CDI QUALITY INSTITUTE

Provider Led Entity

CDI Quality Institute PLE
Shoulder Pain AUC
2021 Update

09/14/2021

Appropriateness of advanced imaging procedures* in patients with shoulder pain and the following clinical presentations:

*Including MRI, MR arthrography, CT, CT arthrography, bone scan, PET, SPECT

Abbreviation list:

AAOS	American Academy of Orthopaedic Surgeons
AC	Acromioclavicular
ACR	American College of Radiology
APTA	American Physical Therapy Association
AUC	Appropriate Use Criteria
CE	Contrast-enhanced
CT	Computed tomography
CTA	Computed tomographic arthrography
GH	Glenohumeral
LR	Likelihood Ratio
MAVRIC	Multiacquisition variable-resonance imaging combination
MRA	Magnetic resonance arthrography
MRI	Magnetic resonance imaging
OA	Osteoarthritis
PET	Positron emission tomography
PLE	Provider Led Entity
SLAP	Superior labrum anterior and posterior
SPECT	Single-photon emission computed tomography
US, U/S	Ultrasound

Appropriate Use Criteria: How to Use this Document

The CDI Quality Institute follows the recommendation framework defined by the Appraisal of Guidelines for Research & Evaluation (AGREE II), AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) and a modified version of the QUADAS-2 (Quality Assessment of Diagnostic Accuracy Studies) to evaluate the strength of recommendations concerning advanced imaging. Considerations used to determine a recommendation are listed below.

Primary recommendation (green): A strong recommendation for initial imaging for this presentation; there is confidence that the desirable effects of imaging outweigh its undesirable effects.

Alternative recommendation (yellow): A conditional recommendation for imaging; the desirable effects of imaging likely outweigh its undesirable effects, although some uncertainty may exist. The individual patient's circumstances, preferences, and values should be considered on a case-by-case basis. This may include: contraindication to the primary recommendation, specific clinical circumstances that require use of the alternative recommendation, or the primary recommendation has results that are inconclusive or incongruent with the patient's clinical diagnosis. Case-by-case indications to consider have been noted in brackets when appropriate.

Recommendation against imaging (red): The undesirable effects of imaging outweigh any desirable effects. Additionally, the recommendation may be impractical or not feasible in the targeted population and/or practice setting(s).

Shoulder pain AUC summary:

- In most instances, **MRI without IV contrast** is the advanced imaging procedure of choice for shoulder pain. It is indicated in the acute setting for suspected full-thickness rotator cuff tears, traumatic dislocations, and occult fractures not identified on initial radiographs.
    - MRI is otherwise generally indicated for patients whose pain and dysfunction persists after four to six weeks of conservative therapy. MRI is useful to detect and direct treatment decisions for rotator cuff tears, labral tears, bicep tendon tears, chondral loss of the glenohumeral joint, and bursitis.
    - The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis.
- **MR arthrography** may increase the sensitivity of MRI for partial-thickness rotator cuff tears and labral tears. It is also useful in patients with a history of previous surgery and in patients with indeterminate or nondiagnostic findings on previous MRI.
- **CT arthrography** is generally reserved for patients unable to undergo MRI or for patients who have had prior shoulder arthroplasty surgery.
- **CT without IV contrast** is recommended for characterizing bony Bankart lesions and Hill-Sachs deformities for surgical planning, and to assess glenoid version and posterior glenoid wear in osteoarthritis patients undergoing evaluation for shoulder arthroplasty. It can also be useful to detect occult fractures that are suspected following radiographs.
- **Conventional radiographs** are commonly used for the initial evaluation of a suspected fracture or dislocation, osteoarthritis, or calcific tendinitis.
- **Ultrasound**, while not defined as an advanced imaging modality, can be useful to assess suspected complete biceps tendon tears, full-thickness rotator cuff tears and high-grade partial-thickness rotator cuff tears. Its use should be limited to trained and experienced experts.

Shoulder pain with suspected full-thickness rotator cuff tear in patients who are candidates for early surgical repair:

- Green – **MRI shoulder without IV contrast**
- Yellow – **MR arthrography shoulder**
  [Previous noncontrast MRI findings are indeterminate]
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Yellow – **CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- Red – **MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- Red – **CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- Red – **PET; bone scan; SPECT**

Level of Evidence:

- High level evidence that MRI, MR arthrography, and ultrasound (US) are accurate in the diagnosis of full-thickness rotator cuff tears
- Moderate level evidence that MRI and MR arthrography are accurate for the diagnosis of partial-thickness rotator cuff tears

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can improve the detection and definition of rotator cuff tears (*CO Department of Labor* 2014; Liu et al 2020; *AAOS* 2019; PLE expert panel consensus opinion). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:

Overview:

Conventional radiographs are the preferred initial study following acute shoulder injuries to rule out fractures, avulsions, and dislocation (Amini et al [*ACR*] 2018). Advanced imaging is indicated in patients with suspected full-thickness rotator cuff tears who are candidates for early surgical repair. This includes suspected tears following trauma, a palpable defect at the greater tuberosity following trauma, and/or a new onset of significant weakness on elevation or rotation (i.e., drop arm) (PLE expert panel consensus opinion). While not considered to be an advanced imaging modality, ultrasound can also be useful in the evaluation of rotator cuff tears when utilized by an experienced operator (Bussieres et al 2008; *CO Department of Labor* 2014; Hopman et al 2013; PLE expert panel consensus opinion).

MRI shoulder:

Multiple high quality guidelines note that MRI (without IV contrast) is widely used to provide more definitive visualization of soft tissue structures, and is generally accepted as the gold standard to evaluate for a rotator cuff tear (Bussieres et al 2008; Hopman et al 2013; *CO Department of Labor* 2014; Amini et al [*ACR*] 2018; *AAOS* 2019; strength of recommendation: strong; Hegmann et al [ACOEM]

2016). MRI has been found to be a moderate to strong test for ruling in a full thickness tear over no tear (*AAOS* 2019). Patients with suspected full thickness rotator cuff tear following trauma, a palpable defect at the greater tuberosity following trauma or new significant weakness on elevation or rotation should have early use of MRI (*CO Department of Labor* 2014; PLE expert panel consensus opinion). MRI may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP) (PLE expert panel consensus opinion).

MR arthrography shoulder:
MR arthrography can improve the diagnostic accuracy of a full-thickness rotator cuff tear when initial MRI is inconclusive, but the procedure is invasive (Bussieres et al 2008; Hopman et al 2013; *CO Department of Labor* 2014; *AAOS* 2019; strength of recommendation: strong). It may also be marginally more sensitive and specific than MRI for assessing glenohumeral lesions (*CO Department of Labor* 2014). MR arthrography may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP) (PLE expert panel consensus opinion).

CT arthrography shoulder:
CT arthrography can be useful to evaluate a suspected rotator cuff tear in patients with significant metal artifact, in patients following total shoulder arthroplasty, or with contraindication to MRI (Amini et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion).

CT shoulder:
Routine CT is not recommended for the evaluation of acute or subacute shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence). However, for instances where evaluation and surgical planning of bone abnormality is necessary, a noncontrast CT is generally recommended (Hegmann et al [ACOEM] 2016; *CO Department of Labor* 2014; PLE expert panel consensus opinion).

Ultrasound:
Ultrasound is accurate for full-thickness rotator cuff tears, particularly in patients with severe pain and those who cannot undergo MRI, but it is much less sensitive for partial-thickness tears (Bussieres et al 2008; *CO Department of Labor* 2014; *AAOS* 2019; strength of recommendation: strong; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion). A positive ultrasound test was found to produce a moderate increase in probability of full-thickness tears vs. partial/no tears (pooled positive LR=5.20 (3.20, 8.20) (*AAOS* 2019). A negative test produced a small but important decrease in the probability a patient did not have a full thickness tear, but instead either had a partial tear or no tear (*AAOS* 2019). The accuracy of ultrasound for rotator cuff tears is highly operator-dependent, and the performance of ultrasound may vary significantly depending on local expertise (Bussieres et al 2008; *CO Department of Labor* 2014; Hopman et al 2013). Ultrasound can be used as an option for evaluation of rotator cuff tears in patients following total shoulder arthroplasty (PLE expert panel consensus opinion).

