

**American College of Radiology  
ACR Appropriateness Criteria®  
Shoulder Pain–Atraumatic**

**Variant 1:                   Atraumatic shoulder pain. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography shoulder	Usually Appropriate	⊕
CT arthrography shoulder	Usually Not Appropriate	⊕ ⊕ ⊕ ⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MR arthrography shoulder	Usually Not Appropriate	○
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
MRI shoulder without IV contrast	Usually Not Appropriate	○
US shoulder	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊕

**Variant 2:                   Atraumatic shoulder pain. Suspect rotator cuff disorders (tendinosis, tear, calcific tendinitis). Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	Usually Appropriate	○
MR arthrography shoulder	May Be Appropriate	○
CT arthrography shoulder	May Be Appropriate	⊕ ⊕ ⊕ ⊕
Radiography shoulder additional views	Usually Not Appropriate	⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊕

**Variant 3:**

**Atraumatic shoulder pain. Suspect labral tear and instability. Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography shoulder	Usually Appropriate	○
MRI shoulder without IV contrast	Usually Appropriate	○
CT arthrography shoulder	May Be Appropriate	⊕ ⊕ ⊕ ⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
US shoulder	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊕
Radiography shoulder additional views	Usually Not Appropriate	⊕

**Variant 4:**

**Atraumatic shoulder pain. Suspect bursitis. Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	Usually Appropriate	○
CT arthrography shoulder	Usually Not Appropriate	⊕ ⊕ ⊕ ⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MR arthrography shoulder	Usually Not Appropriate	○
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊕

**Variant 5:****Atraumatic shoulder pain. Suspect adhesive capsulitis. Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	May Be Appropriate (Disagreement)	○
X-ray arthrography shoulder	May Be Appropriate	⊕
MR arthrography shoulder	Usually Not Appropriate	○
CT arthrography shoulder	Usually Not Appropriate	⊕ ⊕ ⊕ ⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI shoulder without and with IV contrast	Usually Not Appropriate	○

**Variant 6:****Atraumatic shoulder pain. Suspect biceps tendinitis, bursitis, dislocation, or tear. Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	Usually Appropriate	○
MR arthrography shoulder	May Be Appropriate (Disagreement)	○
CT arthrography shoulder	Usually Not Appropriate	⊕ ⊕ ⊕ ⊕
CT shoulder with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without and with IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
CT shoulder without IV contrast	Usually Not Appropriate	⊕ ⊕ ⊕
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊕

**Variant 7:****Pain after rotator cuff repair. Initial radiographs normal or inconclusive. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography shoulder	Usually Appropriate	○
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	Usually Appropriate	○
CT arthrography shoulder	May Be Appropriate	⊗ ⊗ ⊗ ⊗
CT shoulder with IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
CT shoulder without and with IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
CT shoulder without IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊗

**Variant 8:****Atraumatic shoulder pain. Neurogenic pain (excluding plexopathy). Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI shoulder without IV contrast	Usually Appropriate	○
US shoulder	May Be Appropriate	○
CT shoulder without IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
Radiography shoulder	Usually Not Appropriate	⊗
CT arthrography shoulder	Usually Not Appropriate	⊗ ⊗ ⊗ ⊗
CT shoulder with IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
CT shoulder without and with IV contrast	Usually Not Appropriate	⊗ ⊗ ⊗
MR arthrography shoulder	Usually Not Appropriate	○
MRI shoulder without and with IV contrast	Usually Not Appropriate	○
X-ray arthrography shoulder	Usually Not Appropriate	⊗

## SHOULDER PAIN–ATRAUMATIC

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### **Summary of Literature Review**

#### **Introduction/Background**

Shoulder pain is one of the most common reasons for musculoskeletal-related physician visits [1]. Imaging plays an important role in identifying the specific cause of atraumatic shoulder pain. Atraumatic shoulder pain can be attributed to structures related to the rotator cuff, glenohumeral articulation, joint capsule, biceps tendon, labrum, and bony structures. In conjunction with a focused history and physical examination, imaging studies play an important role in the accurate diagnosis and subsequent treatment of patients with atraumatic shoulder pain.

#### **Overview of Imaging Modalities**

##### **Radiography**

Imaging of the painful shoulder should begin with radiographs. Radiography is a safe and fast imaging modality that effectively demonstrates many conditions affecting the shoulder. Radiographic shoulder series include frontal views that may be anterior-posterior (AP) in internal and external rotation and/or AP oblique Grashey views [2,3]. Axillary lateral and/or scapular “Y” views are advisable if there is a question of instability or dislocation [3,4]. These views may be supplemented with additional radiographic projections depending on the clinical concern.

##### **Arthrography**

Until the advent of MRI, diagnostic arthrography was the mainstay in the evaluation of rotator cuff disease. Currently, shoulder arthrography is usually performed in conjunction with other imaging modalities, such as MRI or CT. Fluoroscopy, CT, or ultrasound (US) can be used to guide needle placement for arthrography.

##### **Nuclear Medicine**

In the setting of atraumatic shoulder pain, nuclear medicine studies are rarely used. Sometimes a PET scan is used in conjunction with CT and MRI in the workup of soft-tissue tumors, bone tumors, and metastases. Otherwise, in the setting of atraumatic shoulder pain, bone scintigraphy, gallium, and indium scans have been largely replaced by MRI and CT.

##### **CT**

CT plays an important role in the evaluation of osseous structures. In conjunction with arthrography, the CT arthrogram is often used as a second-line modality in the evaluation of the rotator cuff and labrum.

##### **MRI**

Given its excellent depiction of soft-tissue structures, MRI is considered the gold standard in the evaluation of the shoulder for entities involving the glenoid labrum and rotator cuff [5]. In conjunction with arthrography, the MR arthrogram increases the diagnostic sensitivity and specificity in the evaluation of glenoid labral tears and certain types of rotator cuff tears. MRI is well tolerated and involves no ionizing radiation.

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## US

The development of high-resolution transducers along with the high-speed image processing capabilities of the current generation of US scanners provide exquisite evaluation of musculoskeletal soft tissues in real time. Consequently, US has played an increasingly important role in shoulder imaging, demonstrating accuracies in the detection of rotator cuff and adjacent soft-tissue abnormalities equivalent to MRI [6]. US is usually well tolerated and, as with MRI, involves no ionizing radiation. Imaging in real time allows direct functional assessment of the shoulder during provocative maneuvers (ie, impingement) as well as providing guidance for a variety of interventions. As in other modalities, the upper extremity must be positioned to optimally visualize the anatomy of interest.

