall fracture on radiographs or difficulty in obtaining successful reduction, noncontrast CT is usually appropriate to evaluate if surgical fixation of the posterior acetabular wall fracture is warranted or if there are intra-articular fracture fragments that impede complete/anatomic relocation.
- **Variant 5:** MRI of the hip without contrast is usually appropriate when evaluating for clinically suspected tendon, muscle, or ligament injury as the source of acute hip pain after negative or indeterminate radiographs.

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.

Gender Equality and Inclusivity Clause

The ACR acknowledges the limitations in applying inclusive language when citing research studies that pre-dates the use of the current understanding of language inclusive of diversity in sex, intersex, gender and gender-diverse people. The data variables regarding sex and gender used in the cited literature will not be changed. However, this guideline will use the terminology and definitions as proposed by the National Institutes of Health [60].

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 [61].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	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."

References

1. Brauer CA, Coca-Perraillon M, Cutler DM, Rosen AB. Incidence and mortality of hip fractures in the United States. JAMA 2009;302:1573-9.

2. Kani KK, Porrino JA, Mulcahy H, Chew FS. Fragility fractures of the proximal femur: review and update for radiologists. *Skeletal Radiol* 2019;48:29-45.
3. Khan SK, Kalra S, Khanna A, Thiruvengada MM, Parker MJ. Timing of surgery for hip fractures: a systematic review of 52 published studies involving 291,413 patients. *Injury* 2009;40:692-7.
4. Lefaivre KA, Macadam SA, Davidson DJ, Gandhi R, Chan H, Broekhuysen HM. Length of stay, mortality, morbidity and delay to surgery in hip fractures. *J Bone Joint Surg Br* 2009;91:922-7.
5. Bretherton CP, Parker MJ. Early surgery for patients with a fracture of the hip decreases 30-day mortality. *Bone Joint J* 2015;97-B:104-8.
6. Nyholm AM, Gromov K, Palm H, et al. Time to Surgery Is Associated with Thirty-Day and Ninety-Day Mortality After Proximal Femoral Fracture: A Retrospective Observational Study on Prospectively Collected Data from the Danish Fracture Database Collaborators. *J Bone Joint Surg Am* 2015;97:1333-9.
7. Bartolotta RJ, Belfi LM, Ha AS. Breaking Down Fractures of the Pelvis and Hip. *Semin Roentgenol* 2021;56:39-46.
8. Mandell JC, Marshall RA, Weaver MJ, Harris MB, Sodickson AD, Khurana B. Traumatic Hip Dislocation: What the Orthopedic Surgeon Wants to Know. *Radiographics* 2017;37:2181-201.
9. Walker MR, El Naga AN, Atassi OH, Perkins CH, Mitchell SA. Effect of initial emergency room imaging choice on time to hip reduction and repeat imaging. *Injury* 2019;50:686-89.
10. Weissman BN, Palestro CJ, Fox MG, et al. ACR Appropriateness Criteria® Imaging After Total Hip Arthroplasty. *J Am Coll Radiol* 2023;20:S413-S32.
11. Jawetz ST, Fox MG, Blankenbaker DG, et al. ACR Appropriateness Criteria® Chronic Hip Pain: 2022 Update. *J Am Coll Radiol* 2023;20:S33-S48.
12. American College of Radiology. ACR Appropriateness Criteria®: Stress (Fatigue-Insufficiency) Fracture Including Sacrum Excluding Other Vertebrae. Available at: <https://acsearch.acr.org/docs/69435/Narrative/>. Accessed September 30, 2024.
13. Pierce JL, Perry MT, Wessell DE, et al. ACR Appropriateness Criteria® Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot): 2022 Update. *J Am Coll Radiol* 2022;19:S473-S87.
14. Stephenson JW, Davis KW. Imaging of traumatic injuries to the hip. *Semin Musculoskelet Radiol* 2013;17:306-15.
15. Harding J, Chesser TJ, Bradley M. The Bristol hip view: its role in the diagnosis and surgical planning and occult fracture diagnosis for proximal femoral fractures. *ScientificWorldJournal* 2013;2013:703783.
16. Khurana B, Mandell JC, Rocha TC, et al. Internal Rotation Traction Radiograph Improves Proximal Femoral Fracture Classification Accuracy and Agreement. *AJR Am J Roentgenol* 2018;211:409-15.
17. Garcia-Serrano MC, Garcia-Guerrero LF, Gomez-Gelvez A, Pinzon-Rendon AA. Diagnostic imaging concordance study: Are traction radiographs necessary in a hip fracture? *Injury* 2021;52:1445-49.
18. Alabousi M, Gauthier ID, Li N, et al. Multi-detector CT for suspected hip fragility fractures: A diagnostic test accuracy systematic review and meta-analysis. *Emerg Radiol* 2019;26:549-56.
19. Davidson A, Silver N, Cohen D, et al. Justifying CT prior to MRI in cases of suspected occult hip fracture. A proposed diagnostic protocol. *Injury* 2021;52:1429-33.
20. Haj-Mirzaian A, Eng J, Khorasani R, et al. Use of Advanced Imaging for Radiographically Occult Hip Fracture in Elderly Patients: A Systematic Review and Meta-Analysis. *Radiology* 2020;296:521-31.
21. Kellock TT, Khurana B, Mandell JC. Diagnostic Performance of CT for Occult Proximal Femoral Fractures: A Systematic Review and Meta-Analysis. *AJR Am J Roentgenol* 2019;213:1324-30.
22. Lanotte SJ, Larbi A, Michoux N, et al. Value of CT to detect radiographically occult injuries of the proximal femur in elderly patients after low-energy trauma: determination of non-inferiority margins of CT in comparison with MRI. *Eur Radiol* 2020;30:1113-26.
23. Foex BA, Russell A. BET 2: CT versus MRI for occult hip fractures. *Emerg Med J* 2018;35:645-47.
24. Haims AH, Wang A, Yoo BJ, Porrino J. Negative predictive value of CT for occult fractures of the hip and pelvis with imaging follow-up. *Emerg Radiol* 2021;28:259-64.
25. Gatt T, Cutajar D, Borg L, Giordmaina R. The Necessity of CT Hip Scans in the Investigation of Occult Hip Fractures and Their Effect on Patient Management. *Adv Orthop* 2021;2021:8118147.
26. Baffour FI, Glazebrook KN, Morris JM, et al. Clinical utility of virtual noncalcium dual-energy CT in imaging of the pelvis and hip. *Skeletal Radiol* 2019;48:1833-42.
27. Kellock TT, Nicolaou S, Kim SSY, et al. Detection of Bone Marrow Edema in Nondisplaced Hip Fractures: Utility of a Virtual Noncalcium Dual-Energy CT Application. *Radiology* 2017;284:798-805.