<u>Clinical/imaging notes:</u>

- High-field strength MRI provides better resolution than low-field strength imaging. Low-field strength imaging may be indicated, however, in patients with severe claustrophobia or if a patient cannot fit in the high-field strength scanner (*CO Department of Labor* 2014).
- The specificity of ultrasound for a full-thickness tear is 96%, and a negative US exam does not exclude a full-thickness tear (*CO Department of Labor* 2014).

<u>Evidence update (2012–present):</u>
High Level of Evidence:

Roy et al (2015), in a systematic review, found an equivalent performance of US, MRI, and MR arthrography for the diagnosis of full- or partial-thickness rotator cuff tears (Sn: 0.90 to 0.91; Sp: 0.86 to 0.90) (high level of evidence). In studies with a low risk of bias, MR arthrography had the best likelihood ratio profile (LR+ 16.6, LR- 0.2) followed by MRI (LR+ 8.3, LR-0.1) and ultrasound (LR+ 7.6, LR- 0.3) for the diagnostic accuracy of full-thickness tears. The authors found no difference in diagnostic accuracy or likelihood ratios for full-thickness tear at $\leq$ 1.5T or 3.0T for either MRI or MR arthrography.

Moderate Level of Evidence:
Liu et al (2020), in a network meta-analysis, examined which of three common imaging modalities (MRI, MR arthrography [MRA], ultrasound [US]) is optimal for diagnosing rotator cuff tears. Data were extracted from 144 diagnostic studies (14,212 shoulders). A network meta-analysis was performed using an arm-based model to pool absolute sensitivity and specificity, relative sensitivity and specificity, diagnostic odds ratio, and superiority index for ranking the probability of these techniques (**note* "superiority index" measures the superiority of a diagnostic test compared to others by simultaneously optimizing test assessment measures [e.g., sensitivity, specificity, likelihood ratio, predictive value]*). Results found that, for the detection of full-thickness (FT) tears, partial-thickness (PT) tears, or any tear, MRA had the highest sensitivity, specificity, and superiority index. For the detection of any tear, MRI had better performance than US (sensitivity: 0.84 vs 0.81, specificity: 0.86 vs 0.82, and superiority index: 0.98 vs 0.22, respectively). With regard to FT tears, MRI had a higher sensitivity and superiority index than US (0.91 vs 0.87 and 0.67 vs 0.28, respectively) and a similar specificity (0.88 vs 0.88, respectively). The results for PT tears were similar to the detection of FT tears.

Liu et al (2020), in a meta-analysis, sought to compare the accuracy of MRI with MR arthrography in detection of rotator cuff tears. A total of 12 studies (n = 1032 shoulders) were included. Analysis results showed that MR arthrography has a higher sensitivity and specificity than MRI for the detection of full thickness and partial thickness tears. With advances in technology, however, MRI has shown similar accuracy in detecting moderate to large full thickness tears. The authors caution that MR arthrography is invasive, uses ionizing radiation, and can lead to adverse reactions. Considering for both accuracy and practicality factors, MR arthrography is not required as the initial examination, and MRI is recommended to be a first-choice imaging modality for the detection of rotator cuff tears.

Lenza et al (2013), in a systematic review, concluded that "MRI, MR arthrography and ultrasound (US) have good diagnostic accuracy and any of these tests could equally be used for detection of full-thickness tears in people with shoulder pain for whom surgery is being considered". "MRI and US may have poor sensitivity for detecting partial-thickness rotator cuff tears and the sensitivity of US may be much lower than MRI".

Smith et al (2012a), in a meta-analysis of 2751 shoulders in 2710 patients, reported that MRI had a sensitivity of 0.91 and specificity of 0.97 for full-thickness tears, and a sensitivity of 0.80 and specificity of 0.95 for partial-thickness tears (high level of evidence). Results indicated superior overall diagnostic accuracy for 3.0T imaging compared to 1.5T or $\leq$ 1.0T MRI systems for both full-thickness and partial-thickness tears (LR+ 30 [6.6-139] at 3.0T; 8.6 [2.4-31.2] at 1.5T).

Low Level of Evidence:
Khil et al (2021), in a retrospective study, evaluated the diagnostic performance and reliability of MR arthrography (MRA) in diagnosing subscapularis (SSC) tendon tears in 272 patients with arthroscopic confirmations. A total of 548 shoulder MRAs were evaluated by two musculoskeletal radiologists, and SSC tendon pathologies were classified into three groups: intact tendon (n = 149), partial-thickness tear

(n = 92), or full-thickness tear (n = 31). For full-thickness tears, mean values of sensitivity, specificity, and accuracy of reviewer one/reviewer two were 71.0%/87.1%, 97.3%/98.3%, and 94.4%/95.5%, respectively. For partial-thickness tears, mean values of sensitivity, specificity, and accuracy were 72.8%/73.4%, 78.3%/81.2%, and 76.5%/78.5%, respectively. Intra- and inter-observer reliabilities for both reviewers were good to very good ($k = 0.85/0.93$, $p < 0.001$; $k = 0.74–0.89$, $p < 0.001$). The authors conclude that MRA showed high diagnostic performance for SSC tendon tears, especially full-thickness tears, with good inter- and intra-observer reliabilities.

Malavolta et al (2019), in a systematic review and meta-analysis, sought to determine the diagnostic accuracy of MRI in the detection of subscapularis tendon tears. A total of 14 articles (n = 1858 shoulders with 613 subscapularis tears) were included. For overall subscapularis tears, sensitivity of MRI was 0.68 (95% CI 0.64–0.72) and specificity was 0.90 (95% CI 0.89–0.92). Sensitivity of MRI was 0.93 (95% CI 0.83–0.98) for full-thickness tears and 0.74 (95% CI 0.66–0.82) for partial tears. Specificity of MRI was 0.97 (95% CI 0.94–0.98) for full-thickness tears and 0.88 (95% CI 0.85–0.91) for partial tears. Among studies with MRI field of strength ≥ 1.5 T, sensitivity was 0.80 (95% CI 0.76–0.84) and specificity 0.84 (95% CI 0.81–0.87). The authors conclude that MRI is an accurate method for diagnosing subscapularis tendon tears; however, its accuracy is lower than that of overall rotator cuff tears, due to its lower sensitivity.

Lee et al (2018) conducted a retrospective study of 120 consecutive patients undergoing 3T MR arthrography to evaluate for subscapularis (SSC) tendon tear, using arthroscopic findings as reference standard. Two musculoskeletal radiologists, blinded to results, evaluated T1-weighted spectral presaturation with inversion-recovery sequences (T1 SPIR) and T2-weighted turbo spin-echo sequences (T2 TSE) images in separate sessions, examining normal/articular-surface partial-thickness tear (PTTa)/full-thickness tear (FTT). Significant differences were found between T1 SPIR and T2 TSE among 74 SSC tendon tears: sensitivity 95.9−94.6% vs. 71.6−75.7% and accuracy 90.8−91.7% vs. 79.2−83.3% for detecting tear; 55.3% vs. 31.6−34.2% and 85.8% vs. 78.3−79.2%, respectively, for FTT; and 91.7−97.2% vs. 58.3−61.1% and 89% vs. 78−79.3%, respectively, for PTTa. The authors conclude that T1 SPIR is more sensitive and accurate compared to T2 TSE in detecting SSC tendon tear on 3T MR arthrography.