### **Discussion of Procedures by Variant**

#### **Variant 1: Atraumatic shoulder pain. Initial imaging.**

##### **Radiography**

Radiographs should be the initial imaging study performed in patients with shoulder pain. Standard radiographs, including AP internal rotation, AP external rotation, scapular “Y” views, and axillary views, are often the initial radiographs obtained. Accurate interpretation of radiographs can often obviate additional imaging or be complementary to subsequent imaging studies [2]. Radiographs can evaluate for unexpected fracture (or pathologic fracture) and stigmata of prior anterior or posterior dislocation. Other disease entities that are seen well on radiographs include osteoarthritis, rheumatoid arthritis, avascular necrosis of the humeral head, and calcific tendonitis (hydroxyapatite deposition disease).

##### **X-ray Arthrography Shoulder**

There are currently no data to support using arthrography as the first imaging study to evaluate atraumatic shoulder pain.

##### **CT Shoulder**

CT is not routinely used in the initial evaluation of atraumatic shoulder pain.

##### **CT Arthrography Shoulder**

CT arthrography is not routinely used in the initial evaluation of atraumatic shoulder pain.

##### **MRI Shoulder**

MRI is not routinely used in the initial evaluation of atraumatic shoulder pain.

##### **MR Arthrography Shoulder**

MR arthrography is not routinely used in the initial evaluation of atraumatic shoulder pain.

##### **US Shoulder**

Radiographic evaluation should generally be the first imaging study ordered in patients with shoulder pain. In certain instances where clinical examination suggests rotator cuff disease/adhesive capsulitis, symptoms of impingement, or painful palpable mass, US may be considered as an initial imaging study. US has the advantage of allowing provocative maneuvers to assess impingement. It is very sensitive in detecting calcifications in cases of calcium hydroxyapatite deposition [7]. US also can be used to provide guidance for therapeutic interventions when appropriate at the time of examination.

##### **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the initial evaluation of atraumatic shoulder pain

#### **Variant 2: Atraumatic shoulder pain. Suspect rotator cuff disorders (tendinosis, tear, calcific tendinitis). Initial radiographs normal or inconclusive. Next imaging study.**

##### **Radiography Shoulder Additional Views**

There have been several reports assessing special views for the evaluation of shoulder impingement and the anterior acromion [8-10]. Outlet views can be used to determine acromial shape and have been shown to be more accurate than a single-slice MRI [11]. The Rockwood view is an angled frontal projection that can be used to detect anterior acromial osteophytes [2]. Radiography can also be helpful in the evaluation of calcific tendinitis, as it can assess its extent, location, and density [12,13]. Cysts seen within the lesser tuberosity on radiographs have been shown to be associated with subscapularis tendon tears with 87% specificity [14]. In chronic rotator cuff tear, there can be a decrease in the acromiohumeral distance and concavity and remodeling of the acromial undersurface [15].

### **X-ray Arthrography Shoulder**

Arthrography with contrast injection performed under fluoroscopic guidance followed by radiography was the mainstay of evaluation for rotator cuff tear until the advent of shoulder CT and MRI. Conventional arthrography is currently used only as a potential study in patients with suspected rotator cuff disease when other preferred examinations cannot be performed.

### **CT Shoulder**

Calcific tendinitis of the rotator cuff is well seen on CT examination. In the evaluation of calcific tendinitis, CT can be helpful in evaluating osseous involvement and is the most accurate modality in evaluating the consistency of the deposit, which may be important when planning intervention [13,16,17]. Intravenous (IV) contrast-enhanced CT examinations are not usually utilized when evaluating for rotator cuff disorders.

### **CT Arthrography Shoulder**

CT arthrography has shown good diagnostic performance for depicting tendon tears with reported respective sensitivity and specificity of 99% and 100% for the supraspinatus tendon, 97.4% and 99.5% for the infraspinatus tendon, and 64.7% and 98.2% for the subscapularis tendon [18]. CT arthrography provides a comparable alternative to MR arthrography in the evaluation of rotator cuff tendon tears [19,20]. In addition, with its excellent spatial resolution, CT arthrography is able to detect very subtle articular surface defects, even though the therapeutic impact of these subtle irregularities may be limited [21,22].

CT arthrography is helpful in the preoperative planning of total shoulder arthroplasty. Evaluation of potentially irreparable rotator cuff disease is critical in determining arthroplasty type (conventional versus reverse). CT provides important osseous detail in the evaluation of glenoid morphology, version, and extent and location of glenoid bone loss. This information is critical in the appropriate presurgical planning of total shoulder arthroplasty.

The major limitation of CT arthrography is its insensitivity to bursal-sided and purely intrasubstance tears because they do not fill with contrast material injected into the glenohumeral joint [19-21]. MRI and MR arthrography are able to depict these lesions with fluid-sensitive sequences [21].

### **MRI Shoulder**

MRI of the shoulder is a highly accurate tool in the assessment of the rotator cuff [5,23]. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for rotator cuff disorders. Tendinosis is accurately and frequently diagnosed on MRI. Full-thickness tears of the rotator cuff tendons can be reliably identified using conventional MRI with high sensitivity and specificity [23-25].

Tendon retraction, muscle atrophy, and fatty infiltration are associated important findings that are well seen on MRI. This essential information aids in decisions regarding conservative versus operative repair, type of operative repair (open, miniopen, or arthroscopic cuff repair; substitute, or muscle transfer), and to provide a postoperative prognosis [26].

In addition to evaluating the rotator cuff, MRI can aid in detecting extra-articular abnormalities including osseous and soft-tissue findings that may predispose to or be the result of shoulder impingement [27,28]. MRI can also evaluate other extra-articular etiologies that can contribute to shoulder pain including bone marrow lesions and bursal and other soft-tissue abnormalities. MRI is important in the evaluation of calcific tendinitis as it helps to evaluate the extent of soft-tissue abnormalities and other causes of shoulder pain [13,29].

### **MR Arthrography Shoulder**

Although the correct diagnosis of a partial articular surface tear of the rotator cuff is difficult on both routine MRI and MR arthrogram, MR arthrography provides greater sensitivity and specificity in evaluating a partial articular surface tear [6,25,28,30]. MR arthrography is a minimally invasive procedure.

Some authors suggest that adding an abduction external rotation imaging position to an MR arthrogram improves the accuracy in diagnosing partial articular surface tears [31,32]. Partial bursal and purely intrasubstance tears will have similar rates of detection on conventional MRI and MR arthrography because the diagnosis is dependent on the same fluid-sensitive sequences on both examinations.

### **US Shoulder**

US has been shown to have comparable accuracy to MRI in assessing rotator cuff disease [25,33,34]. It provides the most sensitive evaluation for soft-tissue calcification. It also can be used to provide guidance for therapeutic

intervention when appropriate at the time of examination. US-guided barbotage has been shown to be a highly effective percutaneous treatment in patients with suspected calcific tendinitis [35,36]. Likewise, the real-time aspect of US makes it the method of choice for newer methods of intratendinous therapy, including tenotomy (eg, Tenex), or platelet-rich plasma or autologous blood injections.