28. Rogers NB, Hartline BE, Achior TS, et al. Improving the Diagnosis of Ipsilateral Femoral Neck and Shaft Fractures: A New Imaging Protocol. *J Bone Joint Surg Am* 2020;102:309-14.
29. Khurana B, Okanobo H, Ossiani M, Ledbetter S, Al Dulaimy K, Sodickson A. Abbreviated MRI for patients presenting to the emergency department with hip pain. *AJR Am J Roentgenol* 2012;198:W581-8.
30. Sun EX, Mandell JC, Weaver MJ, Kimbrell V, Harris MB, Khurana B. Clinical utility of a focused hip MRI for assessing suspected hip fracture in the emergency department. *Emerg Radiol* 2021;28:317-25.
31. Wilson MP, Nobbe D, Murad MH, et al. Diagnostic Accuracy of Limited MRI Protocols for Detecting Radiographically Occult Hip Fractures: A Systematic Review and Meta-Analysis. *AJR Am J Roentgenol* 2020;215:559-67.
32. Cohen A, Li T, Greco J, et al. Hip effusions or iliopsoas hematomas on ultrasound in identifying hip fractures in the emergency department. *Am J Emerg Med* 2023;64:129-36.
33. Tsukamoto H, Kijima H, Saito K, Saito H, Miyakoshi N. Diagnostic accuracy of ultrasonography for occult femoral neck fracture. *J Clin Orthop Trauma* 2023;36:102087.
34. Zamora T, Klaber I, Ananias J, et al. The influence of the CT scan in the evaluation and treatment of nondisplaced femoral neck fractures in the elderly. *J Orthop Surg (Hong Kong)* 2019;27:2309499019836160.
35. Hardy J, Collin C, Mathieu PA, Vergnenegre G, Charissoux JL, Marcheix PS. Is non-operative treatment still relevant for Garden Type I fractures in elderly patients? The femoral neck impaction angle as a new CT parameter for determining the indications of non-operative treatment. *Orthop Traumatol Surg Res* 2019;105:479-83.
36. Iguchi M, Takahashi T, Matsumura T, et al. Addition of 3D-CT evaluation to radiographic images and effect on diagnostic reliability of current 2018 AO/OTA classification of femoral trochanteric fractures. *Injury* 2021;52:3363-68.
37. Wada K, Mikami H, Amari R, Toki S, Takai M, Sairyo K. A novel three-dimensional classification system for intertrochanteric fractures based on computed tomography findings. *J Med Invest* 2019;66:362-66.
38. Wada K, Mikami H, Toki S, Amari R, Takai M, Sairyo K. Intra- and inter-rater reliability of a three-dimensional classification system for intertrochanteric fracture using computed tomography. *Injury* 2020;51:2682-85.
39. Noh J, Lee KH, Jung S, Hwang S. The Frequency of Occult Intertrochanteric Fractures among Individuals with Isolated Greater Trochanteric Fractures. *Hip Pelvis* 2019;31:23-32.
40. Walsh PJ, Farooq M, Walz DM. Occult fracture propagation in patients with isolated greater trochanteric fractures: patterns and management. *Skeletal Radiol* 2022;51:1391-98.
41. Kent WT, Whitchurch T, Siow M, et al. Greater trochanteric fractures with Intertrochanteric extension identified on MRI: What is the rate of displacement when treated nonoperatively? *Injury* 2020;51:2648-51.
42. Mandell JC, Marshall RA, Banffy MB, Khurana B, Weaver MJ. Arthroscopy After Traumatic Hip Dislocation: A Systematic Review of Intra-articular Findings, Correlation With Magnetic Resonance Imaging and Computed Tomography, Treatments, and Outcomes. *Arthroscopy* 2018;34:917-27.
43. Mullis BH, Dahners LE. Hip arthroscopy to remove loose bodies after traumatic dislocation. *J Orthop Trauma* 2006;20:22-6.
44. Chona DV, Minetos PD, LaPrade CM, et al. Hip Dislocation and Subluxation in Athletes: A Systematic Review. *Am J Sports Med* 2022;50:2834-41.
45. Chung CB, Robertson JE, Cho GJ, Vaughan LM, Copp SN, Resnick D. Gluteus medius tendon tears and avulsive injuries in elderly women: imaging findings in six patients. *AJR Am J Roentgenol* 1999;173:351-3.
46. Cvitanic O, Henzie G, Skezas N, Lyons J, Minter J. MRI diagnosis of tears of the hip abductor tendons (gluteus medius and gluteus minimus). *AJR Am J Roentgenol* 2004;182:137-43.
47. Lequesne M, Djian P, Vuillemin V, Mathieu P. Prospective study of refractory greater trochanter pain syndrome. MRI findings of gluteal tendon tears seen at surgery. *Clinical and MRI results of tendon repair. Joint Bone Spine* 2008;75:458-64.
48. Lindner D, Shohat N, Botser I, Agar G, Domb BG. Clinical presentation and imaging results of patients with symptomatic gluteus medius tears. *J Hip Preserv Surg* 2015;2:310-5.
49. Makridis KG, Lequesne M, Bard H, Djian P. Clinical and MRI results in 67 patients operated for gluteus medius and minimus tendon tears with a median follow-up of 4.6 years. *Orthop Traumatol Surg Res* 2014;100:849-53.
50. Zhu MF, Musson DS, Cornish J, Young SW, Munro JT. Hip abductor tendon tears: where are we now? *Hip Int* 2020;30:500-12.

