CLINICAL PRACTICE GUIDELINE: HIP PAIN (4A)

SYSTEMATIC REVIEW FOR IMAGING OF HIP PAIN

CPG 4A Abstract (Updated November 2019)

Disorders of the hip joint can impact individuals of all ages with a wide array of presentations. Mobility may or may not be affected, pain may or may not be present, and symptoms may be acute or chronic in nature. Sources other than the hip joint can cause perceived 'hip pain' (referred) and include the lumbar spine, pelvis, knee, or abdomen. Common etiologies of hip pain include arthritis (osteoarthritis, inflammatory, septic, and crystal-induced), trauma with/without fracture, impingement, labral tear, greater trochanteric pain syndrome (GTPS), avascular necrosis (AVN), and primary tumor/metastatic lesions. Occasionally, alternative etiologies other than the hip joint itself can cause perceived 'hip pain' (referred pain) and include the lumbar spine, pelvis, knee, or abdomen. Historically, osteoarthritis, the most common disease involving the hip joint, was reported to be most accurately diagnosed by physical examination rather than radiographically (Chong et al., 2013). Conversely, XR imaging has now become part of the initial evaluation of most hip symptoms at presentation. Imaging of the hip joint has changed in recent years due to greater understanding of the biomechanics of the hip joint and the development of new hip-preserving surgical techniques. XR is now used as a screening tool for most hip complaints. Specifically, reserving the use of radiography for middle-aged and elderly populations is no longer standard practice. Currently, younger patients frequently undergo imaging especially when being evaluated for conditions such as femoroacetabular impingement (FAI) that may lead to premature osteoarthritis of the hip. In this example, magnetic resonance (MR) imaging is key to making early diagnostic and treatment decisions before irreversible complications develop (Chiamil & Abarca, 2016). Highlights of imaging modalities used in evaluating hip pain with specific clinical scenarios are discussed below.

Diagnostic Imaging

Conventional radiography (XR) is used as the initial or 'screening' imaging study for the hip, particularly when hip symptoms are associated with trauma (i.e., fracture, dislocation, avulsion), sports injury, arthritis, or as a screening tool for avascular necrosis (AVN), infection, or tumor. It is important to note, however, that XR can fail to detect some fractures (particularly non-displaced and those involving proximal structures), bone marrow edema associated with early AVN, early osteomyelitis, and early septic arthritis. XR is generally not as good as other imaging modalities when delineation of soft tissue structures (ligaments/tendons/labrum) is desired; for example, anatomic detail of the acetabular labrum, is best studied with magnetic resonance (+/-arthrography) or ultrasound (see below).

Magnetic resonance (MR) is generally preferred when assessment of soft tissue structures, cartilage, tumors, and bone marrow is desired. It may detect osteomyelitis and AVN early—weeks before XR abnormalities appear. Further, MR can differentiate between periarticular soft-tissue infections versus osteomyelitis. MR can also quantify extent of disease in chronic osteomyelitis where CT cannot. Also, when initial XR studies are negative/equivocal for fracture, MR can be used to detect 'occult' fractures (i.e. non-displaced, femoral neck) (Sankey et al., 2009).

MR arthrography is the imaging modality of choice for assessment of the acetabular labrum due to its fibro-cartilaginous and connective tissue composition (non-osseous structure). In the literature, however, debate remains as to whether MR alone or combined with arthrography is preferred (Reiman et al., 2013). Trials comparing these two imaging techniques have been small (limiting statistical analysis) but meta-analysis of these trials reports diagnostic accuracy for acetabular labral tears with MR-arthrography to be superior to MR alone, according to receiver operating characteristic analysis (Smith et al., 2011). Conversely, MR-arthrography was not found to be superior to MR alone for the detection of cartilage defects involving the acetabular/femoral surfaces (Zlatkin et al., 2010).