### **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the evaluation of rotator cuff tears.

**Variant 3: Atraumatic shoulder pain. Suspect labral tear and instability. Initial radiographs normal or inconclusive. Next imaging study.**

### **Radiography Shoulder Additional Views**

Standard radiographs including AP internal rotation, AP external rotation, scapular “Y” views, and axillary views are often the initial radiographs obtained. Additional Stryker notch and West Point views help to evaluate for the presence of a Hill-Sachs lesion or Bankart fracture, respectively [2,37].

### **X-ray Arthrography Shoulder**

Arthrography is not routinely used in the evaluation of labral tear and instability.

### **CT Shoulder**

In patients with repeated dislocations or chronic instability, CT is an invaluable tool in appropriate preoperative planning. CT is often preferable to MRI when evaluating for small fracture fragments of the glenoid rim and assessing bone stock in patients with recurrent dislocation [38-41]. Surgeons will often plan surgical technique (open versus arthroscopic) based on the severity of the osseous glenoid defect [37,42]. After conventional CT examination has been performed, 2-D reformations and 3-D reconstructions can be created. These images can be used to quantify osseous defect width and glenoid surface area [37,43,44]. IV contrast-enhanced CT examinations are not usually utilized when evaluating for labral tears and instability.

### **CT Arthrography Shoulder**

CT arthrography can be used when there is an absolute or relative contraindication to MRI or MR arthrogram, such as an MR-incompatible implanted medical device, claustrophobia, or obesity [21]. With the introduction of high-resolution multidetector CT technology, CT examinations are being used for a growing number of indications [21,45]. CT arthrograms have been shown to be an accurate modality in the assessment of instability in its depiction of osseous, cartilaginous, and labroligamentous injuries [21,45]. Although CT arthrography aids in the evaluation of underlying soft tissues, the injected contrast may limit evaluation of the underlying osseous structures and cortical fragments as the injected contrast solution often has similar attenuation to cortical bone [37]. Other limitations include the need for an invasive arthrography procedure, ionizing radiation with close proximity to the thyroid and breast, poor assessment of bone marrow edema, and extra-articular structures, including the subacromial or subdeltoid bursa and bursal surface of the rotator cuff [45].

### **MRI Shoulder**

Conventional MRI has shown sensitivities and specificities ranging from 44% to 100% and 66% to 95% in diagnosing labral tears [40,46,47]. The MR arthrogram adds value to conventional shoulder MRI, including 3T MRI in diagnosing labral tears [48]. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for labral tears and instability.

### **MR Arthrography Shoulder**

MR arthrography is highly effective in the detection of labroligamentous lesions with sensitivities ranging from 88% to 96% [27,49-51] and specificities ranging from 86% to 96% [40,50,51]. Provocative positioning maneuvers, including abduction external rotation, are important in improving detection of nondisplaced anteroinferior labral tears [52-54] and have been shown to be helpful in the evaluation of multidirectional instability [55]. Flexion-adduction internal rotation may improve assessment of the posterior labrum and capsule [52].

### **US Shoulder**

In certain cases of dynamic instability, US may provide useful dynamic information as to a potential etiology, provided there is acoustic access [52]. It is of limited value in assessing the labroligamentous complex, articular surfaces, or subchondral bone.



## **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the evaluation of labral tears and instability.

**Variant 4: Atraumatic shoulder pain. Suspect bursitis. Initial radiographs normal or inconclusive. Next imaging study.**

### **Radiography Shoulder**

The subacromial or subdeltoid bursa is a soft-tissue potential space and is not directly visualized on radiographs. There is a peribursal fat plane between the rotator cuff tendons and the deltoid muscle. Partial or complete obliteration of the peribursal fat stripe is not a specific indicator of shoulder pathology [56,57] and may be seen in normal subjects [57]. The subacromial or subdeltoid bursa can be seen on radiographs when involved by calcific bursitis, usually secondary to hydroxyapatite crystal deposition [56,58] or sometimes when distended, such as may be seen with rotator cuff tear, inflammatory arthritis, crystal deposition disease, or septic bursitis [56].

### **X-ray Arthrography Shoulder**

Arthrography is not routinely used in the evaluation of suspected subacromial/subdeltoid bursitis.

### **MRI Shoulder**

Although MRI is excellent for evaluation of soft-tissue structures and nicely depicts the bursae around the shoulder, it is not usually ordered as a first-line modality in the patient with suspected bursitis after initial radiographs. Fluid accumulation within the subacromial or subdeltoid bursa is often a nonspecific finding and may be seen with rotator cuff tear, inflammatory arthritis, crystal deposition disease or with septic bursitis [56]. MRI with IV contrast is not usually necessary to evaluate for subacromial/subdeltoid bursitis.

### **MR Arthrography Shoulder**

MR arthrography is not routinely used in the evaluation of suspected subacromial/subdeltoid bursitis.

### **CT Shoulder**

CT is not routinely used in the evaluation of suspected subacromial/subdeltoid bursitis.

### **CT Arthrography Shoulder**

CT arthrography is not routinely used in the evaluation of suspected subacromial/subdeltoid bursitis.

### **US Shoulder**

US allows excellent evaluation of the bursae situated about the shoulder. US is the most sensitive method to differentiate fluid from soft tissue and allows directed aspiration of localized fluid collections. Color flow imaging may provide additional information as to disease activity [59,60].

## **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the evaluation of suspected subacromial/subdeltoid bursitis.

**Variant 5: Atraumatic shoulder pain. Suspect adhesive capsulitis. Initial radiographs normal or inconclusive. Next imaging study.**

### **Radiography Shoulder**

Although radiographs are often negative in adhesive capsulitis, there can be associated focal osteopenia of the humeral head and neck [61]. The main function of radiographs in the setting of suspected adhesive capsulitis is to exclude other conditions such as osteoarthritis and calcific tendinitis.

### **X-ray Arthrography Shoulder**

After injection of intra-articular contrast, conventional arthrography will demonstrate a decrease in joint capacity, obliteration of the axillary recess, and variable filling of the biceps tendon sheath [62,63].

### **CT Shoulder**

CT is not routinely used in the evaluation of suspected adhesive capsulitis.

### **CT Arthrography Shoulder**

CT arthrography is not routinely used in the evaluation of suspected adhesive capsulitis.

