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

- **Green** – MRI
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Yellow** – CT arthrography in patients with prior shoulder arthroplasty
- **Yellow** – MR arthrography as the initial study or to evaluate indeterminate findings on previous noncontrast MRI
- **Orange** – MRI or MR arthrography in patients with prior shoulder arthroplasty (see clinical notes below)
- **Red** – PET, bone scan

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

Notes concerning applicability and/or patient preferences: none

Guideline summary:
Bussières et al. (2008) state that MRI is the gold standard to evaluate for a rotator cuff tears. MR arthrography improves diagnostic accuracy, but is invasive. Ultrasound (US) is also accurate for full-thickness rotator cuff tears, but is much less sensitive for partial-thickness tears. They also state that the quality of ultrasound studies is variable.
The Colorado Department of Labor guideline (2014) states that MRI is generally accepted and widely used to provide more definitive visualization of soft tissue structures. It states that:

- Patients with suspected full-thickness tear and a history of trauma should have early use of MRI.
- MRI, US, and MR arthrography are each accurate at identifying full-thickness tears, and there is inadequate evidence to compare accuracy for partial-thickness tears.
- High field strength MRI provides better resolution than low field strength imaging. 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.
- MR arthrography may be marginally more sensitive and specific for glenohumeral lesions, but is invasive. MR arthrography may be ordered for surgical planning with or without prior MRI.
- For US, they state that the specificity for a full-thickness tear is 96%, and that a negative ultrasound exam does not exclude a full-thickness tear.
- For CT, they state that CT can be useful to evaluate for bony abnormalities and in patients with metal artifact.
- For both MRI and US, they state that performance and accuracy depends on operator skill and experience.

The University of New South Wales guideline (Hopman et al., 2013) states that MRI is recommended for the evaluation of rotator cuff syndrome. MRI and ultrasound (US) have similar accuracy for rotator cuff tears, however, in primary care settings, US may not be as accurate secondary to differences in operator skill and experience. MR arthrography and CT arthrography may identify rotator cuff lesions not detected on MRI and may be superior to MRI for the detection of labral lesions; however, these procedures are invasive. MR arthrography and CT arthrography may be ordered on the rare occasion that MRI is inconclusive.

The American College of Radiology (ACR; Wise, et al., 2011)* recommends MRI (9), ultrasound (8) and MR arthrography (7) for the diagnosis of rotator cuff tears. CT arthrography (5) is recommended if MRI or ultrasound cannot be performed (5), or in patients with prior arthroplasty (7).

The American Academy of Orthopaedic Surgeons (AAOS, 2010) guideline states that early surgical repair is an option for patients with a rotator cuff tear following acute trauma (limited evidence).

The British Orthopaedic Association (2014) states that rotator cuff repair should be considered in patients with acute traumatic or degenerative rotator cuff tear.

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.

Clinical notes:

- X-rays are useful to exclude fractures, avulsions and dislocation in patients with shoulder pain following acute trauma.
- MRI, MR arthrography, and US are highly accurate methods for the diagnosis of full-thickness rotator cuff tears, with high positive likelihood ratios and low negative likelihood ratios.
- MRI and MR arthrography may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVRIC or WARP).
• MRI may be preferred in patients following acute injury as it can identify intra-articular effusions, which if present would indicate an intra-articular injury. An effusion would be masked by the presence of intra-articular contrast.

• Ultrasound can be useful to evaluate for full-thickness tears in patients with severe pain and in patients who cannot undergo MRI.

• The accuracy of ultrasound for rotator cuff tears is highly operator-dependent, and the performance of ultrasound may vary significantly depending on local expertise.

Evidence update (2010-present):

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” (moderate level of evidence). “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.”

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 ≤ 1.5T or 3.0T for either MRI or MR arthrography.

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 of their analysis indicated superior overall diagnostic accuracy for 3.0T imaging compared to 1.5T or ≤ 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 (moderate level of evidence). 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.

Foad and Wijdicks (2012), in a study of 39 consecutive patients with MRI or MR arthrography undergoing subscapularis repair, found that MRI had a sensitivity of 40% and MR arthrography had a sensitivity of 36% for subscapularis tears (low level of evidence).