Lee et al (2015), in a retrospective study of 333 patients who underwent MRI or MR arthrography and arthroscopic surgery, found that indirect MR arthrography was not superior to noncontrast MRI for the diagnosis of supraspinatus-infraspinatus tendon tears, except for a tendency for a slightly higher sensitivity for diagnosing articular-surface partial-thickness tears. However, improved accuracy may be expected for preoperative diagnosis and for the grading subscapularis tendon tears using indirect MR arthrography.

Shoulder pain with suspected rotator cuff tear in patients who have failed an appropriate course (≥ 4 weeks) of conservative therapy:

- Green – **MRI shoulder without IV contrast**
- Yellow – **MR arthrography shoulder**
  [Previous noncontrast MRI findings are indeterminate]
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Yellow – **CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- Red – **MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- Red – **CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- Red – **PET; bone scan; SPECT**

Level of Evidence: moderate

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can improve the detection and definition of rotator cuff tears (*CO Department of Labor* 2014; Liu et al 2020; *AAOS* 2019; expert panel consensus opinion). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:

Overview:

Patients with rotator cuff syndrome and suspected rotator cuff tears commonly respond to a 4 to 6 week course of conservative care and may be able to avoid surgery (Hegmann et al [ACOEM] 2016; Hopman et al 2013; *CO Department of Labor* 2014; PLE expert panel consensus opinion). As such, advanced imaging is typically not indicated in the first 4-6 weeks for patients presenting with suspected rotator cuff syndrome in the absence of "red flags" (Hopman et al 2013, Grade C; Hegmann et al [ACOEM] 2016). Both full-thickness and partial-thickness rotator cuff tears commonly occur in asymptomatic patients (28-35%), and correlation with clinical findings is important (*CO Department of Labor* 2014). Advanced imaging may not always be indicated in patients with clinically suspected rotator cuff tears who do not have pain (PLE expert panel consensus opinion)

MRI shoulder:

Multiple high quality guidelines note that MRI (without IV contrast) is widely used to provide more definitive visualization of soft tissue structures, and is generally accepted as the gold standard to evaluate for a rotator cuff tear (Bussieres et al 2008; Hopman et al 2013; *CO Department of Labor* 2014; Small et al. [*ACR*] 2018; *AAOS* 2019; strength of recommendation: strong). MRI should be considered when shoulder pain is refractory to conservative care, such as an appropriate shoulder rehabilitation program, for 4 to 6 weeks (Hopman et al 2013; *CO Department of Labor* 2014; *British Orthopaedic Association*, 2014; PLE expert panel consensus opinion). A positive MRI has been found to produce a

small, but sometimes important increase in probability of a partial tear (*AAOS* 2019). MRI may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP) (PLE expert panel consensus opinion).

MR arthrography shoulder:
MR arthrography can improve the diagnostic accuracy of a full-thickness rotator cuff tear when MRI is inconclusive, but the procedure is invasive (Bussieres et al 2008; Hopman et al 2013; *CO Department of Labor* 2014; *AAOS* 2019; strength of recommendation: strong). A positive MR arthrography test for full-thickness tears was found to produce a large increase in probability that a patient truly had a full tear instead of a partial or no tear (*AAOS* 2019). It may also be marginally more sensitive and specific than MRI for assessing glenohumeral lesions (*CO Department of Labor* 2014). MR arthrography may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP) (PLE expert panel consensus opinion).

CT arthrography shoulder:
CT arthrography can be useful to evaluate a suspected rotator cuff tear in patients with significant metal artifact, in patients following total shoulder arthroplasty, or in those with contraindication to MRI (Small et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion).

CT shoulder:
Routine CT is not recommended for the evaluation of chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence). However, for instances where evaluation and surgical planning of bone abnormality is necessary, a noncontrast CT is generally recommended (Hegmann et al [ACOEM] 2016; *CO Department of Labor* 2014; PLE expert panel consensus opinion).

Ultrasound:
Ultrasound can be considered when shoulder pain is refractory to conservative care for 4 to 6 weeks (*CO Department of Labor* 2014). A positive ultrasound test was found to produce a moderate increase in probability of full- thickness tears vs. partial/no tears (pooled positive LR=5.20 (3.20, 8.20). A negative test produced a small but important decrease in the probability a patient did not have a full thickness tear, but instead either had a partial tear or no tear (*AAOS* 2019). The accuracy of ultrasound for rotator cuff tears is highly operator-dependent, and the performance of ultrasound may vary significantly depending on local expertise (Bussieres et al 2008; CO Department of Labor 2014; Hopman et al 2013). Ultrasound can be used as an option for evaluation of rotator cuff tears in patients following total shoulder arthroplasty (PLE expert panel consensus opinion).

<u>Clinical/imaging notes:</u>

- Patients with rotator cuff syndrome and suspected rotator cuff tears commonly respond to a 4 to 6 week course of conservative care and may be able to avoid surgery (Hopman et al 2013; *CO Department of Labor* 2014; PLE expert panel consensus opinion).
- Radiographs may be useful to evaluate for osteoarthritis or calcific tendonitis in patients with rotator cuff syndrome (Bussieres et al 2008).
- MRI, MR arthrography, and ultrasound are highly accurate methods for the diagnosis of full-thickness rotator cuff tears, with high positive likelihood ratios and low negative likelihood ratios (*CO Department of Labor* 2014; Roy et al 2015; Smith et al 2012a).
- 3.0T MRI has been reported to have overall increased accuracy for rotator cuff tears compared to 1.5T, 1.0T or lower field strength MRI systems (Smith et al., 2012b; *CO Department of Labor* 2014). Lower-field strength imaging may be indicated, however, in patients with severe

claustrophobia or if a patient cannot fit in the high-field strength scanner (*CO Department of Labor* 2014).

- Despite its invasiveness, MR arthrography can demonstrate more of the small articular-sided partial-thickness tears and demonstrate the extent of the tear more precisely than MR imaging without arthrography. In addition, MR arthrography has the potential to differentiate partial articular-sided defects from concealed interstitial delamination (CID) lesions, which can be difficult to detect at arthroscopic shoulder surgery if underestimated on imaging reports (Stoppino et al 2013).
- Approximately one-third of patients with rotator cuff disease have concomitant articular cartilage lesions. However, cartilage lesions of the glenohumeral joint are not routinely diagnosed on preoperative MRI despite their prevalence and clinical significance. Patients undergoing surgery for rotator cuff pathology should be informed that the presence and severity of cartilage lesions may be underestimated on MRI and this might affect their ultimate prognosis (VanBeek et al 2014).

Evidence update (2012–present):

High Level of Evidence:

Roy et al (2015), in a systematic review, found an equivalent performance of US, MRI, and MR arthrography for the diagnosis of full- or partial-thickness rotator cuff tears (Sn: 0.90 to 0.91; Sp: 0.86 to 0.90) (high level of evidence). In studies with a low risk of bias, MR arthrography had the best likelihood ratio profile (LR+ 16.6, LR- 0.2) followed by MRI (LR+ 8.3, LR-0.1) and US (LR+ 7.6, LR- 0.3) for diagnostic accuracy of full-thickness tears. The authors found no difference in diagnostic accuracy or likelihood ratios for full-thickness tear at $\leq$ 1.5T or 3.0T for either MRI or MR arthrography.

Moderate Level of Evidence:

Liu et al (2020), in a network meta-analysis, examined which of three common imaging modalities (MRI, MR arthrography [MRA], ultrasound [US]) is optimal for diagnosing rotator cuff tears. Data were extracted from 144 diagnostic studies (14,212 shoulders). A network meta-analysis was performed using an arm-based model to pool absolute sensitivity and specificity, relative sensitivity and specificity, diagnostic odds ratio, and superiority index for ranking the probability of these techniques (**note* "superiority index" measures the superiority of a diagnostic test compared to others by simultaneously optimizing test assessment measures [e.g., sensitivity, specificity, likelihood ratio, predictive value]*). Results found that, for the detection of full-thickness (FT) tears, partial-thickness (PT) tears, or any tear, MRA had the highest sensitivity, specificity, and superiority index. For the detection of any tear, MRI had better performance than US (sensitivity: 0.84 vs 0.81, specificity: 0.86 vs 0.82, and superiority index: 0.98 vs 0.22, respectively). With regard to FT tears, MRI had a higher sensitivity and superiority index than US (0.91 vs 0.87 and 0.67 vs 0.28, respectively) and a similar specificity (0.88 vs 0.88, respectively). The results for PT tears were similar to the detection of FT tears.