### **MRI Shoulder**

There are discrepant results reported in the literature regarding MRI and MR arthrogram findings related to adhesive capsulitis. Zhao et al [64] showed that thickening of the coracohumeral ligament and the capsule and complete obliteration of the subcoracoid fat triangle are the most characteristic findings of adhesive capsulitis on

standard MRI. Emig et al [65] found that there was no significant difference in the thickness of the coracohumeral ligament between patients with adhesive capsulitis and asymptomatic volunteers on standard MRI. They also found that the rotator interval was not useful for assessing changes of adhesive capsulitis. In the same study, thickening of the capsule and synovium was characteristic of adhesive capsulitis (specificity 95%, sensitivity 70%). As inflammation plays a role in adhesive capsulitis, dynamic MRI with intravenous gadolinium has been shown to enhance the synovium. Tamai et al [66] demonstrated a greater increase of signal intensity in the glenohumeral joint synovium in subjects with frozen shoulder compared to healthy volunteers or patients with subacromial impingement syndrome. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for adhesive capsulitis.

### **MR Arthrography Shoulder**

Manton et al [67] showed in 28 patients no significant difference in the capsular and synovial thickness on MR arthrography between symptomatic and asymptomatic groups. Alternatively, Mengiardi et al [68] reported that thickening of the coracohumeral ligament (specificity of 95%, sensitivity of 59%), thickening of the joint capsule (specificity 86%, sensitivity 64%) and obliteration of the subcoracoid triangle (specificity 100%, sensitivity 32%) are characteristic MR arthrographic findings in frozen shoulder.

### **US Shoulder**

US in this setting is to exclude rotator cuff tear (due to US high negative predictive value) and to provide guidance for therapeutic injection. Peribursal thickening and thickening of the coracohumeral ligament can be seen in the setting of adhesive capsulitis and suggest the diagnosis.

**Variant 6: Atraumatic shoulder pain. Suspect biceps tendinitis, biceps dislocation, or biceps tear. Initial radiographs normal or inconclusive. Next imaging study.**

### **X-ray Arthrography Shoulder**

Arthrography is not routinely used in the evaluation of biceps tendinitis, dislocation or tear.

### **CT Shoulder**

In a study with a small number of subjects, pooled sensitivity and specificity for proximal biceps lesions including degeneration, tendon luxation, and partial and complete tear using CT were shown to be 31% and 95%, respectively [69]. In addition, some studies have shown that certain morphological features of the lesser tuberosity and the intertubercular groove are associated with biceps tendon pathology [70,71]. These may be demonstrated on CT. IV contrast-enhanced CT examinations are not usually utilized when evaluating for biceps tendon pathology.

### **CT Arthrography Shoulder**

CT arthrography is not routinely used in the evaluation of biceps tendinitis, dislocation, or tear.

### **MRI Shoulder**

Standard noncontrast MRI is limited in detecting bicep abnormalities including tendinosis and partial or complete ruptures of the long head of the biceps. Studies have shown MRI to both under- and overdiagnose intra-articular biceps pathology [72-74], with sensitivities and specificities of 27.7% and 84.2% (partial) and 56.3% and 98% (full thickness), respectively [73]. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for biceps tendon pathology.

### **MR Arthrography Shoulder**

MR arthrography has been shown to improve the accuracy of MRI in the detection of long head of the bicep tears. MR arthrogram appears to be sensitive and moderately specific in the diagnosis of long head of the biceps tendon disorders with sensitivity of 92% and specificity of 56% [75]. Imaging findings assessed in both the axial and parasagittal planes appear to increase the accuracy in diagnosis [75]. These findings include visibility of the biceps tendon, caliber changes, contour irregularities, and signal abnormalities.

### **US Shoulder**

Apart from the biceps anchor, the intra-articular and extra-articular portions of the biceps tendon are well seen on routine US imaging. Tendinosis, tears and rupture, tenosynovitis, subluxation, and frank dislocation are readily assessed. Provocative maneuvers may be helpful while observing in real time to assess the degree of subluxation. US guidance is the method of choice in performing image-guided tendon sheath injection.

## **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the evaluation of suspected biceps tendinitis, dislocation, or tear.

### **Variant 7: Pain after rotator cuff repair. Initial radiographs normal or inconclusive. Next imaging study.**

#### **Radiography Shoulder**

Radiography is often used as an initial imaging modality in the postoperative shoulder. Standard radiographic series with the addition of axillary views may be helpful in postoperative rotator cuff patients to evaluate alignment [76]. In addition, if further imaging by MRI or CT is being considered, radiographs can help guide clinicians in choosing the appropriate modality based on the types of indwelling hardware and their associated artifact [76].

#### **X-ray Arthrography Shoulder**

Arthrography is not routinely used in the evaluation of pain after rotator cuff repair.

#### **MRI Shoulder**

As with preoperative imaging of the rotator cuff, MRI is an excellent imaging modality in the evaluation of the postoperative rotator cuff. If there is metallic hardware within the shoulder, there are several MRI optimizing techniques that can be implemented to decrease associated metallic artifact [77,78]. Of note, fluid or contrast within the subacromial or subdeltoid bursa on routine and MR arthrogram examinations can be a nonspecific finding that can be seen with a functional nonwatertight repair, a recurrent tear in the rotator cuff, or an otherwise normal postoperative rotator cuff [79-81]. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for pain after rotator cuff repair.

#### **MR Arthrography Shoulder**

As with preoperative imaging of the rotator cuff, MR arthrography is an excellent imaging modality in the evaluation of the postoperative rotator cuff. If there is metallic hardware within the shoulder, there are several MRI optimizing techniques that can be implemented to decrease associated metallic artifact [77,78]. Of note, fluid or contrast within the subacromial or subdeltoid bursa on routine and MR arthrogram examinations can be a nonspecific finding that can be seen with a functional nonwatertight repair, a recurrent tear in the rotator cuff, or an otherwise normal postoperative rotator cuff [79-81].

#### **CT Shoulder**

CT is not routinely used in the evaluation of pain after rotator cuff repair.

#### **CT Arthrography Shoulder**

CT arthrography can be used in postoperative rotator cuff evaluation as an alternative to US, MRI, or MR arthrogram.

#### **US Shoulder**

An advantage of US evaluation of the postoperative shoulder is the absence of metal-induced artifact when examining the rotator cuff and adjacent soft tissues. The presence of soft-tissue inflammation and fluid collections is therefore readily assessed and often amenable to US-guided intervention. US evaluation of the postoperative rotator cuff can be challenging. It has been documented that the postoperative rotator cuff can show altered morphology for years following the repair, which can manifest as loss of fibrillar architecture and abnormal echogenicity on US. Compounding this situation, 20% to 50% of repairs may show discrete defects that may persist for years with some potential for healing, albeit slowly [82,83]. Given these limitations, US still provides an excellent method to assess repair integrity, as well as potential complications following surgery and during rehabilitation. The ability to perform provocative maneuvers can further demonstrate abnormalities that other forms of imaging would be incapable of performing.