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 (low level of evidence).
Nontraumatic shoulder pain with suspected rotator cuff tear, with or without impingement syndrome, in patients who have failed a course of conservative therapy for 4-6 weeks:

- **Green** – MRI
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Yellow** – CT arthrography in patients with prior shoulder arthroplasty
- **Yellow** – MR arthrography as the initial study or to evaluate indeterminate findings on previous noncontrast MRI
- **Orange** – MRI or MR arthrography in patients with prior shoulder arthroplasty (see clinical note below)
- **Orange** – bone scan without history of cancer and without osteolytic or osteosclerotic lesions on plain radiography
- **Red** – PET, bone scan

**Level of Evidence:** Moderate

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:**
Four out of four guidelines state that no imaging is indicated in patients with suspected nontraumatic rotator cuff tear unless the patient has failed a course of conservative therapy for 4-6 weeks.

Bussières et al. (2008) state that MRI is the gold standard to evaluate for a rotator cuff tear. Ultrasound (US) is also accurate for full-thickness rotator cuff tears, but is much less sensitive for partial-thickness tears. MR arthrography improves diagnostic accuracy. They also state that the quality of ultrasound studies is variable.

The *Colorado Department of Labor* guideline (2014) states that MRI is generally accepted and widely used to provide more definitive visualization soft tissue structures:

- MRI or US should be considered when shoulder pain is refractory to conservative care for 4-6 weeks.
- Patients with significant weakness on elevation or rotation or a palpable defect at the greater tuberosity should have early use of MRI.
- It states that MRI, US, and MR arthrography are each accurate at identifying full-thickness tears, and there is insufficient evidence to compare accuracy for partial-thickness tears.
- For MRI, it states that in general, high field strength MRI provides better resolution than low field strength imaging. 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.
- MR arthrography may be marginally more sensitive and specific for glenohumeral lesions, but is invasive. MR arthrography may be ordered for surgical planning with or without prior MRI. The appearance of 3.0T imaging may over time eliminate the need for arthrography.
- For US, it states that the specificity for a full-thickness tear is 96% and that a negative ultrasound exam does not exclude a full-thickness tear.
- For CT, it states that CT can be useful to evaluate for bony abnormalities and in patients with metal artifact.
• For both MRI and US, it states that performance and accuracy depends on operator skill and experience.

The Colorado Department of Labor guideline (2014) also states that for rotator cuff tears, adjunctive testing such as sonography or MRI should be considered for cases refractory to 4 to 6 weeks of an appropriate shoulder rehabilitation program. Cases with significant weakness on elevation or rotation or a palpable defect should have early use of MRI.

The University of New South Wales guideline (Hopman et al., 2013) states that x-rays and imaging are not indicated in the first 4-6 weeks for an injured worker presenting with suspected rotator cuff syndrome in the absence of ‘red flags’ (Grade C). MRI is recommended for injured workers with rotator cuff syndrome with significant pain and activity restriction persisting for 4-6 weeks. MRI and US have similar accuracy for rotator cuff tears; however, US in primary care settings may not be as accurate secondary to differences in operator skill and experience. MR arthrography and CT arthrography may identify rotator cuff lesions not detected on MRI and may be superior to MRI for the detection of labral lesions, however, these procedures are invasive. MR arthrography and CT arthrography may be ordered on the rare occasion that MRI is inconclusive.

The ACR (Wise et al., 2011)* recommends MRI (9), ultrasound (8) and MR arthrography (7) for the diagnosis of rotator cuff tears. CT arthrography (5) is recommended if MRI or ultrasound cannot be performed (5), or in patients with prior arthroplasty (7).

The AAOS guideline (2010) states that:
• Rotator cuff repair is an option for patients with chronic full-thickness rotator cuff tears (limited); and
• Surgery should not be performed for asymptomatic full-thickness rotator cuff tears (consensus).

The British Orthopaedic Association (2014) states that rotator cuff repair should be considered in patients with persistent subacromial shoulder pain and weakness with an US or MRI diagnosis of full-thickness rotator cuff tear after adequate and appropriate conservative treatment.

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.