Liu et al (2020), in a meta-analysis, sought to compare the accuracy of MRI with MR arthrography in detection of rotator cuff tears. A total of 12 studies (n = 1032 shoulders) were included. Analysis results showed that MR arthrography has a higher sensitivity and specificity than MRI for the detection of full thickness and partial thickness tears. With advances in technology, however, MRI has shown similar accuracy in detecting moderate to large full thickness tears. The authors caution that MR arthrography is invasive, uses ionizing radiation, and can lead to adverse reactions. Considering for both accuracy and practicality factors, MR arthrography is not required as the initial examination, and MRI is recommended to be a first-choice imaging modality for the detection of rotator cuff tears.

VanBeek et al (2014), in a study of 84 consecutive patients undergoing arthroscopic surgery for rotator cuff disease, showed that the overall accuracy of noncontrast MRI in detecting glenohumeral articular cartilage lesions is good. However, detection of cartilage lesions is reader dependent. Furthermore, accurate characterization of a lesion by MRI, including location, depth, and size, is difficult, probably secondary to the relatively thin glenohumeral articular cartilage. Orthopedic surgeons must exercise caution when relying on noncontrast MRI for the detection and characterization of cartilage lesions.

Lenza et al (2013), in a systematic review, concluded that "MRI, MR arthrography and US have good diagnostic accuracy and any of these tests could equally be used for detection of full-thickness tears in people with shoulder pain for whom surgery is being considered". "MRI and US may have poor sensitivity for detecting partial-thickness rotator cuff tears and the sensitivity of US may be much lower than MRI".

Smith et al (2012a), in a meta-analysis of 2751 shoulders in 2710 patients, reported that MRI had a sensitivity of 0.91 and specificity of 0.97 for full-thickness tears, and a sensitivity of 0.80 and specificity of 0.95 for partial-thickness tears (high level of evidence). The results indicated superior overall diagnostic accuracy for 3.0T imaging compared to 1.5T or $\leq$ 1.0T MRI systems for both full- thickness and partial-thickness tears (LR+ 30 [6.6-139] at 3.0T; 8.6 [2.4-31.2] at 1.5T).

Omoumi et al (2012), in a prospective study of MR arthrography and CT arthrography in 56 consecutive patients with arthroscopic correlation, showed that the diagnostic performance and interobserver agreement of these techniques for detecting rotator cuff lesions are comparable. In practice when comparing these two techniques, one also has to consider other limitations that are inherent to each modality. CT arthrography exposes the patient to ionizing radiation, whereas the use of MR arthrography is limited by general contraindications to MR imaging, claustrophobia, and metallic artifacts in postsurgical patients.

Low Level of Evidence:
Khil et al (2021), in a retrospective study, evaluated the diagnostic performance and reliability of MR arthrography (MRA) in diagnosing subscapularis (SSC) tendon tears in 272 patients with arthroscopic confirmations. A total of 548 shoulder MRAs were evaluated by two musculoskeletal radiologists, and SSC tendon pathologies were classified into three groups: intact tendon (n = 149), partial-thickness tear (n = 92), or full-thickness tear (n = 31). For full-thickness tears, mean values of sensitivity, specificity, and accuracy of reviewer one/reviewer two were 71.0%/87.1%, 97.3%/98.3%, and 94.4%/95.5%, respectively. For partial-thickness tears, mean values of sensitivity, specificity, and accuracy were 72.8%/73.4%, 78.3%/81.2%, and 76.5%/78.5%, respectively. Intra- and inter-observer reliabilities for both reviewers were good to very good ($k = 0.85/0.93$, $p < 0.001$; $k = 0.74–0.89$, $p < 0.001$). The authors conclude that MRA showed high diagnostic performance for SSC tendon tears, especially full-thickness tears, with good inter- and intra-observer reliabilities.

Malavolta et al (2019), in a systematic review and meta-analysis, sought to determine the diagnostic accuracy of MRI in the detection of subscapularis tendon tears. A total of 14 articles (n = 1858 shoulders with 613 subscapularis tears) were included. For overall subscapularis tears, sensitivity of MRI was 0.68 (95% CI 0.64–0.72) and specificity was 0.90 (95% CI 0.89–0.92). Sensitivity of MRI was 0.93 (95% CI 0.83–0.98) for full-thickness tears and 0.74 (95% CI 0.66–0.82) for partial tears. Specificity of MRI was 0.97 (95% CI 0.94–0.98) for full-thickness tears and 0.88 (95% CI 0.85–0.91) for partial tears. Among studies with MRI field of strength ≥ 1.5 T, sensitivity was 0.80 (95% CI 0.76–0.84) and specificity 0.84 (95% CI 0.81–0.87). The authors conclude that MRI is an accurate method for diagnosing subscapularis tendon

tears; however, its accuracy is lower than that of overall rotator cuff tears, due to its lower sensitivity.

Cortes et al (2019) conducted a prospective study to determine the value of MRI when used before a trial of conservative therapy in patients with atraumatic shoulder pain. A total of 51 prospective, consecutive patients were included; all were suspected to have cuff tendinopathy based on clinical findings. Every patient underwent MRI and was offered an initial trial of conservative management. Patients had an average follow-up of 28 months after imaging to determine whether surgery was performed. Of the cohort, 46 (90%) patients did not go on to surgical intervention, with 5 (10%) doing so an average 68 days after imaging. The authors conclude that the use of MRI before a trial of conservative management in patients with atraumatic shoulder pain, minimal to no strength deficits on physical examination, and suspected cuff tendinopathy other than full-thickness tears provides negative value in the management of patients, at both the individual and population level.

Lee et al (2018) conducted a retrospective study of 120 consecutive patients undergoing 3T MR arthrography to evaluate for subscapularis (SSC) tendon tear, using arthroscopic findings as reference standard. Two musculoskeletal radiologists, blinded to results, evaluated T1-weighted spectral presaturation with inversion-recovery sequences (T1 SPIR) and T2-weighted turbo spin-echo sequences (T2 TSE) images in separate sessions, examining normal/articular-surface partial-thickness tear (PTTa)/full-thickness tear (FTT). Significant differences were found between T1 SPIR and T2 TSE among 74 SSC tendon tears: sensitivity 95.9−94.6% vs. 71.6−75.7% and accuracy 90.8−91.7% vs. 79.2−83.3% for detecting tear; 55.3% vs. 31.6−34.2% and 85.8% vs. 78.3−79.2%, respectively, for FTT; and 91.7−97.2% vs. 58.3−61.1% and 89% vs. 78−79.3%, respectively, for PTTa. The authors conclude that T1 SPIR is more sensitive and accurate compared to T2 TSE in detecting SSC tendon tear on 3T MR arthrography.

Lee et al (2015), in a retrospective study of 333 patients who underwent MRI or MR arthrography and arthroscopic surgery, found that indirect MR arthrography was not superior to noncontrast MRI for the diagnosis of supraspinatus-infraspinatus tendon tears, except for a tendency for a slightly higher sensitivity for diagnosing articular-surface partial-thickness tears. However, improved accuracy may be expected for preoperative diagnosis and for the grading subscapularis tendon tears using indirect MR arthrography.