## **Nuclear Medicine**

Nuclear medicine studies are not routinely used in the evaluation of pain after rotator cuff repair.

### **Variant 8: Atraumatic shoulder pain. Neurogenic pain (excluding plexopathy). Initial imaging.**

Neuropathic pain is caused by disease or damage affecting the somatosensory nervous system [84]. Atraumatic neuropathic pain in the shoulder often involves the suprascapular and/or axillary nerves. Common causes of suprascapular neuropathy include compression, traction injury, and inflammation [85].

### **Radiography Shoulder**

Although radiographs are generally not helpful in the assessment of neurogenic pain, radiographs can be used to exclude other shoulder pain etiologies. In addition to excluding other causes of shoulder pain, radiographs can evaluate for fracture, osseous dysplasia, bone tumors, and variants of the suprascapular notch that can cause suprascapular neuropathies [86].

### **X-ray Arthrography Shoulder**

Arthrography is not routinely used in the initial evaluation of neurogenic pain.

### **CT Shoulder**

Although CT is of limited value in the evaluation of the majority of patients with suprascapular neuropathy, it is the study of choice in identifying an ossified transverse scapular ligament and in characterizing fractures [86]. IV contrast-enhanced CT examinations are not usually utilized when evaluating for neurogenic pain.

### **CT Arthrography Shoulder**

CT arthrography is not routinely used in the initial evaluation of neurogenic pain.

### **MRI Shoulder**

MRI allows for direct anatomic visualization of the nerve, compressive etiologies by a space-occupying lesion and is considered superior in delineating the associated indirect signs of muscle denervation [87-89]. MR neurography has been increasingly used to further evaluate suprascapular neuropathies [85,90]. MR neurography can determine site and extent of injury by demonstrating imaging characteristics of pathologic nerves, including alterations in caliber, contour, continuity, and signal intensity [85,91]. IV contrast-enhanced MRI examinations are not usually utilized when evaluating for neurogenic pain.

### **MR Arthrography Shoulder**

MR arthrography is not routinely used in the initial evaluation of neurogenic pain.

### **US Shoulder**

Paralabral cysts that extend to the spinoglenoid notch, suprascapular notch, and quadrilateral space can be identified by US. Based on loss in muscle bulk and increased echogenicity due to replacement by fat, US can also evaluate associated loss of muscle bulk. Paralabral or ganglion cyst aspiration under US guidance can be attempted [92,93]. The suprascapular nerve may occasionally be visualized on US in the spinoglenoid notch adjacent to the suprascapular artery [94].

### **Bone Scan**

Bone scintigraphic abnormalities may be seen in patients with complex regional pain syndrome (CRPS), formerly known as reflex sympathetic dystrophy [95-97]. Meta-analyses have found only moderate concordance between bone scintigraphy and the presence or absence of CRPS [98], and low sensitivity for detection of CRPS when compared to clinical diagnostic criteria [99-101]. Bone scintigraphic does have high specificity, and can be used to rule out CRPS [101].

### **Summary of Recommendations**

- **Variation 1:** Radiographs of the shoulder are the most appropriate initial imaging study.
- **Variation 2:** Either MRI without IV contrast or US should be performed when rotator cuff abnormalities are suspected and initial radiographs are normal or inconclusive.
- **Variation 3:** Either MR arthrography or MRI shoulder without IV contrast should be performed when instability and labral tear are suspected and initial radiographs are normal or inconclusive.
- **Variation 4:** Either MRI without IV contrast or US should be performed when bursitis is suspected and initial radiographs are normal or inconclusive.
- **Variation 5:** MRI shoulder without IV contrast should be performed when adhesive capsulitis is suspected and initial radiographs are normal or inconclusive.
- **Variation 6:** Either MRI shoulder without IV contrast or US should be performed when a biceps tendon abnormality is suspected and initial radiographs are normal or inconclusive.
- **Variation 7:** Either MR arthrogram, MRI of the shoulder without IV contrast, or US, should be performed in the setting of shoulder pain after rotator cuff repair when initial radiographs are normal or inconclusive.

- **Variation 8:** MRI shoulder without IV contrast should be performed in the setting of neurogenic shoulder pain (excluding plexopathy).

**Summary of Evidence**

Of the 102 references cited in the *ACR Appropriateness Criteria® Shoulder Pain-Atraumatic* document, 11 are categorized as therapeutic references including 1 well-designed study, 6 good-quality studies, and 1 quality study that may have design limitations. Additionally, 87 references are categorized as diagnostic references including 15 good-quality studies, and 25 quality studies that may have design limitations. There are 50 references that may not be useful as primary evidence. There are 4 references that are meta-analysis studies.

The 102 references cited in the *ACR Appropriateness Criteria® Shoulder Pain-Atraumatic* document were published from 1961 to 2017.

Although there are references that report on studies with design limitations, 22 well-designed or good-quality studies provide good evidence.

**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, 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 [102].

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”.

### Supporting Documents

For additional information on the Appropriateness Criteria methodology and other supporting documents go to [www.acr.org/ac](http://www.acr.org/ac).

### References

1. Department of Research & Scientific Affairs, American Academy of Orthopaedic Surgeons. Physician Visits for Musculoskeletal Symptoms and Complaints. Available at: <http://www.aaos.org/research/stats/patientstats.asp>. Accessed March 30, 2018.
2. Goud A, Segal D, Hedayati P, Pan JJ, Weissman BN. Radiographic evaluation of the shoulder. *Eur J Radiol* 2008;68:2-15.
3. Pavlov H, Warren RF, Weiss CB, Jr., Dines DM. The roentgenographic evaluation of anterior shoulder instability. *Clin Orthop Relat Res* 1985:153-8.
4. Silfverskiold JP, Strahley DJ, Jones WW. Roentgenographic evaluation of suspected shoulder dislocation: a prospective study comparing the axillary view and the scapular 'Y' view. *Orthopedics* 1990;13:63-9.
5. Iannotti JP, Zlatkin MB, Esterhai JL, Kressel HY, Dalinka MK, Spindler KP. Magnetic resonance imaging of the shoulder. Sensitivity, specificity, and predictive value. *J Bone Joint Surg Am* 1991;73:17-29.
6. de Jesus JO, Parker L, Frangos AJ, Nazarian LN. Accuracy of MRI, MR arthrography, and ultrasound in the diagnosis of rotator cuff tears: a meta-analysis. *AJR Am J Roentgenol* 2009;192:1701-7.
7. Miller J, Miller T, Adler R. Sensitivity of Imaging Modalities for Detecting Calcium Hydroxyapatite in a Soft Tissue Phantom. Radiological Society of North America 2009 Scientific Assembly and Annual Meeting, November 29 - December 4, 2009, Chicago IL. Available at: <http://archive.rsna.org/2009/8007524.html>. Accessed May 23, 2017.
8. De Smet AA. Anterior oblique projection in radiography of the traumatized shoulder. *AJR Am J Roentgenol* 1980;134:515-8.
9. De Smet AA. Axillary projection in radiography of the nontraumatized shoulder. *AJR Am J Roentgenol* 1980;134:511-4.
10. Kilcoyne RF, Reddy PK, Lyons F, Rockwood CA, Jr. Optimal plain film imaging of the shoulder impingement syndrome. *AJR Am J Roentgenol* 1989;153:795-7.
11. Mayerhoefer ME, Breitenhofer MJ, Roposch A, Treitl C, Wurnig C. Comparison of MRI and conventional radiography for assessment of acromial shape. *AJR Am J Roentgenol* 2005;184:671-5.
12. Depalma AF, Kruper JS. Long-term study of shoulder joints afflicted with and treated for calcific tendinitis. *Clin Orthop* 1961;20:61-72.
13. Siegal DS, Wu JS, Newman JS, Del Cura JL, Hochman MG. Calcific tendinitis: a pictorial review. *Can Assoc Radiol J* 2009;60:263-72.

