CLINICAL PRACTICE GUIDELINE: SHOULDER PAIN (3A)

SYSTEMATIC REVIEW FOR IMAGING OF SHOULDER PAIN (INCLUDING ROTATOR CUFF INJURY)

CPG 3A Abstract (Updated March 2018)

The complex anatomy and physiology of the shoulder underscores the fact that shoulder pain is a common musculoskeletal complaint. Shoulder pain/dysfunction has a wide array of causes including traumatic injury as well as acute and chronic inflammation of the joint itself, its tendons, ligaments, or periarticular structures. Such complexity, in turn, requires familiarity with different imaging options in order to choose the best study based on a given clinical scenario.

There is general agreement that plain film radiography or X-ray (XR) is the initial imaging modality for nearly all shoulder pathologies. XR is often the only imaging study needed for the evaluation of acute shoulder trauma, calcific tendonitis, and osteoarthritis involving the shoulder (Willick & Sanders, 2004).

Computed tomography (CT) is less frequently used for shoulder imaging and is generally reserved for evaluation of fractures, angulation/displacement, and prosthetic shoulder joints. Access to axial, sagittal, coronal, as well as 3-dimensional (3D) images provided by CT imaging is central for pre-operative planning.

Given the superior ability of magnetic resonance imaging (MR) to delineate soft tissue structures, MR is often the imaging modality of choice when evaluating the rotator cuff, the biceps muscle, tendons/ligaments, and bursae. When MR images remain unclear, arthrography can be used in conjunction (i.e., MR-arthrography) to help outline intra-articular structures differentiating them from surrounding soft tissue.

US has a role in the evaluation of bone and soft tissue structures, is free of radiation hazard, and is cost-effective. However, this technique is highly operator dependent and may be difficult for others not involved in the scanning process to interpret. It is an excellent technique for diagnosing disorders such as rotator cuff tears, superficial tendon integrity, and synovial fluid collections. US can be used to guide needle aspiration of fluid collections and inject corticosteroids into areas of inflammation.

Multiple factors affect the decision-making process when evaluating the appropriateness of ordering imaging studies. These include availability, patient preference and expectations, risks such as radiation exposure or unnecessary procedures, prior imaging results, and presence of contraindications (e.g. pregnancy, contrast allergy, renal insufficiency) for a specific modality. Further, such factors are not always quantifiable and frequently vary across therapeutic settings. Panelists review available literature to recommend appropriate imaging studies in specific clinical scenarios but must realize that these other variables impact the decision-making process and are not necessarily addressed by published literature. In the recommendation justifications, these issues would be part of the consideration, especially when the resulting "grade" is judged to be "Consensus" rather than based upon strong clinical evidence.

Search Strategy: A systematic search and thorough review was conducted of the current medical literature published through January 2018. Below mentioned databases were systematically searched for literature pertaining to shoulder pain and associated imaging. Articles concentrating on the pediatric population were excluded. The search was focused on diagnostic imaging techniques as opposed to treatment modalities. Final inclusion was based on the specific PICO question being addressed.

Keywords: Shoulder pain, shoulder x-ray, shoulder CT, shoulder US, shoulder MRI, shoulder MR, shoulder lesion, shoulder fracture, arthrography, shoulder arthrography, shoulder trauma, rotator cuff tear, shoulder injury

Methods: The databases mentioned below were used to identify relevant publications. Abstracts and unpublished studies were not included. An initial search for shoulder pain in adults and imaging found 3435 citations. The search was further limited by adding the terms "diagnosis" and "English only" which resulted in 1047 citations. After further review, 125 relevant studies were obtained in full text form. These studies were then reviewed by the committee for inclusion. Articles for final analysis were chosen based on study design, quality of research, publication date, sample size and relevance.

Database source: ResearchGate, PubMed, Cochrane Library, Google Scholar, Cochrane Central Registry of Controlled Trials, the Cochrane Database of Systematic Reviews

Clinical Focus Questions

PICO #1: In adults with shoulder pain (traumatic or non-traumatic) when is management without imaging appropriate for optimal patient outcome(s)?

PICO #2: In adults with shoulder pain (traumatic or non-traumatic) which clinical scenarios warrant initial imaging with XR for optimal patient outcome(s)?

PICO #3: In adults presenting with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with US for optimal patient outcome(s)?

PICO #4: In adults with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with CT for optimal patient outcome(s)?

PICO #5: In adults with shoulder pain (traumatic or non-traumatic) when is MR imaging warranted for optimal diagnostic accuracy?

PICO #6: In adults with shoulder pain who are surgical candidates, have had an MR and require arthrography, is MR-arthrography recommended compared to CT-arthrography for optimal patient outcome(s)?

PICO #1: In adults with shoulder pain (traumatic or non-traumatic) when is management without imaging appropriate for optimal patient outcome(s)?

SEMPI Grading QOE — Table 3A.1a—Summary of Findings						
PICO #1: In adults with shoulder pain (traumatic or non-traumatic) when is management without imaging appropriate for optimal patient outcome(s)?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Codogan et al., 2013 Diagnostic accuracy of clinical examination features for identifying large rotator cuff tears in primary health care	Prospective consecutive blinded cohort study	203 adults evaluated for shoulder pain (RCT)	Clinical assessment versus imaging (XR and US)	24 patients had RCT. Constant pain (OR 3.04) and pain with abduction (OR 13.97) were the strongest predictors of RCT Combinations of ten history and physical examination variables demonstrated highest levels of sensitivity when five or fewer were positive: Sensitivity = 100%, (95: 0.86–1.00) --LR = 0.00 (95: 0.00–0.28] and highest specificity when eight or more were positive: Specificity = 0.91 (95: 0.86–0.95) +LR = 4.66 (95: 2.34–8.74)	Combinations of patient history and physical examination findings were able to accurately detect the presence of a MLM rotator cuff tear	**Moderate**
Hegedus et al., 2012 Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review with meta-analysis of individual tests	Systematic literature review with meta-analysis QUADAS was used to critique the quality of each paper (77 studies included)	Adults with shoulder complaints undergoing physical exam	Clinical assessment vs imaging or operative findings	Combinations of shoulder physical exam (ShPE) tests provide better accuracy. These findings stress a comprehensive clinical examination including history and physical examination	Use of any single shoulder physical exam (ShPE) test to make a pathognomonic diagnosis cannot be unequivocally recommended	**Moderate**