Spencer et al (2013), in a prospective study of 44 patients, showed that the overall accuracy of MRI for articular cartilage lesions in patients undergoing arthroscopic surgery for rotator cuff disease is moderate. In the study, the overall accuracy of detecting articular cartilage lesions on MRI was 69%. The accuracy of detecting humeral lesions was 62% (sensitivity, 36%; specificity, 80%), and the accuracy of detecting glenoid lesions was 73% (sensitivity, 28%; specificity, 82%).

Suspected recurrent rotator cuff tear (following rotator cuff repair) in patients who are candidates for surgical repair:

- **Green – MRI shoulder without IV contrast**
- **Green – MR arthrography shoulder**
- **Yellow – CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- **Yellow – CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- **Red – MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- **Red – CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- **Red – PET; bone scan; SPECT**

Level of Evidence: low

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can improve the detection and definition of rotator cuff tears particularly in patients with a history of prior rotator cuff repair (*CO Department of Labor* 2014; Liu et al 2020; expert panel consensus opinion). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:

Overview:

Multiple high quality guidelines note that MRI (without IV contrast) is widely used to provide more definitive visualization of soft tissue structures, and is generally accepted as the gold standard to evaluate for a rotator cuff tear (Bussieres et al 2008; Hopman et al 2013; *CO Department of Labor* 2014; *AAOS* 2019; strength of recommendation: strong). MR arthrography, on the other hand, can help overcome micrometallic artifact in patients who have undergone previous subacromial decompression and rotator cuff repair (Small et al [*ACR*] 2018). AS such, either MRI or MR arthrography are useful as the initial advanced imaging modality for patients with pain after rotator cuff repair (Small et al [*ACR*] 2018). MR imaging may also be used in patients following shoulder arthroplasty if systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP) (PLE expert panel consensus opinion). CT arthrography can be useful to evaluate a suspected rotator cuff tear in patients with significant metal artifact, in patients following total shoulder arthroplasty, or in those with contraindication to MRI (Small et al. [*ACR*] 2018; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion). Routine CT is not recommended for the evaluation of acute, subacute, or chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence). However, for instances where evaluation and surgical planning of bone abnormality is necessary, a noncontrast CT is generally recommended (Hegmann et al [ACOEM] 2016; *CO Department of Labor* 2014; PLE expert panel consensus opinion). The accuracy of ultrasound for rotator cuff tears is highly operator-dependent, and the performance of ultrasound may

vary significantly depending on local expertise (Bussieres et al 2008; *CO Department of Labor* 2014; Hopman et al 2013).

Clinical/imaging notes:

- Areas of rotator cuff attenuation and/or perforation may persist in patients with prior rotator cuff repair (PLE expert panel consensus opinion).
- Advanced imaging is used primarily to evaluate for moderate or large full-thickness defects and tendon retraction (PLE expert panel consensus opinion).

Evidence update (2012–present):

High Level of Evidence:

None

Moderate Level of Evidence:

None

Low Level of Evidence:

None

Suspected labral tear, with or without instability, following acute trauma or when symptoms persist following an appropriate course (≥ 4 weeks) of conservative therapy:

- Green – **MRI shoulder without IV contrast**
- Green – **MR arthrography shoulder**
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Yellow – **CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- Red – **MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- Red – **CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- Red – **PET; bone scan; SPECT**

Level of Evidence: high

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can enhance definition of selected pathologies, particularly labral tears (*CO Department of Labor* 2014). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:

Overview:
Advanced imaging is indicated in patients with shoulder pain whenever acute labral tear with or without instability is suspected, or when symptoms persist following an appropriate trial (4-6 weeks) of conservative therapy (Amini et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; Bussieres et al 2008; *CO Department of Labor* 2014; PLE expert panel consensus opinion).

MRI shoulder:
In patients with traumatic shoulder pain and suspected labral tear, instability, and/or Bankart or Hill-Sachs lesion, MRI is a preferred advanced imaging modality (Amini et al [*ACR*] 2018). In the acute setting, MRI nicely shows labral, Bankart, ligamentous, and tendinous injuries that results from dislocations and can lead to instability (Bussieres et al 2008). In the acute setting, it is also useful in identifying joint effusions, which, if present, indicate the presence of injuries to intra-articular structures (Amini et al [*ACR*] 2018; PLE expert panel consensus opinion). MRI is also useful to evaluate for labral detachment and capsular stress injury or laxity after conservative therapy (*CO Department of Labor* 2014).

MR arthrography shoulder:
In patients with traumatic shoulder pain and suspected labral tear, instability, and/or Bankart or Hill-Sachs lesion, MR arthrography is a preferred advanced imaging modality (Amini et al [*ACR*] 2018). Its use

is also recommended for diagnosing labral tears in patients with subacute or chronic shoulder pain (Hegmann et al [ACOEM] 2016). It is considered to be more accurate than MRI in diagnosing and excluding labral tears, and more accurate than CT arthrography in the assessment of labroligamentous injuries (Amini et al [*ACR*] 2018). In the setting of chronic instability, MR arthrography best evaluates labral, Bankart, ligamentous, and tendinous injuries that result from dislocations and can lead to instability (Bussieres et al 2008). MR arthrography has the highest reported accuracy for the diagnosis and classification of SLAP lesions, and is also useful to evaluate for labral detachment and capsular stress injury or laxity after conservative therapy (*CO Department of Labor* 2014).

CT arthrography shoulder:
While CT arthrography and MR arthrography have comparable diagnostic accuracy in evaluation of SLAP tears, Bankart lesions, and Hill-Sachs fractures, CT arthrography exposes the patient to ionizing radiation (Amini et al [*ACR*] 2018). It can be useful to evaluate labral detachment and capsular stress injury or laxity in patients with significant metal artifact, in patients following total shoulder arthroplasty, or in those with contraindication to MRI (Amini et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; *CO Department of Labor* 2014; PLE expert panel consensus opinion).

CT shoulder:
Routine CT is not recommended for the evaluation of acute, subacute, or chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence. However, CT without contrast can be useful to detect and grade bony Bankart lesions and Hills-Sachs deformities prior to surgery (Amini et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion).

Clinical/imaging notes:

- Early imaging and surgical repair may be considered in young patients active in sports following an acute dislocation and in older patients with an acute dislocation and significant rotator cuff tear (*CO Department of Labor* 2014).
- 3T MRI and modern 1.5T MRI systems with optimized technique may have comparable accuracies to MR arthrography (Arirachakaran et al 2017; PLE expert panel consensus opinion).
- If a patient is to undergo low field strength imaging because of claustrophobia or bariatric issues, MR arthrography should be considered instead of MRI for improved diagnostic accuracy in the detection of labral tears (PLE expert panel consensus opinion).

Evidence update (2012-present):
High Level of Evidence:
None

Moderate Level of Evidence:
Vopat et al (2020), in a systematic review, examined the reliability and accuracy of different imaging modalities in assessing Hill-Sachs lesions within the setting of anterior shoulder instability. Forty studies (2,560 shoulders) met inclusion criteria. For diagnosing the presence of Hill-Sachs lesions, computed tomography (CT) arthrography had the highest reported accuracy (median, 91%; range, 66%-100%). For the same assessment, CT arthrography also had the greatest reported sensitivity (median, 94%; range, 50%-100%). For the quantification of Hill-Sachs lesion parameters, reported intraobserver reliabilities were highest for three-dimensional (3D) CT (intraclass correlation coefficient [ICC] range, 0.916-0.999), followed by 2-dimensional CT (ICC range, 0.858-0.861) and MRI (ICC range, 0.28-0.97). For the same quantification parameters, interobserver reliabilities were also reported for 3D CT (ICC range, 0.772-0.996), 2-dimensional CT (ICC range, 0.721-0.879), and MRI (k range, 0.444-0.700). Intraobserver

reliabilities for determining glenoid tracking were only reported for 3D CT (k range, 0.730-1.00; ICC range, 0.803-0.901) and MRI (ICC range, 0.770-0.790). The authors conclude that the current literature supports a variety of different imaging modalities that provide clinically acceptable accuracy in diagnosing and quantifying Hill-Sachs lesions.