51. Westacott DJ, Minns JI, Foguet P. The diagnostic accuracy of magnetic resonance imaging and ultrasonography in gluteal tendon tears--a systematic review. *Hip Int* 2011;21:637-45.
52. Allahabadi S, Salazar LM, Obioha OA, Fenn TW, Chahla J, Nho SJ. Hamstring Injuries: A Current Concepts Review: Evaluation, Nonoperative Treatment, and Surgical Decision Making. *Am J Sports Med* 2024;52:832-44.
53. Arner JW, McClincy MP, Bradley JP. Hamstring Injuries in Athletes: Evidence-based Treatment. *J Am Acad Orthop Surg* 2019;27:868-77.
54. Koulouris G, Connell D. Evaluation of the hamstring muscle complex following acute injury. *Skeletal Radiol* 2003;32:582-9.
55. Forlizzi JM, Nacca CR, Shah SS, et al. Acute Proximal Hamstring Tears Can be Defined Using an Imaged-Based Classification. *Arthrosc Sports Med Rehabil* 2022;4:e653-e59.
56. Lungu E, Michaud J, Bureau NJ. US Assessment of Sports-related Hip Injuries. *Radiographics* 2018;38:867-89.
57. Boric I, Isaac A, Dalili D, Ouchinsky M, De Maeseneer M, Shahabpour M. Imaging of Articular and Extra-articular Sports Injuries of the Hip. *Semin Musculoskelet Radiol* 2019;23:e17-e36.
58. Kho J, Azzopardi C, Davies AM, James SL, Botchu R. MRI assessment of anatomy and pathology of the iliofemoral ligament. *Clin Radiol* 2020;75:960 e17-60 e22.
59. Fearon AM, Scarvell JM, Cook JL, Smith PN. Does ultrasound correlate with surgical or histologic findings in greater trochanteric pain syndrome? A pilot study. *Clin Orthop Relat Res* 2010;468:1838-44.
60. National Academies of Sciences, Engineering, and Medicine; Division of Behavioral and Social Sciences and Education; Committee on National Statistics; Committee on Measuring Sex, Gender Identity, and Sexual Orientation. *Measuring Sex, Gender Identity, and Sexual Orientation*. In: Becker T, Chin M, Bates N, eds. *Measuring Sex, Gender Identity, and Sexual Orientation*. Washington (DC): National Academies Press (US) Copyright 2022 by the National Academy of Sciences. All rights reserved.; 2022.
61. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed September 30, 2024.

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.