Computed tomography (CT) is useful in the assessment of osseous (bone) structures including hip, pelvic, and sacral fractures, pre- and post-operative planning after hip prosthetic surgery, and diagnostic assessment/therapeutic intervention of tumor involving the hip joint. Intra-articular calcified bodies can also be detected by CT. Acetabular labral tears (traumatic or degenerative) are being diagnosed with increasing frequency and these commonly coincide with underlying osseous abnormalities (i.e. hip dysplasia) that are often best delineated by CT (Dolan et al., 2011). Thus, CT may be used in an "adjunctive" fashion with MR imaging in patients with suspected/diagnosed acetabular labral tears to guide treatment and surgical repair.

CT arthrography can be used to assess acetabular labrum pathology, when MR is contra-indicated or unavailable. However, its sensitivity has been reported to be lower than that of MR-arthrography (Yamamoto et al., 2007).

Ultrasound (US) is a widely available, low-cost imaging tool to detect joint effusion, muscle/tendon tears, hematomas, and soft tissues. It also enables hands-on examination of a painful site, dynamic evaluation of moving structures, and comparison with the contralateral hip. Such qualities make US particularly useful in the assessment of greater trochanteric pain syndrome (GTPS) and various impingement syndromes (such as "snapping hip") resulting in hip pain (Chowdhury et al., 2014). Diagnostic performance varies, however, with US demonstrating poor diagnostic accuracy for the detection of acetabular labral tears with low sensitivity and

specificity (Troelsen et al., 2007). In contrast, US is superior to MR imaging in diagnostic accuracy for gluteal tendon tears (Westacott et al., 2011). Despite discrepancy in type classification, US can predict the presence of pseudotumors in a failed hip replacement with adequate sensitivity when compared to surgical revision findings (Lainiala et al., 2015). US may also be used, like MR and CT, for diagnostic aspiration/therapeutic injection of the hip joint without having to consider metal artifact or radiation exposure, respectively.

Radionuclide bone scanning is primarily used for detection of malignant metastatic bone lesions. Prior to the advent of MR and CT imaging, radionuclide bone scans were used to detect occult fractures, AVN, osteomyelitis, and septic arthritis (and may still be used when CT/MR is unavailable). Due to low specificity and delayed diagnostic results, however, use of radionuclide bone scanning for many of these conditions has largely been abandoned.

Hip Arthroplasty Imaging

Complications following total hip arthroplasty (THA) include pseudotumor formation, aseptic loosening, particle-induced osteolysis, infection, periprosthetic fracture, heterotopic ossification, hardware failure, and a range of soft tissue complications. Patients with hip pain after joint replacement are first assessed by analyzing the clinical presentation using conventional XR findings. When this step is inconclusive, different imaging techniques can be used to identify post-op complications (Hargunani et al., 2016).

XR imaging, in the setting of hip arthroplasty, is routinely obtained postoperatively at set intervals (i.e. 1, 3, 5 years). Plain radiographs are readily available, offer no metal artifact and are the usual initial investigation of choice for unexpected/prolonged hip pain following THA. Component positioning is readily assessed on XR. Periprosthetic fractures, hardware failure, and osseous complications are often visible on XR but occasionally may be missed (i.e., 'occult' fracture). Soft tissue complications, nerve entrapment, and fluid collections are generally poorly characterized by XR.

CT provides detailed evaluation of bone texture and morphology and is often reserved for selected cases where high-resolution 3-dimensional osseous assessment is required. CT can be used to delineate complications such as loosening of an implanted (cemented or uncemented) component, particle-induced osteolysis, or hardware failure (see also MR below) as well as assess rotational alignment. CT is often required as a preoperative planning tool for complex revision surgery involving a prior THA.

MR remains the modality of choice for cross-sectional investigation of a painful hip following THA, if XR is unrevealing, given its combination of soft tissue contrast resolution as well as its ability to demonstrate marrow edema. Conventional MR requires

modification to limit metal-induced artifact and techniques to reduce such artifacts have led to its increased use in the investigation of prosthetic joints. MR can be used to delineate post-op complications such as loosening, particle-induced osteolysis, or hardware failure. It can also be used to evaluate soft tissue masses or fluid collections around the prosthesis. Nerve-entrapment ("piriformis" and "hamstring") syndromes can be caused by hip replacement surgery causing 'pseudosciatica' or referred hip pain. MR is useful in the evaluation of these syndromes by demonstrating inflammation of the sciatic nerve near the piriformis muscle or the biceps femoris muscle, respectively. Lastly, both MR and CT can be helpful in surgical planning for hip prosthesis revision.