Diercks et al., 2014 Guideline for Diagnosis and Treatment of Subacromial Pain Syndrome: a Multidisciplinary Review by the Dutch Orthopaedic Association	Systematic literature review using Grade methodology	Adults evaluated for shoulder pain	Clinical assessment versus imaging versus operative findings (when available)	Ultrasound is advised as the most valuable and cost-effective diagnostic imaging modality if a first period of non-operative treatment fails – usually 6 wks	To determine subacromial pain syndrome (SAPS) or 'subacromial impingement syndrome', a combination of the Hawkins-Kennedy test, the painful arc test, and the infraspinatus muscle strength test should be used; and for a rotator cuff tear, the drop-arm test and the infraspinatus and supraspinatus muscle strength tests should be used	**Low**
Hahn et al., 2015 Predictors of Clinically Significant Radiographic Shoulder Pathology in the Emergency Department	Retrospective review	Adults presenting to the ED with a complaint of shoulder pain who were imaged by plain radiograph (XR)	Clinical exam versus XR findings (Univariate screening was performed to find variables associated with injury and were subsequently included in a multivariable prediction model)	Five of the predetermined factors were found to be associated with the likelihood of injury: -history of trauma -range of motion -deformity -age -duration of pain Receiver operating characteristics revealed an area under the curve of 80%.	It is not practical to develop clinical decision radiograph ordering rules for ED patients with shoulder pain	**Low**
Fraenkel et al., 1998 The Use of Radiographs to Evaluate Shoulder Pain in the ED	Retrospective review	312 adult patients evaluated for shoulder pain	Clinical exam versus XR findings Radiographs were classified as therapeutically uninformative (TU) & therapeutically informative (TI) –	Deformity present on shoulder examination was the strongest discriminating variable and correctly classified 21 of 23 subjects as having informative X-rays. Of the remaining patients (n = 162), only those older than 43.5 years with a history of a precipitating fall (n = 40) had a high likelihood of having	This study suggests that clinical variables (e.g., deformity, precipitating fall) can distinguish between patients with positive and negative X-rays	**Low**

			i.e., requiring therapy	therapeutically informative X-rays. No patients without a deformity or fall (n = 90) had an informative XR		
Fraenkel et al., 2000 Improving the selective use of plain radiographs in the initial evaluation of shoulder pain	Prospective, cohort study	206 adult ER patients with shoulder pain who were evaluated by plain film (XR) radiography Patients with deformities, penetrating wounds, referred pain, and f/u patients were excluded	Clinical exam versus XR findings Radiographs were classified as therapeutically uninformative (TU), fracture, AC joint separation, infection, or malignancy	3 sets of low risk patients with a high percentage of TU radiographs were identified: (1) no fall, no swelling (99% TU, n = 106) (2) a fall, but no swelling, and no pain at rest (100% TU, n = 18) (3) a fall, pain at rest, but no swelling and normal range of motion (100% TU, n = 10)	Specific clinical criteria (no swelling, normal range-of-motion) are capable of identifying patients who do not need radiographs in the initial evaluation of shoulder pain	**Moderate**
Initial QOE Score across studies for PICO #1: **Moderate (2)**						

SEMPI Grading QOE — Table 3A.1b—Risk of Bias		
PICO #1: In adults with shoulder pain (traumatic or non-traumatic) when is management without imaging appropriate for optimal patient outcome(s)?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	Highly pre-selected patients (often only including those who were imaged) with no follow-up data
Inconsistency	Serious	Studies differed in type of shoulder pathology investigated
Indirectness	Not Serious	Indirectness reflected in 'Inconsistency' downgrade above
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	Accuracy data with wide confidence intervals
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: Downgraded to Low		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE — Table 3A.1c—Evidence to Recommendations				
PICO #1: In adults with shoulder pain (traumatic or non-traumatic) when is management without imaging appropriate for optimal patient outcome(s)?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Codogan et al., 2013 Diagnostic accuracy of clinical examination features for identifying large rotator cuff tears in primary health care	Combinations of patient history and physical examination findings were able to accurately detect the presence of a MLM rotator cuff tear	Moderate	Low (3)	Consensus (B)
Hegedus et al., 2012 Which physical examination tests provide clinicians with the most value when examining the shoulder? Update of a systematic review w/ meta-analysis of individual tests	Combinations of shoulder physical exam (ShPE) tests provide better accuracy. These findings stress a comprehensive clinical examination including history and physical examination	Moderate		
Diercks et al., 2014 Guideline for Diagnosis and Treatment of Subacromial Pain Syndrome: a Multidisciplinary Review by the Dutch Orthopaedic Association	To determine 'subacromial impingement syndrome', a combination of the Hawkins-Kennedy test, the painful arc test, and the infraspinatus muscle strength test should be used; and for a rotator cuff tear, the drop-arm test and the infraspinatus and supraspinatus muscle strength tests should be used	Low		
Hahn et al., 2015 Predictors of Clinically Significant Radiographic Shoulder Pathology in the Emergency Department	It is not practical to develop clinical decision radiograph ordering rules for ED patients with shoulder pain	Low		
Fraenkel et al., 1998 The Use of Radiographs to Evaluate Shoulder Pain in the ED	This study suggests that clinical variables (e.g., deformity, precipitating fall) can distinguish between patients with positive and negative X-rays	Low		
Fraenkel et al., 2000 Improving the selective use of plain radiographs in the initial evaluation of shoulder pain	Specific clinical criteria are capable of identifying patients who do not need radiographs (no swelling, normal range-of-motion) in the initial evaluation of shoulder pain	Moderate		

Recommendation Rating: 3B—Consensus recommendation for the intervention based on low quality evidence
Justification: Significant risk of bias and heterogenous literature is sufficient to downgrade the evidence and strength of recommendation to 'Consensus'

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**

Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: Clinical evaluation of shoulder discomfort has limited ability to discern the cause of shoulder pathology. Due to the lack of diagnostic decision rules, the threshold to perform additional diagnostic evaluation remains low. However, many common shoulder conditions can be diagnosed without imaging, and may be initially treated conservatively (rest, topical analgesics, and physical therapy). Pain, loss of strength, decreased range of motion and instability are the most common symptoms that can be caused by different shoulder pathologies. A systematic clinical examination of the shoulder joint (history and physical tests) can help in establishing a diagnosis or form the basis for further diagnostic imaging.