Foti et al (2020), in a prospective study, compared the diagnostic accuracy of dual-energy CT arthrography (DE-CTA) and MR arthrography (MRA) of the shoulder in depicting glenoid labral tears. 47 consecutive patients underwent both DE-CTA and MRA the same day. Two radiologists, blinded to clinical data, evaluated the presence of labral tears on standard CTA and DE-CTA images. A third radiologist evaluated the MRA images. Diagnostic accuracy values were calculated with surgery as reference standard; surgery revealed the presence of labral tear in 38/47 patients (80.9%). Sensitivity and specificity values were 84.2% and 77.8% for MRA, and average values were 84.2% and 83.4% for CTA, and 90.8% and 88.9% for DE-CTA. Inter-observer agreements were near perfect for CTA (k = 0.84) and substantial for DE-CTA (k = 0.76). Intra-observer agreements were near perfect for both CTA (k = 0.88) and DE-CTA (k = 0.82). The authors conclude that a nonsignificant increase in diagnostic accuracy in diagnosing labral tears was obtained by using CTA in comparison with MRA. DE-CTA allowed a further but not significant increase in diagnostic accuracy, when compared to both MRA and CTA.

Arirachakaran et al (2017), in a systematic review, report that MR arthrography was superior to MRI to detect SLAP lesions by both direct and indirect meta-analysis. There was higher sensitivity (0.87 vs. 0.76), specificity (0.92 vs. 0.87), positive likelihood ratio (10.28 vs. 5.89) and negative likelihood ratio (0.14 vs. 0.28) and area under the curve (0.94 vs. 0.88) of MR arthrography compared to MRI for the detection of SLAP lesions. The accuracy of 3.0T MRI was superior to that with 1.5T and is comparable to MR arthrography

Smith et al (2012b), in a meta-analysis, reported that overall MR arthrography appears marginally superior to MRI for the detection of glenohumeral labral lesions (MR arthrography sensitivity 88%, specificity 93% vs. MRI sensitivity 76%, specificity 87%).

Low Level of Evidence:
Jonas et al (2012), in a retrospective study of 90 consecutive patients with clinical shoulder instability with arthroscopic correlations, found that MR arthrography had a sensitivity of 65% and specificity of 100%. The sensitivity for an anterior labral tear was lower at 58%.

Suspected long head of the biceps tendon tear/tendinopathy:

- Green – **MRI shoulder without IV contrast**
- Green – **MR arthrography shoulder**
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Yellow – **CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- Red – **MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- Red – **CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- Red – **PET; bone scan; SPECT**

Level of Evidence: low

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can enhance definition of selected pathologies, particularly labral tears (*CO Department of Labor* 2014). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none

Guideline and PLE expert panel consensus opinion summary:
Overview:
Advanced imaging is recommended for patients with suspected full-thickness biceps tendon tear, and in patients whose symptoms persist after 4-6 weeks of conservative therapy (*CO Department of Labor* 2014; Hegmann et al [ACOEM] 2016). When initial radiographs are normal or inconclusive, MRI without contrast or MR arthrography are generally recommended for atraumatic biceps tendinitis, bursitis, or tear (Small et al [*ACR*] 2018; PLE expert panel consensus opinion). MRI and ultrasound are also accurate for the diagnosis of full-thickness biceps tendon tears (Amini et al [*ACR*] 2018; PLE expert panel consensus opinion). MR arthrography is the optimal test for the evaluation of biceps pulley lesions and evaluation for the rotator cuff interval widening, which can be associated with instability (PLE expert panel consensus opinion). Routine CT is not recommended for the evaluation of acute, subacute, or chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence). However, for instances where evaluation and surgical planning of bone abnormality is necessary, a noncontrast CT is generally recommended (Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion).

Clinical/imaging notes:

- Patients with bicipital tendon disorders may present with aching, burning and/or stabbing pain in the anterior medial aspect of the shoulder. They may also report snapping with a subluxing tendon (*Colorado Department of Labor*, 2014).

- Immediate sharp pain in the biceps region along with tenderness, bruising and a "Popeye" deformity may indicate an acute full-thickness tear of the long head of the biceps following trauma (*Colorado Department of Labor*, 2014).
- Biceps tears and tendinopathy are often associated with anterior supraspinatus abnormalities, superior subscapularis pathology, and subacromial bursitis. These entities may be difficult to distinguish on physical exam (PLE expert panel consensus opinion).
- Ultrasound is accurate in the evaluation of full-thickness biceps tendon tears and is useful to perform directed therapeutic injections into the biceps tendon sheath (Amini et al [*ACR*] 2018; PLE expert panel consensus opinion).
- There is no difference in the diagnostic accuracy for MRI or MR arthrography for biceps tears or tendinosis. However, MR arthrography is invasive and is associated with patient discomfort as well as a small risk of infection and allergic reaction (Tadros et al 2015).
- CT arthrography and MR arthrography have comparable diagnostic accuracies in the detection of biceps tendon pathology; however, CT exposes the patient to ionizing radiation (De Maeseneer et al 2012).

Evidence update (2012–present):

High Level of Evidence:

None

Moderate Level of Evidence:

None

Low Level of Evidence:

Razmjou et al (2016), in a retrospective study evaluating the accuracy of MRI for biceps tendon abnormalities in 183 patients with rotator cuff disorders, showed the following sensitivities and specificities: 0.54 and 0.98 for full tears, 0.27 and 0.86 for partial tears, and 1.0 and 0.83 for subluxation/dislocation.

Tadros et al (2015) found that both MRI and MR arthrography had good diagnostic accuracy with no significant difference for tears and had good specificity but low sensitivity for tendinosis. For tears, MRI versus MR arthrography showed 75–83% and 64–73% sensitivity; 73–75% and 82–91% specificity; 66–69% and 41– 62% PPV; 82–87% and 92–94% NPV; and 74–78% and 79– 88% accuracy, respectively. For tendinosis, MRI versus MR arthrography showed 18–36% and 15–38% sensitivity; 69–79% and 83–91% specificity; 22–28% and 18–50% PPV; 74–76% and 80–86% NPV; and 61–64% and 70–81% accuracy, respectively.

De Maeseneer et al (2012) found no statistically significant difference between CT arthrography and MR arthrography with low sensitivity and good specificity for diagnosis of tendon abnormalities. The interobserver agreement was poor for both modalities.

Suspected adhesive capsulitis:

- Green – **MRI shoulder without IV contrast**
- Yellow – **MRI shoulder without and with IV contrast** or **MRI shoulder with IV contrast**
- Yellow – **MR arthrography shoulder**
  [Previous noncontrast MRI findings are indeterminate]
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Red – **CT shoulder; Bone scan; PET; SPECT**

Level of Evidence: low

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The use of MRI with IV contrast may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012). The addition of intra-articular contrast (arthrography) can enhance definition of selected pathologies (*CO Department of Labor* 2014).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:
Overview:
MRI is generally the preferred advanced imaging modality of choice helping to diagnose suspected adhesive capsulitis (Kelley et al [*APTA*] 2013; Small et al [*ACR*] 2018; Bussieres et al 2008), as several studies of symptomatic patients have shown abnormalities of the capsule and rotator cuff interval (Kelley et al [*APTA*] 2013. Thickening of the capsule/synovium in the axillary recess appears to be useful criterion for the diagnosis of adhesive capsulitis on coronal oblique T2-weighted MR arthrography images (Bussieres et al 2008). Routine CT is not recommended for the evaluation of subacute or chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence).