Clinical notes:
• Patients with rotator cuff syndrome and suspected rotator cuff tears commonly respond to a 4-6 week course of conservative care and may be able to avoid surgery.
• Patients with marked weakness/drop arm may be candidates for early imaging and early surgery.
• X-rays may be useful to evaluate for osteoarthritis or calcific tendonitis in patients with rotator cuff syndrome.
• MRI, MR arthrography, and US are highly accurate methods for the diagnosis of full-thickness rotator cuff tears, with high positive likelihood ratios and low negative likelihood ratios.
• MRI, MR arthrography, and US are moderately accurate methods for the detection of partial-thickness rotator cuff tears.
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).

Despite its invasiveness, MR arthrography may be preferred by some radiologists and surgeons as it 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).

MR arthrography does not improve the accuracy for partial-thickness bursal surface tears.

CT arthrography is useful to evaluate for rotator cuff tears in patients following total shoulder arthroplasty. MR or MR arthrography may also be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVERIC or WARP).

The accuracy of ultrasound for rotator cuff tears may vary significantly depending on local expertise.

Both full-thickness and partial-thickness rotator cuff tears commonly occur in asymptomatic patients (28-35%), and correlation with clinical findings is important (Colorado Department of Labor, 2014).

Advanced imaging may not be indicated in patients with clinically suspected rotator cuff tears who do not have pain.

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 (2010-present):
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 ≤ 1.5T or 3.0T for either MRI or MR arthrography.

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 of their analysis indicated superior overall diagnostic accuracy for 3.0T imaging compared to 1.5T or < 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).

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” (moderate level of evidence). “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.”
Oh et al. (2010), in a study of 168 consecutive patients who underwent CT arthrography or MR arthrography of the shoulder and a subsequent arthroscopic surgical procedure, found that the sensitivity, specificity, agreement, and the AUROC curves for CT arthrography and MR arthrography were excellent for full-thickness rotator cuff tears. The sensitivity, PPV, and k coefficient of MR arthrography for partial-thickness cuff tears were 74%, 100%, and 0.78, whereas those of CT arthrography were 22%, 38%, and 0.10, respectively (moderate level of evidence).

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 (moderate level of evidence). 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.

Stoppino et al. (2013) found that magnetic resonance arthrography showed a sensitivity of 92% and a specificity of 78% for the overall detection of tears involving the RC footprint. MRI is extremely accurate for the diagnosis of rotator cuff footprint tears as most of these lesions are articular-sided (moderate level of evidence).

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 (moderate level of evidence).

Chun et al. (2010) reported that MR arthrography is a useful diagnostic tool for partial-thickness rotator cuff tears, but has limitations in that it has low sensitivity in bursal- and articular-/bursal-sided tears. The sensitivities and specificities were 85% and 90% for articular surface tears, 62% and 95% for bursal surface tears, and 45% and 99% for both articular and bursal surface tears, respectively. Partial-thickness tears were overestimated as full-thickness tears. The interobserver agreement was excellent for articular-surface tears, moderate for bursal-sided tears, and fair for articular- and bursal-sided tears (low level of evidence).

Foad and Wijdicks (2012), in a study of 39 consecutive patients with MRI or MR arthrography undergoing subscapularis repair, found that MRI had a sensitivity of 40% and MR arthrography had a sensitivity of 36% for subscapularis tears (low level of evidence).

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 (low level of evidence).
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%) (low level of evidence).
Suspected recurrent rotator cuff tear (following rotator cuff repair) in patients who are candidates for surgical repair:

- **Green** – MRI and MR arthrography
- **Yellow** – CT arthrography in patients unable to undergo MRI
- **Yellow** – MR arthrography in patients with indeterminate findings on MRI
- **Yellow** – CT arthrography in patients with prior shoulder arthroplasty
- **Orange** – MRI or MR arthrography in patients with prior shoulder arthroplasty (see clinical note below)
- **Red** – PET, bone scan

**Level of Evidence:** Low

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:**
The ACR (Wise et al., 2011)* recommends MRI (9), MR arthrography (9) or ultrasound (9) for the diagnosis of recurrent rotator cuff tears following previous rotator cuff repair. CT arthrography (5) is recommended if MRI or ultrasound cannot be performed (5), or in patients with prior arthroplasty (7).

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.