Final Recommendation: **3B**—In adults with shoulder pain (traumatic or non-traumatic) conservative management without initial imaging is recommended when a diagnosis is established by clinical exam (e.g. frozen shoulder) or **all** the following physical exam findings are present:

- Normal range of motion (with or without impingement symptoms)
- No deformity or instability
- No loss of strength or muscle atrophy

PICO #2: In adults with shoulder pain (traumatic or non-traumatic) which clinical scenarios warrant initial imaging with XR for optimal patient outcome(s)?

SEMPI Grading QOE —Table 3A.2a—Summary of Findings						
PICO #2: In adults with shoulder pain (traumatic or non-traumatic) which clinical scenarios warrant initial imaging with XR for optimal patient outcome(s)?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Kahn et al., 2007 The role of post-reduction radiographs after shoulder dislocation	Prospective, observational cohort Blinded radiologists	N=55 ER setting	XR pre/post-shoulder dislocation reduction	16 fractures were seen on post-reduction XR, of which, 6 (37.5%) were not seen on pre-reduction XR	Although the majority of fractures associated with shoulder dislocations are seen on pre-reduction x-rays, foregoing post-reduction x-rays will miss approximately one-third of fractures associated with shoulder dislocation	**Moderate**
Bahrs et al., 2009 Indications for computed tomography (CT-) diagnostics in proximal humeral fractures: a comparative study of plain radiography and computed tomography	Prospective, consecutive enrollment, comparative study 2 Level 1 Trauma centers	N=44 proximal humerus fracture	Plain film (XR) imaging and CT imaging of proximal humerus fracture (all patients had both XR and CT)	Conventional X-rays with AP view and a scapular Y-view are useful for primary diagnostics of the fracture CT allowed a significantly better assessment of the relevant structures than XR in complex fractures CT should be performed when the proximal humerus and the shoulder joint are not presented with sufficient X-ray-quality to establish a treatment plan	Plain film radiography (XR) is recommended as "first line" imaging in patients with suspected shoulder fracture If image quality impairs fracture visualization or if osseous overlap prevents the visualization of the fractured structures, CT should be performed	**Low**
Moor et al., 2013 Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?	Retrospective case-control study	N=277 Controls (63) OA (92) RCT (122) OA-osteoarthritis	XR-determined critical shoulder angle (CSA) as predictor of surgery-proven OA or RCT	Inter-observer reliability was high with a bias of 0 degrees between the 2 readers; mean CSA was 33.1° (26.8° to 38.6°) in the control group, 38.0° (29.5° to 43.5°) in the RCT group and 28.1° (18.6° to 35.8°) in the OA group. Of patients with a CSA >	This study introduces a new XR tool, the critical shoulder angle (CSA). Glenohumeral osteoarthritis (OA) is associated with significantly smaller CSAs. Degenerative rotator cuff tear (RCT) is associated with significantly larger CSAs.	**Low**

		RCT-rotator cuff tear		35°, 84% were in the RCT group and of those with a CSA < 30°, 93% were in the OA group. A significant difference (p < 0.0001) of 5° between controls and both RCT and OA groups (95% CI, 4.0-6.0) Sens/Spec for RCT: 0.82/0.92; OA: 0.79/0.97		
Mitchell et al., 2005 Shoulder pain: diagnosis and management in primary care	Systematic review (7 systematic reviews)	N/A	N/A	**Red Flag indicators** **-**History of cancer; symptoms and signs of cancer; unexplained deformity, mass, or swelling: **possible malignancy** -Red skin, fever, systemically unwell: **infection** -Trauma, epileptic fit, electric shock; loss of rotation and normal shape: **unreduced dislocation** -Trauma, acute disabling pain and significant weakness, positive drop arm test: **acute rotator cuff tear** -Unexplained significant sensory or motor deficit: **neurological lesion**	Referral to orthopedic surgery (including radiography) is indicated only if there are "red flag" signs/symptoms of systemic disease (weight loss, generalized joint pains, fever, lymphadenopathy, new respiratory symptoms); history of cancer; or concerning local features such as a mass lesion or bony tenderness or swelling	**Very Low**
Initial QOE Score across studies for PICO #2: **Low (3)**						

TERMS: CSA-Critical shoulder angle; RCT-Rotator cuff tear

SEMPI Grading QOE – Table 3A.2b—Risk of Bias		
PICO #2: In adults with shoulder pain (traumatic or non-traumatic) which clinical scenarios warrant initial imaging with XR for optimal patient outcome(s)?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **LOW**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Not Serious	Studies not randomized, referral population, retrospective in many cases
Inconsistency	Not Serious	
Indirectness	Serious	"Pre-selected" patients not applicable to general population
Imprecision	Serious	XR often providing "surrogate" markers, not specific pathologic process
Positive Bias		
Strength of Association	Low	No direct comparators
Other Consideration	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE — Table 3A.2c—Evidence to Recommendations

PICO #2: In adults with shoulder pain (traumatic or non-traumatic) which clinical scenarios warrant initial imaging with XR for optimal patient outcome(s)?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Kahn et al., 2007 The role of post-reduction radiographs after shoulder dislocation	Although the majority of fractures associated with shoulder dislocations are seen on pre-reduction x-rays, foregoing post-reduction x-rays will miss approximately one-third of fractures associated with shoulder dislocation	Moderate	Low (3)	Strong (A)
Bahrs et al., 2009 Indications for computed tomography (CT-) diagnostics in proximal humeral fractures: a comparative study of plain radiography and computed tomography	Plain film (XR) imaging is recommended as the first line of imaging in patients with suspected shoulder fracture. If image quality impairs fracture visualization or if osseous overlap prevents the visualization of the fractured structures, CT should be performed.	Low		
Moor et al., 2013 Is there an association between the individual anatomy of the scapula and the development of rotator cuff tears or osteoarthritis of the glenohumeral joint?	Glenohumeral osteoarthritis (OA) is associated with significantly smaller CSAs. Degenerative rotator cuff tear (RCT) is associated with significantly larger CSAs.	Low		
Mitchell et al., 2005 Shoulder pain: diagnosis and management in primary care	Referral to orthopedic surgery (including radiography) is indicated only if there are "red flag" signs/symptoms of systemic disease (weight loss, generalized joint pains, fever, lymphadenopathy, new respiratory symptoms); history of cancer; or concerning local features such as a mass lesion or bony tenderness or swelling	Very Low		

Recommendation Rating: 3A—Strong recommendation for the intervention based on low quality evidence

Justification: Low quality evidence supports XR as initial imaging modality for shoulder pain, but XR is the usual and customary practice.