Clinical/imaging notes:

- Adhesive capsulitis is characterized by gradual and insidious onset of pain and restriction of GH joint mobility in multiple planes, particularly with external rotation (Kelley et al [*APTA*] 2013).
- The key clinical difference between adhesive capsulitis and rotator cuff impingement or tear is stiffness (limitation of passive range). In the early stages, the clinical diagnosis can be difficult.
- Adhesive capsulitis may follow trauma, myocardial infarction, neck or cardiac surgery, radiation therapy, and prolonged immobilization (Kelley et al [*APTA*] 2013).
- Risk factors for adhesive capsulitis include diabetes and thyroid disease (Kelley et al [*APTA*] 2013; *University of New South Wales* guideline [Hopman et al., 2013]).
- Radiographs (including a transaxillary view) are useful at the time of initial evaluation to exclude the presence of calcific tendinitis, osteoarthritis, and chronic posterior dislocation, each of which can result in pain and limitations of mobility (Kelley et al [*APTA*] 2013; Bussieres et al 2008; Smith et al [*ACR*] 2018; PLE expert panel consensus opinion).
- Thickening of the axillary capsule with T2 hyperintensity are useful criteria for the diagnosis of adhesive capsulitis. STIR, fat-suppressed PD and fat-suppressed T2-weighted sequences are

more sensitive than non-fat-suppressed sequences for hyperintensity (PLE expert panel consensus opinion).
- Patients with adhesive capsulitis show effacement of fat within the anterior rotator cuff interval, secondary to capsular and ligamentous thickening (PLE expert panel consensus opinion).
- Rotator interval enhancement may increase the specificity of adhesive capsulitis on MRI with IV contrast (Ahn et al., 2015).
- Patients with adhesive capsulitis may also show a disproportionate amount of fluid within the biceps tendon sheath and subcoracoid recess relative to fluid in the joint space (PLE expert panel consensus opinion).

Evidence update (2012–present):

High Level of Evidence:

None

Moderate Level of Evidence:

None

Low Level of Evidence:

Pessis et al (2020) retrospectively compared reliability and performance of MRI measures enhanced with IV gadolinium contrast versus non-enhanced MRI measures for the diagnosis of adhesive capsulitis (AC) among 42 patients. AC was confirmed by arthrography and MRI findings were correlated with clinical stage, etiology, and pain. Results found sensitivity (97.6%) and specificity (97.6%) of axillary-recess capsule signal enhancement for AC diagnosis were significantly superior ($p = 0.02$) to hyperintense signals on T2-weighted fat-suppressed images (sensitivity 90.5%, specificity 92.7%). Authors found 100% specificity of enhancement of the coracohumeral ligament signal for AC diagnosis. The early stage of adhesive capsulitis was positively correlated with joint capsule enhancement in the rotator interval. The authors conclude that IV contrast injection with MRI can be helpful for AC diagnosis in difficult cases.

Ahn et al (2015) reported that capsular thickening and altered signal of the axillary recess of the capsule on both non-CE and CE MRI had similar diagnostic performance with high sensitivity, moderate specificity, and excellent interobserver agreement. Contrast-enhanced MRI may improve assessment of the rotator interval and lend further confidence in the radiologic diagnosis of AC. With respect to the axillary joint capsule thickness, a cutoff value of 5.0 mm provided the highest sensitivity and specificity. Interobserver reliability was excellent for rotator cuff thickness (low level of evidence).

Ahn et al (2012) reviewed findings on contrast-enhanced MRI in 97 patients with adhesive capsulitis. Thickening of the axillary pouch ranged from 5.0 to 15.9 mm, with an average of 8.8 mm. There was a statistically significant negative linear correlation between external rotation in shoulder ROM and thickness of the joint capsule measured on MRI. There was a statistically significant positive linear correlation between the grade of joint capsule enhancement and the thickness of the joint capsule and pain intensity in patients with adhesive capsulitis (low level of evidence).

Shoulder pain in patients with osteoarthritis who are undergoing surgical planning for shoulder arthroplasty:

- **Green – CT shoulder without IV contrast**
- **Green – MRI shoulder without IV contrast**
- **Green – MR arthrography shoulder**
- **Yellow – CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- **Red – MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- **Red – CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- **Red – PET; bone scan; SPECT**

Level of Evidence: low

Notes concerning use of contrast:
When planning for shoulder arthroplasty, MRI without IV contrast or CT without IV contrast can be helpful to evaluate glenoid morphology, version, and extent and location of glenoid bone loss (Small et al [*ACR*] 2018; PLE expert panel consensus opinion). MR arthrography and CT arthrography can be used to evaluate the integrity of the rotator cuff particularly in patients with a history of previous surgery. The addition of IV contrast is not generally indicated in this clinical scenario (PLE expert panel consensus opinion).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:
Overview:
In the absence of reliable evidence, it is recommended that patients with glenohumeral osteoarthritis undergoing arthroplasty should be imaged with axillary and true AP (Grashey view) radiographs, with advanced imaging performed at the discretion of the clinician (*AAOS* 2020, strength of recommendation: consensus). CT can be useful to quantitate glenoid version, subchondral cystic changes, and/or posterior glenoid wear (PLE expert panel consensus opinion). MRI, MR arthrography, or CT arthrography can be used to evaluate the integrity of the rotator cuff (PLE expert panel consensus opinion; *AAOS* 2020).

Clinical/imaging notes:
- Pre-operative evaluation of patients undergoing shoulder arthroplasty helps to define osseous anatomy, pathology and potential component positioning (*AAOS* 2020).
- Conventional radiographs are the initial study of choice for the detection and evaluation of osteoarthritis (Small et al [*ACR*] 2018).
- Conventional radiographs with axillary views are useful for the detection of and to follow posterior glenoid wear (Small et al [*ACR*] 2018).
- Quantifying glenoid version and the presence or severity of subchondral cystic change is useful for surgical planning in anticipation of shoulder arthroplasty (PLE expert panel consensus opinion).
- Three-dimensional (3D) CT imaging has been shown to improve accuracy of the desired implant position, however, there is inadequate data on long term clinical outcomes (*AAOS* 2020).

- Glenoid retroversion can also be assessed on MRI if additional T1 axial images are obtained with the field of view increased to include the medial border of the scapula. CT may be avoided in these patients (PLE expert panel consensus opinion).

Evidence update (2008–present):
Omoumi et al (2015), in a prospective study comparing CT arthrography and MR arthrography in 56 consecutive patients with arthroscopic correlation, showed that the diagnostic performance in detecting glenohumeral cartilage lesions was moderate with both techniques, although statistically significantly better with CT arthrography (moderate level of evidence).

Raymond et al (2013) compared glenoid version on axillary radiographs (AXR) and MRI in 33 consecutive patients with a diagnosis of end-stage osteoarthritis. They found that the mean retroversion measured on AXR was significantly greater than that measured on MRI, with the mean difference of glenoid version of 7.36° ($P < .001$), and the interobserver and intraobserver reliabilities were greater for MRI than for radiography. Glenoid retroversion was greater on radiography in 73% of cases. The authors conclude that axillary radiographs should be interpreted with caution when assessing the pattern and extent of posterior glenoid wear in osteoarthritis. The authors suggest that radiographs should not be used for preoperative templating but may be useful for basic diagnostic purposes. MRI represents a precise and accurate technique for evaluating glenoid wear without exposure to ionizing radiation, in addition to its established role in the assessment of the rotator cuff (low level of evidence).

Hoenecke et al (2010) compared the assessment of glenoid version on two-dimensional (2D) CT versus three-dimensional (3D) CT in 33 consecutive osteoarthritis patients undergoing evaluation for osteoarthritis. When the high-resolution 3D-CT reconstructions were analyzed, the location of maximum wear in arthritic glenoids was most commonly posteroinferior (36% in the posterior direction at 9 o'clock and 21% in the posterior inferior position at 8 o'clock). This maximum wear was detected accurately in only 48% of cases in the clinical 2D axial CT slices. The average absolute error in the version measured on the 2D-CT slice passing through the tip of the coracoid was 5.1 (range, 0-16; $P < .001$) (low level of evidence).