14. Studler U, Pfirrmann CW, Jost B, Rousson V, Hodler J, Zanetti M. Abnormalities of the lesser tuberosity on radiography and MRI: association with subscapularis tendon lesions. *AJR Am J Roentgenol* 2008;191:100-6.
15. Steinbach LS. MR Imaging of the Rotator Cuff. In: Chung CB, Steinbach LS, eds. *MRI of the Upper Extremity : Shoulder, Elbow, Wrist and Hand*. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2010:244.
16. Chung CB, Gentili A, Chew FS. Calcific tendinosis and periarthritits: classic magnetic resonance imaging appearance and associated findings. *J Comput Assist Tomogr* 2004;28:390-6.
17. Farin PU. Consistency of rotator-cuff calcifications. Observations on plain radiography, sonography, computed tomography, and at needle treatment. *Invest Radiol* 1996;31:300-4.
18. Charoussat C, Bellaiche L, Duranthon LD, Grimberg J. Accuracy of CT arthrography in the assessment of tears of the rotator cuff. *J Bone Joint Surg Br* 2005;87:824-8.
19. Oh JH, Kim JY, Choi JA, Kim WS. Effectiveness of multidetector computed tomography arthrography for the diagnosis of shoulder pathology: comparison with magnetic resonance imaging with arthroscopic correlation. *J Shoulder Elbow Surg* 2010;19:14-20.
20. Omoumi P, Bafort AC, Dubuc JE, Malghem J, Vande Berg BC, Lecouvet FE. Evaluation of rotator cuff tendon tears: comparison of multidetector CT arthrography and 1.5-T MR arthrography. *Radiology* 2012;264:812-22.
21. Lecouvet FE, Simoni P, Koutaissoff S, Vande Berg BC, Malghem J, Dubuc JE. Multidetector spiral CT arthrography of the shoulder. Clinical applications and limits, with MR arthrography and arthroscopic correlations. *Eur J Radiol* 2008;68:120-36.
22. Waldt S, Bruegel M, Mueller D, et al. Rotator cuff tears: assessment with MR arthrography in 275 patients with arthroscopic correlation. *Eur Radiol* 2007;17:491-8.
23. Zlatkin MB, Iannotti JP, Roberts MC, et al. Rotator cuff tears: diagnostic performance of MR imaging. *Radiology* 1989;172:223-9.
24. Kneeland JB, Middleton WD, Carrera GF, et al. MR imaging of the shoulder: diagnosis of rotator cuff tears. *AJR Am J Roentgenol* 1987;149:333-7.
25. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K. Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. *J Bone Joint Surg Am* 2004;86-A:708-16.
26. American College of Radiology. ACR Appropriateness Criteria<sup>®</sup>: Shoulder Pain–Traumatic. Available at: <https://acsearch.acr.org/docs/69433/Narrative/>. Accessed March 30, 2018.
27. Chandnani VP, Yeager TD, DeBerardino T, et al. Glenoid labral tears: prospective evaluation with MRI imaging, MR arthrography, and CT arthrography. *AJR Am J Roentgenol* 1993;161:1229-35.
28. Hodler J, Kursunoglu-Brahme S, Snyder SJ, et al. Rotator cuff disease: assessment with MR arthrography versus standard MR imaging in 36 patients with arthroscopic confirmation. *Radiology* 1992;182:431-6.
29. Flemming DJ, Murphey MD, Shekitka KM, Temple HT, Jelinek JJ, Kransdorf MJ. Osseous involvement in calcific tendinitis: a retrospective review of 50 cases. *AJR Am J Roentgenol* 2003;181:965-72.
30. Magee T. 3-T MRI of the shoulder: is MR arthrography necessary? *AJR Am J Roentgenol* 2009;192:86-92.
31. Lee SY, Lee JK. Horizontal component of partial-thickness tears of rotator cuff: imaging characteristics and comparison of ABER view with oblique coronal view at MR arthrography initial results. *Radiology* 2002;224:470-6.
32. Roger B, Skaf A, Hooper AW, Lektrakul N, Yeh L, Resnick D. Imaging findings in the dominant shoulder of throwing athletes: comparison of radiography, arthrography, CT arthrography, and MR arthrography with arthroscopic correlation. *AJR Am J Roentgenol* 1999;172:1371-80.
33. Nazarian LN, Jacobson JA, Benson CB, et al. Imaging algorithms for evaluating suspected rotator cuff disease: Society of Radiologists in Ultrasound consensus conference statement. *Radiology* 2013;267:589-95.
34. Vlychou M, Dailiana Z, Fotiadou A, Papanagiotou M, Fezoulidis IV, Malizos K. Symptomatic partial rotator cuff tears: diagnostic performance of ultrasound and magnetic resonance imaging with surgical correlation. *Acta Radiol* 2009;50:101-5.
35. De Zordo T, Ahmad N, Odegaard F, et al. US-guided therapy of calcific tendinopathy: clinical and radiological outcome assessment in shoulder and non-shoulder tendons. *Ultraschall Med* 2011;32 Suppl 1:S117-23.