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**

Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: Plain radiography (XR) has been generally accepted/recommended as the initial screening modality for adults presenting with shoulder pain. This is based upon long-standing consensus practice and professional society guidelines (Codsi & Howe 2015; IIMAC, 2013). XR is often the only imaging study needed for the evaluation of various conditions affecting the shoulder joint including acute shoulder trauma, calcific tendonitis, and arthritis. XR can be used to assess osteoarthritis of the acromioclavicular and glenohumeral joints as well as for secondary signs of a large rotator cuff tear such as superior migration of the humeral head. Additionally, plain film radiography (XR) is the modality of choice for initial evaluation of shoulder arthroplasty. XR demonstrates complications of the prosthesis such as fracture, subluxation or dislocation, glenoid or humeral component loosening, and peri-prosthetic bone resorption due to particle disease (Feldman, 2006).

Final Recommendation: **3A**—In adults presenting with shoulder pain (traumatic or non-traumatic), initial imaging with XR is recommended in the following clinical scenarios:

- significant trauma involving the shoulder joint and fracture suspected
- decreased range of motion, deformity, instability or loss of strength with history of trauma
- persistent pain/disability involving the shoulder joint despite conservative management
- post-procedural imaging (e.g. arthroplasty, post-reduction)

PICO #3: In adults presenting with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with US for optimal patient outcome(s)?

SEMPI Grading QOE – Table 3A.3a—Summary of Findings						
PICO #3: In adults presenting with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with US for optimal patient outcome(s)?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Ottenheijm et al., 2010 Accuracy of diagnostic ultrasound in patients with suspected subacromial disorders: a systematic review and meta-analysis	Meta-analysis	Full thickness tear- 22 studies, N=1,843 Partial thickness tear- 15 studies, N=1,456 Subacromial bursitis-3 studies, N=377 Calcifying tendinitis-2 studies, N=300 Tendinopathy- 2 studies, N=97	US vs surgical confirmation (one study used MRI as reference standard)	Full thickness tear- Sensitivity-95% Specificity-96% Partial thickness tear- Sensitivity-72% Specificity-93% Subacromial bursitis- Sensitivity-79-81% Specificity-94-98% Calcifying tendinitis- Sensitivity-100% Specificity-85-98% Tendinopathy- Sensitivity-67 and 93% Specificity-88 and 100%	"US can be used to rule in or out full thickness tears, ruled out partial thickness tears and to a lesser extent diagnose tendinopathy, Subacromial bursitis and calcifying tendinitis in patients for whom conservative treatment failed."	**Moderate**
Milosavljevic et al., 2005 Ultrasonography of the rotator cuff: a comparison with arthroscopy in one-hundred-and-ninety consecutive cases	Prospective, unblinded, referral population	N=190 Preop US with Hx of shoulder pain > 3 mos US 3 Dx's: intact, partial-thickness, or full-thickness RCT; correlated with shoulder arthroscopy	US vs arthroscopy	US diagnosed 118 of 124 RCT: Sensitivity 95%, Specificity 94%, PPV 97%, NPV 91% and Accuracy 95% 94 of 94 **full-thickness** RCT- Sensitivity 100%, Specificity 91%, PPV 91%, NPV 100%, and Accuracy 95% 24 of 30 **partial-thickness** RCT- Sensitivity 80%, Specificity 98%, PPV 86%, NPV 96%, and Accuracy 95%	Pre-op US is accurate diagnostic method for detecting **full-thickness** RCT, but is less sensitive in detecting **partial-thickness** RCT	**Moderate**

Swen et al., 1999 Sonography and magnetic resonance imaging equivalent for the assessment of full-thickness rotator cuff tears	Prospective, consecutive enrollment, blinded Only included full-thickness RCT; unclear method of patient selection	N=21 shoulder symptoms from 'possible' full-thickness RCT; US read by radiologist & rheumatologist. MR was evaluated by 2 radiologists. US, MR, and arthroscopy results scored as -/+ for full-thickness RCT Arthroscopy- "gold" standard	US, MR vs arthroscopy	For **full-thickness** RCTs: Sensitivity-0.81-US and 0.81 -MR Specificity-0.94-US and 0.88-MR Positive predictive value- 0.96-US and 0.91-MR Negative predictive value-0.77-US and 0.74-MR Accuracy-0.86-US and 0.83- MR	Pre-op US and MR are equivalent in their ability to accurately diagnose **full-thickness** RCTs US can be done by non-radiologist (i.e. rheumatologist trained in US technique), is less costly and widely available	**Moderate**
Kayser et al., 2005 Validity of ultrasound examinations of disorders of the shoulder joint	Prospective, cross-over, double blind, highly-skilled US provider (one >> other), referral population	N=239 US 4 diagnoses: total/partial RCTs, calcific tendinitis, biceps tendon injuries, subacromial bursitis. Examiner A-US provider and Examiner B-operated in week 1; Examiner B- US provider and Examiner A-operated in week 2. The surgeon was blinded to US results	US vs arthroscopy	**Complete RCT** US: Sensitivity-- 0.99, Specificity--0.99 Accuracy--98.7% Examiners were 'comparable' **Partial RCT** US: sensitivity-- 0.79 Specificity--0.91 Accuracy--88.7% Examiner A: (0.92--0.95) --94.7% Examiner B: (0.68 --0.86) --81.3% **Long biceps tendon** US: Sensitivity--0.53 Specificity--0.9 Accuracy--95.3% Examiner A: (0.58--0.99) --91.7% Examiner B: (0.33--0.97) -- 95.3% **Calcific tendinitis** US: Sensitivity--1.0 Specificity--0.98 Accuracy--98.3 Both examiners identified all 32	Preoperative US of the shoulder permits a reliable diagnosis of complete RCTs and calcium deposits (calcific tendinitis) US can also be used to diagnose partial RCTs and pathology of the long head biceps tendon	**High**