Scalise et al (2008) compared conventional CT with three-dimensional (3D) CT in 44 consecutive patients with end-stage osteoarthritis undergoing surgical planning for shoulder arthroplasty. They found increased assessment reliability for glenoid prosthesis fit for 3D versus two-dimensional (2D) ($p < 0.006$). Surgical decision-making changed 39% of the time in the 3D vs. 2D assessment (low level of evidence).

Further evaluation/surgical planning of suspected or known acute* fracture following radiographs:

- **Green – CT shoulder without IV contrast**
- **Green – MRI shoulder without IV contrast**
- **Red – MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- **Red – CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- **Red – MR arthrography shoulder**
- **Red – CT arthrography shoulder**
- **Red – PET; bone scan; SPECT**

*A fracture occurring within the past 4 weeks is considered an acute fracture (PLE expert panel consensus opinion).

Level of Evidence: Moderate

Notes concerning use of contrast: The addition of contrast is usually not necessary in the assessment of fractures (Amini et al [*ACR*] 2018; PLE expert panel consensus opinion).

Notes concerning applicability and/or patient preferences: Consulting and reporting requirements are not required for orders for applicable imaging services made by ordering professionals under the following circumstances (*42 C.F.R. § 414.94. 2015*):

- Emergency services when provided to individuals with emergency medical conditions.
- For an inpatient and for which payment is made under Medicare Part A.

Guideline and PLE expert panel consensus opinion summary:

Overview:

In patients with traumatic shoulder pain and suspected fracture, conventional radiographs are initially recommended (Amini et al [*ACR*] 2018; Hegmann et al [ACOEM] 2016; *CO Department of Labor* 2014; Bussieres et al 2008). Advanced imaging modalities may be indicated to further evaluate a fracture detected on radiographs, particularly for pre-operative planning (CO Department of Labor 2014; Bussieres et al 2008).

CT shoulder:

If fracture remains a possibility after normal radiographs, CT is generally recommended (Hegmann et al [ACOEM] 2016: recommended, insufficient evidence (I); Bussieres et al 2008). CT without contrast is recommended whenever radiographs show fracture of the humeral head/neck or scapula (*CO Department of Labor* 2014; Amini et al [*ACR*] 2018). CT is also useful for characterizing fractures if more information is needed, such as fracture complexity, displacement, or angulation (Bussieres et al 2008; Amini et al [*ACR*] 2018).

MRI shoulder:

MRI is effective for shoulder pathology evaluation, including assessment of bony morphology and bone loss in patients with traumatic shoulder injuries, however is less often used in the acute setting (Amini et al [*ACR*] 2018; Bussieres et al 2008). In the evaluation of suspected fracture, it may be most useful when

there is suspicion of associated soft-tissue pathology (Amini et al [*ACR*] 2018).

Clinical/imaging notes:

- Radiographs are the initially preferred imaging modality in the setting of traumatic shoulder pain and can identify most shoulder fractures (Amini et al [*ACR*] 2018).

Evidence update (2012-present):

High Level of Evidence:

None

Moderate Level of Evidence:

None

Low Level of Evidence:

None

Nonspecific shoulder pain with indeterminate history, physical examination and radiographs, and with failure of (≥ 4 weeks) conservative care:

- Green – **MRI shoulder without IV contrast**
- Yellow – **MR arthrography shoulder**
  [Previous noncontrast MRI findings are indeterminate]
- Yellow – **CT arthrography shoulder**
  [MRI not available or contraindicated; prior shoulder arthroplasty or significant metal artifact]
- Yellow – **CT shoulder without IV contrast**
  [Further evaluation or surgical planning of bone abnormality]
- Red – **MRI shoulder without and with IV contrast; MRI shoulder with IV contrast**
- Red – **CT shoulder without and with IV contrast; CT shoulder with IV contrast**
- Red – **PET; bone scan; SPECT**

Level of Evidence (for additional detail, see topic-specific AUC recommendation):

- Moderate to high level of evidence that MRI is accurate in the diagnosis of rotator cuff tear, labral tear, and complete biceps tendon tear
- Low quality of evidence that MRI is accurate in the diagnosis of adhesive capsulitis
- Low quality of evidence that MRI is specific but not sensitive for the diagnosis of cartilaginous lesions

Notes concerning use of contrast: MRI without IV contrast is the advanced imaging procedure of choice for visualization of soft tissue structures of the shoulder, including ligaments, tendons, joint capsules, and joint cartilage structures (*CO Department of Labor* 2014; PLE expert panel consensus opinion). The addition of intra-articular contrast (arthrography) can enhance definition of selected pathologies (*CO Department of Labor* 2014). The use of MRI with IV contrast is limited in the shoulder, however may be useful in the evaluation of adhesive capsulitis (Pessis et al 2020; Ahn et al 2015; Ahn et al 2012).

Notes concerning applicability and/or patient preferences: none.

Guideline and PLE expert panel consensus opinion summary:

Overview:

After physical examination and conventional radiographs, advanced imaging, particularly MRI, is indicated in patients with shoulder pain if there is no response to care after 4 weeks (Bussieres et al 2008; Hegmann et al [ACOEM] 2016; PLE expert panel consensus opinion). MRI provides the best imaging details for evaluation of shoulder pathology (osteonecrosis, marrow, and joint disease including infection) (Amini et al [ACR] 2018; Bussieres et al 2008). CT arthrography, MR arthrography, or ultrasound can also be useful for nonlocalized shoulder pain when initial radiographs are negative (Amini et al [*ACR*] 2018). Routine CT is not recommended for the evaluation of subacute or chronic shoulder pain (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence (I). However, noncontrast CT is generally recommended to evaluate bone abnormalities or to evaluate for an occult fracture (PLE expert panel consensus opinion). Bone scanning is not recommended for routine use in shoulder joint evaluations; it is generally thought to be inferior to MRI, as MRI is specific and sensitive (Hegmann et al [ACOEM] 2016: not recommended, insufficient evidence). Bone scan has relatively poor resolution for pathology and localization, and also relatively poor specificity (Amini et al [ACR] 2018; PLE expert panel consensus opinion).

Clinical/imaging notes:

- Radiographs are useful to evaluate for osteoarthritis, periarticular calcium deposition disease, fractures, dislocations and bone lesions in patients with nonspecific pain and an indeterminate history and physical exam (Small et al [*ACR*] 2018).
- MRI is accurate for the evaluation of rotator cuff pathology, full-thickness biceps tendon tears and labral tears. MRI is also useful to identify bone marrow associated with radiographically occult fractures or avulsions (Amini et al [*ACR*] 2018; PLE expert panel consensus opinion).
- MRI is useful for the diagnosis of early radiographically occult osteoarthritis (PLE expert panel consensus opinion).

Evidence update (2012-present):

High Level of Evidence:

None

Moderate Level of Evidence:

None

Low Level of Evidence:

None

General Exclusions:

- Cases meeting the definition of a suspected or confirmed emergency medical condition, including high energy trauma
- Shoulder pain secondary to cancer-related concern
- Shoulder pain secondary to infection
- Suspected synovial abnormality (e.g., osteochondromatosis or PVNS)
- Painful total joint arthroplasty
- Pediatric patients
- Pregnant patients

AUC Revision History:

Revision Date	New Clinical Scenario	Approval Body
05/16/2017	Initial Document Development	CDI Quality Institute's Multidisciplinary Committee
05/22/2018	N/A	CDI Quality Institute's Multidisciplinary Committee
07/09/2019	N/A	CDI Quality Institute's Multidisciplinary Committee
07/28/2020	Shoulder Fracture	CDI Quality Institute's Multidisciplinary Committee
09/14/2021	N/A	CDI Quality Institute Multidisciplinary Committee

Information on our evidence development process, including our conflicts of interest policy is available on our website at **https://www.mycdi.com/ple**

Provider Led Entity

Appropriateness of Advanced Imaging in Patients with Shoulder Pain: Bibliography

09/14/2021

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