**Clinical notes:**
- Areas of attenuation and areas of perforation may persist in patients with prior rotator cuff repair.
- MR and MR arthrography is useful primarily to evaluate for moderate or large full-thickness defects and tendon retraction.
- MRI, MR arthrography, CT arthrography and US are highly accurate methods for the diagnosis of full-thickness rotator cuff tears and tendon retraction.
- MRI and MR arthrography may be used in patients following shoulder arthroplasty if MRI systems utilize advanced metal suppression techniques (e.g., MAVERIC or WARP).
- MR arthrography can help overcome micrometallic artifact in patients who have undergone previous subacromial decompression and rotator cuff repair.

**Evidence update (2010-present):**
There were no new studies which significantly affected the conclusions and recommendations from the high quality guidelines noted above.
Suspected labral tear with or without instability following acute trauma or when symptoms are unresponsive to conservative therapy for 4-8 weeks:

- **Green** – MRI and MR arthrography
- **Green** – CT to assess and characterize bony Bankart lesions and Hill-Sachs deformities for surgical planning
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Yellow** – MR arthrography in a patient with indeterminate or nondiagnostic findings on MRI
- **Orange** – CT arthrography without prior MRI and without contraindications to MRI
- **Red** – bone scan, PET

**Level of Evidence:** High

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:**
Four out of four guidelines recommend MRI or MR arthrography for the evaluation of labral tears with or without instability in patients with acute injuries and/or in patients with chronic pain and no response to conservative therapy for 4-8 weeks.

Bussières et al. (2008) states that in the acute setting, conventional MRI nicely shows labral, Bankart, ligamentous, and tendinous injuries that result from dislocations and can lead to instability. In the setting of chronic instability, MR arthrography or CT arthrography best evaluates these lesions.

The *Colorado Department of Labor* guideline (2014) notes that MRI arthrography has the highest reported accuracy for the diagnosis and classification of SLAP lesions. The authors also note that it may be difficult to differentiate SLAP lesions, especially Type II lesions, from normal anatomic variants and from asymptomatic age-related changes. MRI may have a high negative predictive value with one retrospective study showing that with a negative MRI patients had only a 5% chance of having a SLAP lesion.

The *Colorado Department of Labor* guideline (2014) states that MRI, MR arthrography, or CT arthrography may be useful to evaluate for labral detachment and capsular stress injury or laxity after 4 to 8 weeks of active patient involvement in therapy. MRI and early surgical intervention may be considered following an acute dislocation in young patients active in sports and in older patients significant rotator cuff tears.

The *ACR* (Wise et al., 2011)* recommends MR arthrography (9) or MRI (7) to evaluate patients with suspected labral tear with or without instability on physical exam. CT arthrography is indicated (5) in patient with suspected labral tear who cannot undergo MRI.

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.

**Clinical notes:**
- Expert opinion recommends initial conservative care management for SLAP tears. Early surgery should be considered only in cases where there is evidence of symptomatic suprascapular nerve
compression by an associated paralabral cyst (Labor and Industries' Industrial Insurance Medical Advisory Committee (IIMAC), 2013).

- Early surgical repair and early imaging 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.
- MR arthrography is more accurate than MRI in diagnosing and excluding labral tears.
- 3T MRI and modern 1.5T MRI systems with optimized technique may have comparable accuracies to MR arthrography. (Arirachakaran et al., 2017; panel consensus opinion).
- In the acute setting, MRI without arthrography is useful in identifying joint effusions which, if present, indicate the presence of injuries to the intra-articular structures.
- If a patient is to undergo low field strength imaging because of claustrophobia or bariatric issues, MR arthrography should be considered instead of MRI to improve diagnostic accuracy for the detection of labral tears (panel consensus opinion).
- CT arthrography and MR arthrography have comparable diagnostic accuracy in evaluation of SLAP tears, Bankart lesions, and Hill-Sachs fractures; however, CT arthrography exposes the patient to ionizing radiation.
- CT without arthrography can be used to detect and grade bony Bankart lesions and Hills Sachs deformities prior to surgery.

Evidence update (2010-present):
There were no new studies which significantly affected the conclusions and recommendations from the guidelines noted above. Specific studies of interest are summarized below.

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 (moderate level of evidence). 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.

Oh et al. (2010), in a study of 168 consecutive patients who underwent CT arthrography or MR arthrography of the shoulder and a subsequent arthroscopic surgical procedure, found that the diagnostic efficacy for labral lesions (SLAP and Bankart lesions) was excellent with both imaging studies (moderate level of evidence).