Armstrong et al., 2006 The efficacy of ultrasound in the diagnosis of long head of the biceps tendon pathology	Prospective, consecutive enrollment, inclusion/exclusion defined, OR confirmation	N=71, patients with shoulder pain evaluated by US for long head biceps tendon abnormalities	US vs Arthroscopy	Arthroscopy "gold standard" US--100%-Specificity; 96%--Sensitivity for subluxation or dislocation US detected **all complete ruptures of the biceps tendon** but detected **none of the 23 partial-thickness tears** US diagnosed 35 of 36 normal biceps tendons (Specificity=97%) and 17 of 35 abnormal biceps tendons (Sensitivity, 49%)	US can diagnose complete rupture, subluxation, or dislocation of the biceps tendon It is not reliable for detecting intra-articular partial-thickness tears of the biceps tendon	**Moderate**
Naredo et al., 2004 A randomized comparative study of short term response to blind injection versus sonographic-guided injection of local corticosteroids in patients with painful shoulder	Randomized, prospective, no prior injections or treatments, excluded trauma pts, Rheumatologists blinded to treatment; selection methods not identified	N=41 (20-blind injection vs 21-US guided inj) Clinical assessment included: a visual analog scale (VAS) for pain (0-100), the Shoulder Function Assessment (SFA) scale (0-70), and post-injection adverse effects	Blind vs US-guided steroid injection of shoulder	6 wks after injection, the VAS and the SFA score showed significant improvement in Grp 2 (US-guided) vs Grp 1 (blind injection)-mean VAS score change 34.9 for-Grp 2 vs 7.1 for Grp 1, $p < 0.001$; mean SFA score change 15 for Grp 2 vs 5.6 for Grp 1, $p = 0.012$). One patient in Grp 1 reported post-injection Adverse Event	US-guided corticosteroid injection of the shoulder is preferred to blind injection to improve therapeutic efficacy	**High**
Park et al., 2015 Palpation Versus Ultrasound-Guided Acromioclavicular Joint Intra-articular Corticosteroid Injections: A Retrospective Comparative Clinical Study	Retrospective cohort review	100 patient charts reviewed. 50 had ultrasound guided injections. 50 palpation guided injections	US guidance vs palpation guided injections	48/50 of US group were injected successfully. 31/50 of the palpation group were injected successfully. There was a significant difference in improvement at three months and six months in the ultrasound group	US guided corticosteroid injections showed a significant difference in the alleviation of symptoms compared to palpation guidance	**Low**
Initial QOE Score across studies for PICO #3: **Moderate (2)**						

TERMS: CSA-Critical shoulder angle; RCT-Rotator cuff tear

SEMPI Grading QOE – Table 3A.3b—Risk of Bias		
PICO #3: In adults presenting with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with US for optimal patient outcome(s)?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	Selection criteria not identified, blinding inconsistent, referral populations, often small N
Inconsistency	Not Serious	Articles deal with different uses of US but are consistent in their results
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Confirmed histopathology/direct visualization-OR, arthroscopy, arthrography
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **MODERATE**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE – Table 3A.3c—Evidence to Recommendations				
PICO #3: In adults presenting with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with US for optimal patient outcome(s)?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Ottenheijm et al., 2010 Accuracy of diagnostic ultrasound in patients with suspected subacromial disorders: a systematic review and meta-analysis	US can be used to rule in or out full thickness tears, ruled out partial thickness tears and to a lesser extent diagnose tendinopathy, subacromial bursitis and calcifying tendinitis in patients for whom conservative treatment failed.	Moderate	Moderate (2)	Strong(A)
Milosavljevic et al., 2005 Ultrasonography of the rotator cuff: a comparison with arthroscopy in one-hundred-and-ninety consecutive cases	Pre-op US is accurate diagnostic method for detecting **full-thickness** RCT, but is less sensitive in detecting **partial-thickness** RCT	Moderate		
Swen et al., 1999 Sonography and magnetic resonance imaging equivalent for the assessment of full-thickness rotator cuff tears	Pre-op US and MR are equivalent in their ability to accurately diagnose **full-thickness** RCTs US can be done by non-radiologist (i.e. rheumatologist trained in US technique), is less costly and widely available	Moderate		
Kayser et al., 2005 Validity of ultrasound examinations of disorders of the shoulder joint	Preoperative US of the shoulder permits a reliable diagnosis of complete RCTs and calcium deposits (calcific tendinitis) US can also be used to diagnose partial RCTs and pathology of the long head biceps tendon	High		

Armstrong et al., 2006 The efficacy of ultrasound in the diagnosis of long head of the biceps tendon pathology	US can diagnose complete rupture, subluxation, or dislocation of the biceps tendon It is not reliable for detecting intra-articular partial-thickness tears of the biceps tendon	Moderate		
Naredo et al., 2004 A randomized comparative study of short term response to blind injection versus sonographic-guided injection of local corticosteroids in patients with painful shoulder	US-guided corticosteroid injection of the shoulder is preferred to blind injection to improve therapeutic efficacy	High		
Park et al., 2015 Palpation Versus Ultrasound-Guided Acromioclavicular Joint Intra-articular Corticosteroid Injections: A Retrospective Comparative Clinical Study	US guided corticosteroid injections showed a significant difference in the alleviation of symptoms compared to palpation guidance	Moderate		

Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence
Justification: Although bias present in most references, the strength of association is very high given surgical/arthroscopic data.

Rating Definitions:
Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**
Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: The literature supports the use of US of the shoulder to evaluate rotator cuff tears (especially full-thickness), long biceps tendon injuries, and to improve therapeutic efficacy with corticosteroid injection (versus blind injection). US of the shoulder is not helpful for assessment of adhesive capsulitis. Other conditions involving the shoulder joint including traumatic injury (fracture), instability, and osteoarthritic processes are better assessed by other imaging modalities such as MR, CT, and XR.

Final Recommendation: **2A**—In adults presenting with shoulder pain (traumatic or non-traumatic) US is recommended in the following clinical scenarios:

- Suspected rotator cuff injury
- Suspected long biceps tendon injury
- Suspected calcifying tendonitis
- Guidance required for corticosteroid injection

PICO #4: In adults with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with CT for optimal patient outcome(s)?