36. Yoo JC, Koh KH, Park WH, Park JC, Kim SM, Yoon YC. The outcome of ultrasound-guided needle decompression and steroid injection in calcific tendinitis. *J Shoulder Elbow Surg* 2010;19:596-600.
37. Bencardino JT, Gyftopoulos S, Palmer WE. Imaging in anterior glenohumeral instability. *Radiology* 2013;269:323-37.
38. Bergin D. Imaging shoulder instability in the athlete. *Magn Reson Imaging Clin N Am* 2009;17:595-615, v.
39. Huijsmans PE, de Witte PB, de Villiers RV, et al. Recurrent anterior shoulder instability: accuracy of estimations of glenoid bone loss with computed tomography is insufficient for therapeutic decision-making. *Skeletal Radiol* 2011;40:1329-34.
40. Macmahon PJ, Palmer WE. Magnetic resonance imaging in glenohumeral instability. *Magn Reson Imaging Clin N Am* 2012;20:295-312, xi.
41. Stevens KJ, Preston BJ, Wallace WA, Kerslake RW. CT imaging and three-dimensional reconstructions of shoulders with anterior glenohumeral instability. *Clin Anat* 1999;12:326-36.
42. Dumont GD, Russell RD, Robertson WJ. Anterior shoulder instability: a review of pathoanatomy, diagnosis and treatment. *Curr Rev Musculoskelet Med* 2011;4:200-7.
43. Saito H, Itoi E, Sugaya H, Minagawa H, Yamamoto N, Tuoheti Y. Location of the glenoid defect in shoulders with recurrent anterior dislocation. *Am J Sports Med* 2005;33:889-93.
44. Sugaya H, Moriishi J, Dohi M, Kon Y, Tsuchiya A. Glenoid rim morphology in recurrent anterior glenohumeral instability. *J Bone Joint Surg Am* 2003;85-A:878-84.
45. Acid S, Le Corroller T, Aswad R, Pauly V, Champsaur P. Preoperative imaging of anterior shoulder instability: diagnostic effectiveness of MDCT arthrography and comparison with MR arthrography and arthroscopy. *AJR Am J Roentgenol* 2012;198:661-7.
46. Magee T, Williams D, Mani N. Shoulder MR arthrography: which patient group benefits most? *AJR Am J Roentgenol* 2004;183:969-74.
47. Tuite MJ, De Smet AA, Norris MA, Orwin JF. MR diagnosis of labral tears of the shoulder: value of T2\*-weighted gradient-recalled echo images made in external rotation. *AJR Am J Roentgenol* 1995;164:941-4.
48. Major NM, Browne J, Domzalski T, Cothran RL, Helms CA. Evaluation of the glenoid labrum with 3-T MRI: is intraarticular contrast necessary? *AJR Am J Roentgenol* 2011;196:1139-44.
49. Palmer WE, Brown JH, Rosenthal DI. Labral-ligamentous complex of the shoulder: evaluation with MR arthrography. *Radiology* 1994;190:645-51.
50. Palmer WE, Caslowitz PL. Anterior shoulder instability: diagnostic criteria determined from prospective analysis of 121 MR arthrograms. *Radiology* 1995;197:819-25.
51. Waldt S, Burkart A, Imhoff AB, Bruegel M, Rummeny EJ, Woertler K. Anterior shoulder instability: accuracy of MR arthrography in the classification of anteroinferior labroligamentous injuries. *Radiology* 2005;237:578-83.
52. Beltran LS, Adler R, Stone T, Surace J, Beltran J, Bencardino JT. MRI and Ultrasound Imaging of the Shoulder Using Positional Maneuvers. *AJR Am J Roentgenol* 2015;205:W244-54.
53. Cvitanic O, Tirman PF, Feller JF, Bost FW, Minter J, Carroll KW. Using abduction and external rotation of the shoulder to increase the sensitivity of MR arthrography in revealing tears of the anterior glenoid labrum. *AJR Am J Roentgenol* 1997;169:837-44.
54. Tirman PF, Bost FW, Steinbach LS, et al. MR arthrographic depiction of tears of the rotator cuff: benefit of abduction and external rotation of the arm. *Radiology* 1994;192:851-6.
55. Schaeffeler C, Waldt S, Bauer JS, et al. MR arthrography including abduction and external rotation images in the assessment of atraumatic multidirectional instability of the shoulder. *Eur Radiol* 2014;24:1376-85.
56. Bureau NJ, Dussault RG, Keats TE. Imaging of bursae around the shoulder joint. *Skeletal Radiol* 1996;25:513-7.
57. Kaplan PA, Bryans KC, Davick JP, Otte M, Stinson WW, Dussault RG. MR imaging of the normal shoulder: variants and pitfalls. *Radiology* 1992;184:519-24.
58. Resnick D. Hydroxyapatite Crystal Deposition Disease. In: Resnick D, ed. *Diagnosis of bone and joint disorders*. 3rd ed. Philadelphia: Saunders; 1995:1615-48.
59. Bredahl WH, Newman JS, Taljanovic MS, Adler RS. Power Doppler sonography in the assessment of musculoskeletal fluid collections. *AJR Am J Roentgenol* 1996;166:1443-6.