US may be used in evaluation of painful hip replacements as diagnosing the cause of hip pain after THA can be challenging due to the numerous possible causes. US typically would be aimed at relatively superficial soft tissue assessment including tendons, muscles, fluid collections, and the joint capsule. For example, soft tissue impingement syndromes are an important cause of pain following THA for which US can be used to delineate. US can also facilitate diagnostic/therapeutic procedures (aspiration/injection) particularly when CT and MR are unavailable or contraindicated.

Multiple factors affect the decision-making process when evaluating the appropriateness of ordering imaging studies. These include cost (both initial and 'downstream'), availability, patient preference and expectations, radiation exposure concerns, prior imaging results, and presence of contraindications 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 acknowledge 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.

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

Search Strategy: For this annual review, a systematic search and a thorough review of the medical literature focused on hip pain in adults and appropriate diagnostic imaging techniques, published in the last five year through November 2019, was conducted. The advanced search option in PubMed/Medline was used, incorporating the search strategy utilizing Population, Intervention, Comparator, Outcome (PICO) framework.

Keywords: The following keywords (using MeSH and full-text search strings) were used individually or in combination with one another in different permutations and/or combinations using Boolean Operators ("AND", "OR", "NOT"): hip pain, x-ray of the hip, hip MRI, hip MR, hip lesion, hip fracture, arthrography, hip arthrography, hip trauma, piriformis syndrome, greater trochanteric pain syndrome, sacroiliac joint dysfunction, imaging of the hip, optimal patient assessment, clinical predictors, ultrasonography of the hip joint, computed tomography of the hip, hip prosthesis, pseudotumor, diagnostic accuracy, sensitivity, specificity, surgery of the hip joint, arthrography, MR-arthrography, CT-arthrography, therapeutic injection, imaging-guided injections, hip joint aspiration.

Methods: A total of 1854 articles resulted from the general hip pain topic search. References of relevant articles were scanned for potentially missing studies. Titles and abstracts were scanned, and then full articles were reviewed. The articles were evaluated and considered from the following groups: initial assessment or clinical evaluation (18 articles), x-ray (51 articles), CT (123 articles), MRI (110 articles), Arthrography (32 articles), image guidance (41 articles) and bone scanning (10 articles). Some articles were considered for more than one group. Finally, these articles were evaluated, based, in part, upon study design, sample size, and public availability. They were further reviewed to see if they answer the respective PICO questions.

Based on 2019 literature review the following changes were made to the Clinical Practice Guideline: 1) A new CT PICO was created 2) The ultrasound and magnet resonance imaging comparative literature for pseudotumor and local soft tissue reactions was thoroughly revised to address when ultrasound can be an acceptable alternative or an equivalent for the same diagnosis. 3) All other PICO's were revised (adding new literature, revising conclusion and recommendation).

Clinical Focus Questions

PICO #1: In adults with hip pain, what clinical predictors warrant assessment without initial imaging for optimal patient management?

PICO #2: In adults presenting with hip pain, what clinical predictors warrant conventional radiography (XR) imaging for optimal management?

PICO #3: In adults with hip pain when arthrography is indicated, should MR arthrography be performed compared to CT arthrography for optimal diagnostic accuracy?

PICO #4: In adults with hip pain, what clinical scenarios warrant magnetic resonance (MR) imaging for optimal patient assessment?

PICO #5: In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reactions), should ultrasound (US) be performed compared to magnetic resonance (MR) for optimal assessment?

PICO #6: In adults with suspected infection (e.g. osteomyelitis) is magnetic resonance (MR) imaging the modality of choice for optimal diagnostic accuracy?

PICO #7: In adults who require aspiration or injection of the hip joint, should imaging guidance be performed by ultrasound (US) or fluoroscopy (FL) for optimal patient management?