SEMPI Grading QOE – Table 3A.4a—Summary of Findings						
PICO #4: In adults with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with CT for optimal patient outcome(s)?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Happamaki et al., 2004 Multidetector CT in shoulder fractures	Retrospective Observational (Single facility, trauma level1 facility)	Total patients=210 197 had both XR and CT 210 – CT	CT vs XR (CT – Gold standard)	Compared to CT, XR had sensitivity ranging from 0.8-1.0 to detect humeral fractures. XR missed multiple fracture fragments in 63% of comminuted humeral fracture patients	CT can increase accuracy of fracture classification and reveal occult fractures not identified by XR	**Low**
Griffith et al., 2007 CT compared with arthroscopy in quantifying glenoid bone loss	Prospective	Total patients =50 (with anterior shoulder dislocation 13/50 –single dislocation 37/50 –recurrent dislocation CT preceded arthroscopy in all cases	CT vs Arthroscopy (Arthroscopy-Gold standard)	Glenoid bone loss (41/50 patients) : Sensitivity -92.7% Specificity-77.8% Positive predictive value-95% Severity of glenoid bone loss: r - 0.79 CI- 0.65-0.87 P<0.0001	CT shoulder can detect glenoid bone loss in majority of cases without the need for invasive arthroscopy	**Moderate**
Chuang et al., 2008 Use of Preoperative Three-Dimensional Computed Tomography to Quantify Glenoid Bone Loss in Shoulder Instability	Prospective	Total patients =188 (with anterior glenohumeral instability) 25 patients had 3-D CT evaluation of both shoulder followed by arthroscopy of the unstable shoulder	CT vs Arthroscopy (Arthroscopy – Gold standard)	Arthroscopic findings; Bone loss< 25% = arthroscopic Bankart repair Bone loss>25% = Latarjet reconstruction For 3-D CT glenoid index was calculated Glenoid index >0.75 = patient was predicted to have arthroscopic Bankart repair	CT scan accurately predicts the requirement of bone graft in glenoid bone loss and can be an additional diagnostic tool in preoperative planning	**Low**

				Glenoid index ≤ 0.75 – Open Latarjet procedure 13/25 – Open Latarjet 12/25- Arthroscopic Bankart repair		
Bahrs et al., 2009 Indications for computed tomography (CT-) diagnostics in proximal humeral fractures: a comparative study of plain radiography and computed tomography	Prospective (comparative study) (Level1 trauma centers(2))	44 Adult patients with proximal humerus fracture	CT vs XR	CT was significant ($p<0.05$) in identifying fractures compared to XR. This was independent of the fracture severity	CT should be performed when the proximal humerus and the shoulder joint are not presented with sufficient XR quality to establish a treatment plan	**Low**
Jia et al., 2016 Compared to X-ray, three dimensional computed tomography measurement is a reproducible radiographic method for normal proximal humerus	Retrospective	120 consecutive adult patients (with CT and radiographic data of normal humerus)	CT vs XR	Image modalities differences and correlations of parameters were evaluated All parameters(NSA, TSH, HHT, cASD) in 3-D CT measurement had excellent reproducibility (ICC range 0.878 -0.936) as compared to radiographs (ICC range 0.741-0.858) and were significantly different ($p <0.05$)	3-D CT has more reproducibility than plain XR for assessing the morphology of humerus and this can be utilized for preoperative planning and design of shoulder prostheses	**Low**
Initial QOE Score across studies for PICO #4: **Low (3)**						

SEMPI Grading QOE – Table 3A.4b—Risk of Bias		
PICO #4: In adults with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with CT for optimal patient outcome(s)?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **LOW**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	Selection criteria not well defined and skewed population sample No randomization
Inconsistency	Not Serious	
Indirectness	Serious	Results confined to a subset of sample Small sample size
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Consistent findings for fracture and bone loss
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **LOW**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE – Table 3A.4c—Evidence to Recommendations

PICO #4: In adults with shoulder pain (traumatic or non-traumatic) which clinical predictors warrant imaging with CT for optimal patient outcome(s)?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Authors/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Happamaki et al., 2004 Multidetector CT in shoulder fractures	CT can increase accuracy of fracture classification and reveal occult fractures not identified by XR	Low	Low (3)	Strong (A)
Griffith et al., 2007 CT compared with arthroscopy in quantifying glenoid bone loss	CT shoulder can detect glenoid bone loss in majority of cases without the need for invasive arthroscopy	Moderate		
Chuang et al., 2008 Use of Preoperative Three-Dimensional Computed Tomography to Quantify Glenoid Bone Loss in Shoulder Instability	CT scan accurately predicts the requirement of bone graft in glenoid bone loss and can be an additional diagnostic tool in preoperative planning	Low		
Bahrs et al., 2009 Indications for computed tomography (CT-) diagnostics in proximal humeral fractures: a comparative study of plain radiography and computed tomography	CT should be performed when the proximal humerus and the shoulder joint are not presented with sufficient XR quality to establish a treatment plan	Low		
Jia et al., 2016 Compared to X-ray three-dimensional computed tomography measurement is a reproducible radiographic method for normal proximal humerus	3-D CT has more reproducibility than plain XR for assessing the morphology of humerus and this can be utilized for preoperative planning and design of shoulder prostheses	Low		

Recommendation Rating: 3A--Strong recommendation for the intervention based on low quality evidence
Justification: Although significant bias in literature, consistency of CT findings for fracture and bone loss offsets this bias.

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**
Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: CT imaging of the shoulder is generally limited to evaluation of fractures since it can provide greater detail of fracture complexity, angulation, and displacement. The ability of CT to visualize in the 3-dimensional format as well as in multiple planes (axial, sagittal, and coronal) can assist with pre-operative planning. CT is also useful in detecting bone loss in the glenoid head which can facilitate planning of bone augmentation procedures. Lastly, CT is recommended for LONG TERM follow-up after shoulder arthroplasty due to more reliable detection of prosthetic joint "loosening" compared to XR (Gregory et al., 2014).
Final Recommendation: 3A—CT is recommended for evaluation of fractures, detection of glenoid bone loss, and for prostheses involving the shoulder joint.

PICO #5: In adults with shoulder pain (traumatic or non-traumatic) when is MR imaging warranted for optimal diagnostic accuracy?

SEMPI Grading QOE – Table 3A.5a—Summary of Findings						
PICO #5: In adults with shoulder pain (traumatic or non-traumatic) when is MR imaging warranted for optimal diagnostic accuracy?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Iannotti et al., 1991 Magnetic resonance imaging of the shoulder. Sensitivity, specificity, and predictive value	Prospective cohort	Adult patients (112 surgical+15 asymptomatic volunteers) 127 MR diagnoses in 106 patients 112/127 surgical diagnoses (91/106 patients) 73/112 were rotator cuff diagnosis 39/112 were labrum diagnoses Total MR diagnoses: Rotator cuff=88 (73 surgical +15 volunteers) Labral=39	MR vs operative findings	Diagnosing complete tears: Sensitivity-100% Specificity-95% Labral tears associated with glenohumeral instability: Senstivity-88% Specificity-93% Differentiating tendinitis from degeneration of cuff: Senstivity-82% Specificity-85% Differentiating tendinitis with signs of impingement from normal tendon: Senstivity-93% Specificity–87%	MR is a highly sensitive noninvasive tool to diagnose lesions of rotator cuff and glenohumeral instability	**Moderate**
Nelson et al., 1991 Evaluation of the painful shoulder. A prospective comparison of magnetic resonance imaging, computerized tomographic arthrography, ultrasonography, and operative findings	Prospective cohort	21 patients (pain in shoulder for more than three months) All had MR and CT Arthrography 19 had US 21 patients had Twenty arthroscopic and three operative procedures	MR vs CT-Arthrography vs US Results of imaging studies were compared with operative findings	Full thickness tear of rotator cuff: Operative findings-7, MR -6, CT-6, US-3 Partial tear of rotator cuff: Operative findings-12, MR-8, CT-2, US-4 Impingement and stenosis of coracoacromial arch: Operative findings-8, MR-7, CT-0, US-0 Labral lesion: Operative findings -12, MR-8, CT-9, US-0	MR is the most accurate diagnostic tool for rotator cuff lesions, instability due to glenoid labrum, subacromial impingement and osteoarthrosis of either glenohumeral or acromioclavicular joint	**Moderate**