Simão et al. (2012) reported on an MRI study of fifty-six consecutive patients with diagnosis of chronic anterior instability of the shoulder evaluated for assessment of bone and soft tissue lesions (moderate level of evidence). Twenty-five cases were confirmed by surgery. MR arthrography sensitivity ranged from 80-100% and specificity from 50-100% with good interobserver agreement (0.54-0.70). Ultrasound sensitivity ranged from 20-100% and specificity from 25-90% with fair interobserver agreement (0.19-0.40).

Smith et al. (2012a), 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%) (moderate 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% (low level of evidence).
Suspected long head of the biceps tendon tear/tendinopathy:

- **Green** – MRI or MR arthrography
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Yellow** – MR arthrography in a patient with discordant MRI findings and symptoms
- **Orange** – CT
- **Red** – bone scan, PET

**Level of Evidence:** Low

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:**
The *Colorado Department of Labor* guideline (2014) recommends advanced imaging in patients with suspected full-thickness biceps tendon tear and in patients whose symptoms persist after 4-6 weeks of conservative therapy.

The *ACR* (Wise et al., 2011)* recommends MRI (9) or US (9) in the evaluation of questionable bursitis or long head of biceps tenosynovitis base on clinical findings with radiographs noncontributory.

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.*

**Clinical 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 report snapping with a subluxing tendon (*Colorado Department of Labor* guideline, 2014).
- Immediate sharp pain in the biceps region 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* guideline, 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.
- 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.
- MRI and ultrasound are accurate for the diagnosis of full-thickness biceps tendon tears.
- MRI, MR arthrography, and US have limited diagnostic accuracy for the evaluation of biceps tendinosis and partial-thickness tearing.
- 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.
- CT arthrography and MR arthrography have comparable diagnostic accuracies, however, CT exposes the patient to ionizing radiation.
- 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 (panel consensus opinion).
**Evidence update (2010-present):**
There were no new studies which significantly affected the conclusions and recommendations from the guidelines noted above. Specific studies of interest are summarized below.

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 (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 (low level of evidence).

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 (low level of evidence).

- 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.
Suspected adhesive capsulitis with noncontributory radiographs:

- **Green** – MRI
- **Yellow** – MR arthrography in a patient for initial evaluation or with indeterminate MRI without contrast
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Orange** – CT or CT arthrography as the initial study without contraindications to MRI
- **Red** – bone scan or PET

**Level of Evidence:** Low

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:**
The *American Physical Therapy Association* guideline (Kelley et al., 2013) states that MRI may help with the diagnosis of adhesive capsulitis, as several studies have shown abnormalities of the capsule and rotator cuff interval in patients with adhesive capsulitis.

Bussières et al. (2008) states that for adhesive capsulitis (frozen shoulder), MRI with direct or indirect arthrogram should be considered before manipulation. They state that 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.

**Clinical 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 (*American Physical Therapy Association* guideline (Kelley et al., 2013)).
- The key clinical difference between adhesive capsulitis and rotator cuff impingement or tear is stiffness (limitation of passive range). In the initial stages when the stiffness is not necessarily especially evident, clinical diagnosis can be difficult.
- Adhesive capsulitis may follow trauma, myocardial infarction, neck or cardiac surgery, radiation therapy, and prolonged immobilization (*American Physical Therapy Association* guideline (Kelley et al., 2013)).
- Risk factors for adhesive capsulitis include diabetes and thyroid disease (*American Physical Therapy Association* guideline (Kelley et al., 2013); *University of New South Wales* guideline (Hopman et al., 2013)).
- Plain 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.
- Thickening of the axillary capsule with T2 hyperintensity are useful criteria for the diagnosis of adhesive capsulitis. PD and STIR imaging are more sensitive than T2 images for hyperintensity.
- Patients with adhesive capsulitis show effacement of fat within the anterior rotator cuff interval with both capsular and glenohumeral ligamentous thickening.
- Rotator interval enhancement may increase the specificity of adhesive capsulitis on contrast-enhanced MRI (Ahn et al., 2015).
Patients with adhesive capsulitis may also show a disproportionate amount of fluid within the biceps tendon sheath and subacromial recess relative to fluid in the joint space (panel consensus opinion).