60. Sofka CM, Collins AJ, Adler RS. Use of ultrasonographic guidance in interventional musculoskeletal procedures: a review from a single institution. *J Ultrasound Med* 2001;20:21-6.
61. Binder AI, Bulgen DY, Hazleman BL, Tudor J, Wraight P. Frozen shoulder: an arthrographic and radionuclear scan assessment. *Ann Rheum Dis* 1984;43:365-9.
62. Ekelund AL, Rydell N. Combination treatment for adhesive capsulitis of the shoulder. *Clin Orthop Relat Res* 1992:105-9.
63. Neviaser TJ. Arthrography of the shoulder. *Orthop Clin North Am* 1980;11:205-17.
64. Zhao W, Zheng X, Liu Y, et al. An MRI study of symptomatic adhesive capsulitis. *PLoS One* 2012;7:e47277.
65. Emig EW, Schweitzer ME, Karasick D, Lubowitz J. Adhesive capsulitis of the shoulder: MR diagnosis. *AJR Am J Roentgenol* 1995;164:1457-9.
66. Tamai K, Yamato M. Abnormal synovium in the frozen shoulder: a preliminary report with dynamic magnetic resonance imaging. *J Shoulder Elbow Surg* 1997;6:534-43.
67. Manton GL, Schweitzer ME, Weishaupt D, Karasick D. Utility of MR arthrography in the diagnosis of adhesive capsulitis. *Skeletal Radiol* 2001;30:326-30.
68. Mengiardi B, Pfirrmann CW, Gerber C, Hodler J, Zanetti M. Frozen shoulder: MR arthrographic findings. *Radiology* 2004;233:486-92.
69. De Maeseneer M, Boulet C, Pouliart N, et al. Assessment of the long head of the biceps tendon of the shoulder with 3T magnetic resonance arthrography and CT arthrography. *Eur J Radiol* 2012;81:934-9.
70. Chan TW, Dalinka MK, Kneeland JB, Chervrot A. Biceps tendon dislocation: evaluation with MR imaging. *Radiology* 1991;179:649-52.
71. Pfahler M, Branner S, Refior HJ. The role of the bicipital groove in tendopathy of the long biceps tendon. *J Shoulder Elbow Surg* 1999;8:419-24.
72. Beall DP, Williamson EE, Ly JQ, et al. Association of biceps tendon tears with rotator cuff abnormalities: degree of correlation with tears of the anterior and superior portions of the rotator cuff. *AJR Am J Roentgenol* 2003;180:633-9.
73. Dubrow SA, Streit JJ, Shishani Y, Robbin MR, Gobezie R. Diagnostic accuracy in detecting tears in the proximal biceps tendon using standard nonenhancing shoulder MRI. *Open Access J Sports Med* 2014;5:81-7.
74. Mohtadi NG, Vellet AD, Clark ML, et al. A prospective, double-blind comparison of magnetic resonance imaging and arthroscopy in the evaluation of patients presenting with shoulder pain. *J Shoulder Elbow Surg* 2004;13:258-65.
75. Zanetti M, Weishaupt D, Gerber C, Hodler J. Tendinopathy and rupture of the tendon of the long head of the biceps brachii muscle: evaluation with MR arthrography. *AJR Am J Roentgenol* 1998;170:1557-61.
76. Woertler K. Multimodality imaging of the postoperative shoulder. *Eur Radiol* 2007;17:3038-55.
77. Bancroft LW, Wasyliw C, Pettis C, Farley T. Postoperative shoulder magnetic resonance imaging. *Magn Reson Imaging Clin N Am* 2012;20:313-25, xi.
78. Kanal E, Barkovich AJ, Bell C, et al. ACR guidance document on MR safe practices: 2013. *J Magn Reson Imaging* 2013;37:501-30.
79. Mohana-Borges AV, Chung CB, Resnick D. MR imaging and MR arthrography of the postoperative shoulder: spectrum of normal and abnormal findings. *Radiographics* 2004;24:69-85.
80. Spielmann AL, Forster BB, Kokan P, Hawkins RH, Janzen DL. Shoulder after rotator cuff repair: MR imaging findings in asymptomatic individuals--initial experience. *Radiology* 1999;213:705-8.
81. Tudisco C, Bisicchia S, Savarese E, et al. Single-row vs. double-row arthroscopic rotator cuff repair: clinical and 3 Tesla MR arthrography results. *BMC Musculoskelet Disord* 2013;14:43.
82. Gulotta LV, Nho SJ, Dodson CC, Adler RS, Altchek DW, MacGillivray JD. Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: part I--functional outcomes and radiographic healing rates. *J Shoulder Elbow Surg* 2011;20:934-40.
83. Gulotta LV, Nho SJ, Dodson CC, Adler RS, Altchek DW, MacGillivray JD. Prospective evaluation of arthroscopic rotator cuff repairs at 5 years: part II--prognostic factors for clinical and radiographic outcomes. *J Shoulder Elbow Surg* 2011;20:941-6.
84. IASP Task Force on Taxonomy. IASP Taxonomy. Available at: <http://www.iasp-pain.org/Education/Content.aspx?ItemNumber=1698>. Accessed March 30, 2018.

85. Ahlawat S, Wadhwa V, Belzberg AJ, Batra K, Chhabra A. Spectrum of suprascapular nerve lesions: normal and abnormal neuromuscular imaging appearances on 3-T MR neurography. *AJR Am J Roentgenol* 2015;204:589-601.
86. Boykin RE, Friedman DJ, Higgins LD, Warner JJ. Suprascapular neuropathy. *J Bone Joint Surg Am* 2010;92:2348-64.
87. Bredella MA, Tirman PF, Fritz RC, Wischer TK, Stork A, Genant HK. Denervation syndromes of the shoulder girdle: MR imaging with electrophysiologic correlation. *Skeletal Radiol* 1999;28:567-72.
88. Dong Q, Jacobson JA, Jamadar DA, et al. Entrapment neuropathies in the upper and lower limbs: anatomy and MRI features. *Radiol Res Pract* 2012;2012:230679.
89. Kim SJ, Hong SH, Jun WS, et al. MR imaging mapping of skeletal muscle denervation in entrapment and compressive neuropathies. *Radiographics* 2011;31:319-32.
90. Chalian M, Faridian-Aragh N, Soldatos T, et al. High-resolution 3T MR neurography of suprascapular neuropathy. *Acad Radiol* 2011;18:1049-59.
91. Chhabra A, Andreisek G, Soldatos T, et al. MR neurography: past, present, and future. *AJR Am J Roentgenol* 2011;197:583-91.
92. Chiou HJ, Chou YH, Wu JJ, et al. Alternative and effective treatment of shoulder ganglion cyst: ultrasonographically guided aspiration. *J Ultrasound Med* 1999;18:531-5.
93. Hashimoto BE, Hayes AS, Ager JD. Sonographic diagnosis and treatment of ganglion cysts causing suprascapular nerve entrapment. *J Ultrasound Med* 1994;13:671-4.
94. Martinoli C, Bianchi S, Prato N, et al. US of the shoulder: non-rotator cuff disorders. *Radiographics* 2003;23:381-401; quiz 534.
95. Greyson ND, Tepperman PS. Three-phase bone studies in hemiplegia with reflex sympathetic dystrophy and the effect of disuse. *J Nucl Med* 1984;25:423-9.
96. Kline SC, Holder LE. Segmental reflex sympathetic dystrophy: clinical and scintigraphic criteria. *J Hand Surg Am* 1993;18:853-9.
97. Park SA, Yang CY, Kim CG, Shin YI, Oh GJ, Lee M. Patterns of three-phase bone scintigraphy according to the time course of complex regional pain syndrome type I after a stroke or traumatic brain injury. *Clin Nucl Med* 2009;34:773-6.
98. Ringer R, Wertli M, Bachmann LM, Buck FM, Brunner F. Concordance of qualitative bone scintigraphy results with presence of clinical complex regional pain syndrome 1: meta-analysis of test accuracy studies. *Eur J Pain* 2012;16:1347-56.
99. Schurmann M, Zaspel J, Lohr P, et al. Imaging in early posttraumatic complex regional pain syndrome: a comparison of diagnostic methods. *Clin J Pain* 2007;23:449-57.
100. Lee GW, Weeks PM. The role of bone scintigraphy in diagnosing reflex sympathetic dystrophy. *J Hand Surg Am* 1995;20:458-63.
101. Wertli MM, Brunner F, Steurer J, Held U. Usefulness of bone scintigraphy for the diagnosis of Complex Regional Pain Syndrome 1: A systematic review and Bayesian meta-analysis. *PLoS One* 2017;12:e0173688.
102. 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 March 30, 2018.

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.