				Sensitivity/Specificity: Full thickness rotator cuff tear: 86/93 Partial tear: 67/89 Subacromial Impingement or stenosis: 88/77 Labral lesion: 67/89		
Hayes et al., 2010 Efficacy of diagnostic magnetic resonance imaging for articular cartilage lesions of the glenohumeral joint in patients with instability	Retrospective (consecutive patients)	Total patients = 87 (patients had MR followed by arthroscopy) MRI with contrast = 55 patients MRI without contrast =32 MR images reviewed by two radiologists	MR (Results of MR were confirmed by reviewing arthroscopy reports and images) (Arthroscopy "gold standard")	Compared to Arthroscopy MR identified glenohumeral lesions with Sensitivity -87.2%, Specificity -80.6% Bankart's lesions: Sensitivity-98.4%, Specificity-95.2% Hill-Sachs lesions: Sensitivity-96.3%, Specificity-90.6% No difference between with and without contrast MR	MR demonstrates high sensitivity and specificity for identifying articular lesions in patients with glenohumeral instability	**Low**
Bhatnagar et al., 2016 Correlation between MRI and Arthroscopy in Diagnosis of Shoulder Pathology	Prospective comparative study (Consecutive)	Total patient =39 (Inclusions: Patients with chronic shoulder pain or instability of more than 6 weeks or with clinical signs of impingement or tear) Exclusions: Patients with infection or osteoarthritis	MR followed by arthroscopy (Arthroscopy considered "gold standard")	Rotator cuff tear was most common pathology diagnosed (34 patients) Rotator Cuff tears: Sensitivity - 91% Osteochondral defects: Sensitivity 100% Bankart's lesions: Sensitivity -80% SLAP lesions-Sensitivity 15% No False positive reporting except for 1 (SLAP lesion) Overall Specificity-100%	MR is effective to identify rotator cuff tears, Bankart's lesions and osteochondral defects	**Moderate**
Initial QOE Score across studies for PICO #5: **Moderate (2)**						

SEMPI Grading QOE – Table 3A.5b—Risk of Bias		
PICO #5: In adults with shoulder pain (traumatic or non-traumatic) when is MR imaging warranted for optimal diagnostic accuracy?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	No randomized trial Selection bias
Inconsistency	Not Serious	
Indirectness	Serious	Selective population and results might not be applicable to general practice, small sample size
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Surgical/arthroscopic confirmation
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: MODERATE		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE – Table 3A.5c—Evidence to Recommendations

PICO #5: In adults with shoulder pain (traumatic or non-traumatic) when is MR imaging warranted for optimal diagnostic accuracy?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Iannotti et al., 1991 Magnetic resonance imaging of the shoulder. Sensitivity, specificity, and predictive value	MR is a highly sensitive noninvasive tool to diagnose lesions of rotator cuff and glenohumeral instability and impingement syndrome	Moderate	Moderate (2)	Strong (A)
Nelson et al., 1991 Evaluation of the painful shoulder. A prospective comparison of magnetic resonance imaging, computerized tomographic arthrography, ultrasonography, and operative findings	MR is the most accurate diagnostic tool for rotator cuff lesions, instability due to glenoid labrum, subacromial impingement and osteoarthrosis of either glenohumeral or acromioclavicular joint	Moderate		
Hayes et al., 2010 Efficacy of diagnostic magnetic resonance imaging for articular cartilage lesions of the glenohumeral joint in patients with instability	MR demonstrates high sensitivity and specificity for identifying articular lesions in patients with glenohumeral instability	Low		
Bhatnagar et al., 2016 Correlation between MRI and Arthroscopy in Diagnosis of Shoulder Pathology	MR is effective to identify rotator cuff tears, Bankart's tears and osteochondral defects	Moderate		

Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence
Justification: Prospective studies with "gold standard" "arthroscopic confirmation" and no inconsistency in estimates.

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**
Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: MR is a highly sensitive imaging modality for the identification of rotator cuff tears, Bankart's lesions, Hill –Sachs, and osteochondral defects**.** US and MR imaging have comparable diagnostic accuracy for measuring the size and extent of rotator cuff tears. However, compared to US, MR is more accurate in the identification of impingement pathology, stenosis of subacromial arch, and lesions of the labrum. The ability of MR imaging to clearly demonstrate soft tissue anatomy makes it a valuable tool when US evaluation is insufficient or unavailable. MR imaging is also useful in pre-operative planning.

Final Recommendation: **2A**—In adults with shoulder pain, MR is recommended for the following:

- Suspected rotator cuff injury
- Evaluation of soft tissue pathology
- Evaluation of impingement syndrome in patients who have failed conservative management and/or have inconclusive prior imaging
- Pre-operative surgical evaluation

PICO #6: In adults with shoulder pain who are surgical candidates, have had an MR and require arthrography, is MR-arthrography recommended compared to CT-arthrography for optimal patient outcome(s)?