Evidence update (2010-present):
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 rotator cuff 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 to quantitate glenoid version, subchondral cystic changes, and posterior glenoid wear
- **Green** – MRI to evaluate the integrity of the rotator cuff
- **Yellow** – CT arthrography to evaluate the integrity of the rotator cuff in a patient unable to undergo MRI
- **Red** – PET, bone scan

**Level of Evidence:** Low

**Notes concerning applicability and/or patient preferences:** none

**Guideline summary:** No guidelines have addressed this topic.

**Clinical notes:**

- Conventional radiographs are the initial study of choice for the detection and evaluation of osteoarthritis.
- Conventional radiographs with axillary views are useful for the detection of and to follow posterior glenoid wear.
- Quantifying glenoid version and the presence or severity of subchondral cystic change is useful for surgical planning in anticipation of shoulder arthroplasty.
- Total shoulder arthroplasty with the glenoid component implanted in retroversion predisposes to loosening of the glenoid prosthesis. Correction of glenoid retroversion through anterior eccentric reaming, before glenoid component implantation, is performed to restore normal joint biomechanics. Accurate preoperative assessment is required to ascertain the degree of retroversion and calculate the degree of reaming (Raymond et al., 2013).
- 3D-CT may be more accurate than 2D-CT in the assessment of glenoid version and may change surgical planning in a significant number of cases.
- 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.

**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 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 plain 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 2D-CT versus 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 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 2D (p < 0.006). Surgical decision making changed 39% of the time in the 3D vs 2D assessment (low level of evidence).
Persistent nonspecific shoulder pain with indeterminate history, physical examination, and radiographs, and with failure of conservative care:

- **Green** – MRI
- **Yellow** – CT arthrography in a patient unable to undergo MRI
- **Yellow** – bone scan to evaluate for neoplasm in patients with a history of cancer
- **Orange** – PET (to evaluate indeterminate lesions on CT or MRI in patients with specific pathologic diagnoses)
- **Red** – MR arthrography without history, clinical exam, or previous studies indicating a labral tear or instability
- **Red** – CT arthrography without a contraindication to MRI

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 applicability and/or patient preferences: none

Guideline summary:
Bussières et al. (2008) states that advanced imaging with MRI may be indicated in patients with nontraumatic shoulder pain with full or limited movement if there is no response to care after 4 weeks. They conclude that MRI provides the best imaging details for evaluation of shoulder pathology (osteonecrosis, marrow, and joint disease including infection). They state that, while cost-effective, ultrasonography is operator-dependent and is mostly useful for the diagnosis of full-thickness rotator cuff tears.

The ACR (Wise et al., 2011)* recommends MRI (9) for the evaluation of persistent shoulder pain with nonspecific history and physical findings and radiographs noncontributory. CT arthrography (5) and/or ultrasound (5) are indicated if the patient is unable to undergo MRI.

*The ACR guideline did not meet the AGREE II threshold for inclusion in the CDI Quality Institute guidelines. However, because of the direct relevance of the ACR guideline topics, it was included at the discretion of the shoulder expert panel. A lower AGREE II score may indicate an increased risk of bias.

Clinical notes:
- Ultrasound is useful and accurate for the evaluation of full-thickness rotator cuff tears and for the evaluation of biceps tendon pathology.
- MRI is accurate for the evaluation of rotator cuff pathology, full-thickness biceps tendon tears, and labral tears.
- MRI has a low sensitivity but higher specificity for the diagnosis of chondral lesions.
- MRI is useful for the diagnosis of early radiographically occult osteoarthritis (panel consensus opinion).

Evidence update (2010-present):
There were no new studies which significantly affected the conclusions and recommendations from the guidelines noted above.
General Exclusions:

- AC joint disorders;
- Crystal deposition disease;
- Suspected infection and/or inflammatory arthritis;
- Suspected fracture and fracture for surgical planning;
- Plain radiographs suspicious for neoplasm;
- Primary soft tissue or bone neoplasm;
- Suspected AVN or osteonecrosis and AVN for surgical planning;
- Suspected synovial abnormality (such as osteochondromatosis or PVNS);
- Suspected extra-articular tendon, muscle, or bursal abnormality (pectoralis major tear);
- Painful total joint arthroplasty.