PICO #8: In adults with hip pain, what clinical scenarios warrant computed tomography (CT) imaging for optimal diagnostic accuracy?

PICO #1: In adults with hip pain, what clinical predictors warrant assessment without initial imaging for optimal patient management?

SEMPI Grading QOE—Table 4A.1a—Summary of Findings						
PICO #1: In adults with hip pain, what clinical predictors warrant assessment without initial imaging for optimal patient management?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Sakellariou et al., 2017 EULAR recommendations for the use of imaging in the clinical management of peripheral joint osteoarthritis	Systematic review EULAR guidelines	Patients with peripheral joint arthritis	N/A	N/A	Imaging is not required to diagnose hip osteoarthritis in atraumatic typical presentations but is recommended in atypical presentations. If imaging is needed, conventional radiography (XR) is preferred.	Low
Wilson & Furukawa, 2014 Evaluation of the Patient with Hip Pain	Review article (summary of guidelines)	Adults with hip pain	Clinical exam versus all imaging modalities	N/A	In the evaluation of an adult who presents with hip pain, radiography (XR) should be performed if acute fracture, dislocations, or stress fractures are suspected.	Very Low
Martin & Palmer, 2013 History and Physical Examination of the Hip: The Basics	Review article	Adult patients	N/A	N/A	A clinical evaluation of the hip that incorporates a multifactor thought process (standardized clinical evaluation of the hip) will lead to an accurate diagnosis in a timely manner (without imaging).	Very Low
Altman et al., 1991 The American College of Rheumatology Criteria for the Classification and Reporting of OA of the Hip	Retrospective study	201 adults with hip pain for most days of the prior month	Clinical exam versus XR imaging	Clinical exam alone for dx of osteoarthritis (OA): Sensitivity - 86% Specificity - 75% Clinical + XR for dx of osteoarthritis (OA): Sensitivity – 89% Specificity – 91%	Clinical exam alone can identify OA of the hip in a majority of adult patients with hip pain.	Low
Initial QOE Score across studies for PICO #1**: Low (3)**						

SEMPI Grading QOE—Table 4A.1b—Risk of Bias		
PICO #1: In adults with hip pain, what clinical predictors warrant assessment without initial imaging for optimal patient management?		
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	Mainly review studies
Inconsistency	Not Serious	
Indirectness	Serious	Very different patient populations among studies
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: Downgraded to Very Low		
Final QOE Grade for Outcome Across Studies: **VERY 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 4A.1c—Evidence to Recommendations

PICO #1: In adults with hip pain, what clinical predictors warrant assessment without initial imaging for optimal patient management?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Sakellariou et al., 2017 EULAR recommendations for the use of imaging in the clinical management of peripheral joint osteoarthritis	Imaging is not required to diagnose hip osteoarthritis in atraumatic typical presentations but is recommended in atypical presentations. If imaging is needed, conventional radiography (XR) is preferred.	Low	Very Low (4)	Consensus (B)
Wilson & Furukawa, 2014 Evaluation of the Patient with Hip Pain	In the evaluation of an adult who presents with hip pain, radiography (XR) should be performed if acute fracture or dislocation is suspected.	Very Low		
Martin & Palmer, 2013 History and Physical Examination of the Hip: The Basics	A clinical evaluation of the hip that incorporates a multifactor thought process (standardized clinical evaluation of the hip) will lead to an accurate diagnosis in a timely manner (without imaging).	Very Low		
Altman et al., 1991 The American College of Rheumatology Criteria for the Classification and Reporting of OA of the Hip	Clinical exam alone can identify OA of the hip in a majority of adult patients with hip pain.	Low		

Recommendation Rating: 4B—Recommendation from panel member consensus for the intervention based on very low-quality evidence
Justification: Risk of bias is significant due to "vintage" literature and reliance on "review" of published evidence, supporting QOE downgrade.