SEMPI Grading QOE – Table 3A.6a—Summary of Findings						
PICO #6: In adults with shoulder pain who are surgical candidates, have had an MR and require arthrography, is MR-arthrography recommended compared to CT-arthrography for optimal patient outcome(s)?						
Author/Year/Title	Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Acid et al., 2012 Preoperative imaging of anterior shoulder instability: diagnostic effectiveness of MDCT arthrography and comparison with MR arthrography and arthroscopy	Prospective, consecutive enrollment, selection criteria unclear, small N subgroups; arthroscopy confirmation	40 total- 30 male, 10 female	CT- vs MR-arthrography vs arthroscopy	**Glenoid rim fx's**: CT-arthro—Sensitivity=100% (12/12); Specificity=96% (27/28); Surgical correlation (κ = 0.94) vs MR-arthro (κ = 0.74). **Glenoid cartilage lesions**: CT-arthro--Sensitivity =82% (18/22), Specificity =89% (16/18), Surgical correlation (κ = 0.70) vs MR-arthro (κ = 0.66) **Anterior labral periosteal sleeve avulsion**: CT-arthro--Sensitivity=93% (26/28), Specificity=100% (12/12), Surgical correlation (κ = 0.89) vs MR-arthro (κ = 0.74). **Humeral avulsion of glenohumeral ligament**: CT-arthro—Sensitivity, Specificity- 100% (2/2) Surgical correlation (κ = 1) vs MR-arthro (κ = 0.79)	CT-arthrography was more accurate than MR arthrography in detection of osseous, cartilage, and labroligamentous injuries related to anterior shoulder instability CT-arthrography was particularly reliable for detection of glenoid rim fractures and humeral avulsion of the inferior glenohumeral ligament, crucial findings for preoperative planning CT-arthrography and MR-arthrography are comparable in general	**Moderate**

Oh et al., 2010 Effectiveness of multidetector computed tomography arthrography for the diagnosis of shoulder pathology: Comparison with magnetic resonance imaging with arthroscopic correlation	Prospective Cohort	148 patients randomly assigned to CTA or MRA 78 CTA 70 MRA	MRA vs CTA	CTA Accuracy SLAP Lesion-88% Bankart-93% Hill-Sachs-90% Full thickness RCT-96% Partial thickness RCT-69% MRA Accuracy SLAP Lesion-84% Bankart-99% Hill-Sachs-96% Full thickness RCT-97% Partial thickness RCT-90%	CTA is comparable to MRA and a cost-effective, useful method for evaluation of labral abnormalities and full thickness rotator cuff tears MRA is especially effective for accuracy of partial rotator cuff tears	**Moderate**
Elkhabotly, 2016 Shoulder joint instability evaluation by CT arthrography and MR arthrography.	Prospective Cohort	96 patients: 72 males, 24 females. Their age ranged from 14 to 51 years (mean = 33), complaining of shoulder dislocation whether traumatic or nontraumatic with glenohumeral instability. For every patient, intra-articular contrast injection was done followed by CT and MRI arthrography (CTA & MRA)	CTA vs MRA	**CTA** Bankart Lesion-12/16 Osseous Bankart-14/14 Perthes Lesion-16/28 ALPSA Lesion-10/16 GLAD Lesion-6/8 HAGL Lesion-2/4 GAGL Lesion-4/4 Hill Sachs Lesion-46/60 Reversed Bankart Lesions-4/6 **MRA** Bankart Lesion-16/16 Osseous Bankart-10/14 Perthes Lesion-28/28 ALPSA Lesion-16/16 GLAD Lesion -8/8 HAGL Lesion-4/4 GAGL Lesion-4/4 Hill Sachs Lesion-60/60 Reversed Bankart Lesions-6/6	MR arthrography better able to detect shoulder abnormalities than CT arthrography	**Moderate**
Initial QOE Score across studies for PICO #6: **Moderate (2)**						

SEMPI Grading QOE – Table 3A.6b—Risk of Bias		
PICO #6: In adults with shoulder pain who are surgical candidates, have had an MR and require arthrography, is MR-arthrography recommended compared to CT-arthrography for optimal patient outcome(s)?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score across studies for PICO: **MODERATE**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	Small sample sizes and selection criteria unclear
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Studies had surgical confirmation
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **MODERATE**		
High – Very confident the true effect lies close to that of the estimate of the effect **Moderate** – Moderately confident in the effect estimate (the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different **Low** – Confidence in the effect estimate is limited (the true effect may be substantially different from the estimate of effect) **Very Low** – Very little confidence in the effect estimate (the true effect is likely to be substantially different from the estimate of effect)		

SEMPI Grading QOE – Table 3A.6c—Evidence to Recommendations

PICO #6: In adults with shoulder pain who are surgical candidates, have had an MR and require arthrography, is MR-arthrography recommended compared to CT-arthrography for optimal patient outcome(s)?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Acid et al., 2012 Preoperative imaging of anterior shoulder instability: diagnostic effectiveness of MDCT arthrography and comparison with MR arthrography and arthroscopy	CT arthrography was more accurate than MR arthrography in detection of osseous, cartilage, and labroligamentous injuries related to anterior shoulder instability CT-arthrography was particularly reliable for detection of glenoid rim fractures and humeral avulsion of the inferior glenohumeral ligament, crucial findings for preoperative planning	Moderate	Moderate (2)	Strong (A)
Oh et al., 2010 Effectiveness of multidetector computed tomography arthrography for the diagnosis of shoulder pathology: Comparison with magnetic resonance imaging with arthroscopic correlation	CTA is a cost-effective, useful method for evaluation of labral abnormalities and full thickness rotator cuff tears	Moderate		
Elkhabotly, 2016 Shoulder joint instability evaluation by CT arthrography and MR arthrography.	MR arthrography is more cost beneficial than CT arthrography and should be increasingly used, especially when there is any uncertainty, or when the issue of labral or capsular tear is not obvious from the clinical investigation	Moderate		

Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence

Justification: Significant bias in studies; arthroscopy confirmation only present in subsets within several studies, comparisons inconsistent. However, studies showed similar results and had surgical confirmation.

Rating Definitions:

Quality of Evidence: High quality = **1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4**

Strength of Recommendation: Strong recommendation**= A;** Consensus recommendation **= B**

Conclusion: Arthrography (both MR- and CT-directed) facilitates identification of intra-articular bodies, certain ligament or tendon injuries, synovial or cartilage abnormalities, sinus tracts, and loosening of joint prostheses. The injected contrast outlines intra-articular structures, differentiates them from adjacent soft tissues, and also distends the joint for better separation and visualization of structures. CT arthrography (CTA) has similar accuracy to MR arthrography (MRA) for cartilaginous lesions, but CT-arthrography is not as accurate in detecting partial thickness rotator cuff tears. CTA can and should be used when MRA is contraindicated, unavailable or when shoulder prostheses are being evaluated. MRA has the advantage of no radiation exposure for patients but may be costlier and not as readily available as CTA.
Final Recommendation: 2A--In adults with shoulder pain who have had an MR and require arthrography as surgical candidates, MRA is recommended. CTA is an acceptable alternative when MRA is unavailable or contraindicated.

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