Rating Definitions:

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

Conclusion: No clinical trials were found that identified hip pain patients in whom clinical assessment alone (no imaging) was sufficient; yet, professional society guidelines indicate that initial imaging is not required to diagnose osteoarthritis (OA) of the hip in patients with atraumatic typical presentations. Although, conventional radiography (XR) is regarded by many as best practice in the evaluation of hip pain, not every individual with a complaint of hip discomfort requires XR imaging. Rather, a careful history and physical exam can identify patients who would benefit from initial XR imaging (e.g., those with atypical presentations for hip OA). A reasonable approach to a patient who presents with hip pain and little, if any, disability would be a thorough history and clinical exam including knee and back evaluation. Lastly, hip OA is a chronic condition with well-defined symptoms and clinical course. As such, it would be reasonable, in the absence of new/unexpected symptoms, to forego repeated imaging in the OA population unless the patient is planning to undergo or be evaluated for hip replacement surgery and the affected hip has not been imaged in more than 1 year.

Final Recommendation: 4B—In adults with hip pain, initial imaging is not recommended for patients with any of the following clinical predictors:

- Atraumatic typical presentation for osteoarthritis of the hip based on thorough history and clinical exam
- Normal, painless hip range-of-motion (ROM), no hip deformity and the ability to bear weight
- Known osteoarthritis (OA) with no new symptoms or mechanism for injury

PICO #2: In adults presenting with hip pain, what clinical predictors warrant conventional radiography (XR) imaging for optimal management?

SEMPI Grading QOE—Table 4A.2a—Summary of Findings						
PICO #2: In adults presenting with hip pain, what clinical predictors warrant conventional radiography (XR) imaging for optimal management?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Walker et al., 2019 Effect of initial emergency room imaging choice on time to hip reduction and repeat imaging	Retrospective case-control study XR=x-ray	N=89 patients Group I =29 patients – XR Group II = 59 patients – prereduction CT scan	XR vs CT	Time to reduction Group I (XR)= 74 min Group II (CT)= 129 min, $p < 0.001$ Rate of repeat CT Group I: 0 Group II: 48 (81%), $p < 0.001$	Initial trauma radiography (XR) of the pelvis, prior to CT imaging, could reduce both time to surgical reduction and radiation exposure but prospective, randomized trials are needed to confirm this.	Very Low
Blum et al., 2015 Strategy and optimization of diagnostic imaging in painful hip in adults	Review article	N/A	N/A	N/A	Diagnostic imaging strategy in painful hip depends on many factors, but in all cases, conventional X-ray is the first investigation.	Very Low
Wilson & Furukawa, 2014 Evaluation of the Patient with Hip Pain	Review article	N/A	N/A	N/A	Radiography (XR) of the hip should be performed if acute fracture, dislocation, or stress fracture are suspected. Initial XR of the hip should include an anteroposterior (AP) view of the pelvis and frog-leg lateral view of the symptomatic hip.	Very Low
Altman et al., 1991 The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip	Prospective, case -control Validation of classification tree for osteoarthritis (OA) including X-ray (XR)	Cases— 114 with OA Control— 87 with other causes of hip pain	XR vs No XR	Sensitivity/Specificity of XR findings: Narrow joint space--91/60 Osteophytes--89/90 Sclerosis--80/74 Cysts--48/85	Hip Pain plus 2 of the following features: -ESR < 20 mm/hour -Femoral or acetabular osteophytes -Joint space narrowing provides 89% sensitivity and 91% specificity for diagnosis of hip osteoarthritis.	Moderate
Initial QOE Score across studies for PICO #2**: Very Low (4)**						

SEMPI Grading QOE—Table 4A.2b—Risk of Bias		
PICO #2: In adults presenting with hip pain, what clinical predictors warrant conventional radiography (XR) imaging for optimal management?		
Evaluate Outcome for Risk of Bias Across Studies		
Initial QOE Score Across Studies for PICO: **VERY LOW**		
Criteria	**Assessment**	**Reason for Assessment**
Negative Bias		
Risk of bias	Serious	Review studies, one retrospective study only pertaining to trauma population
Inconsistency	Not Serious	
Indirectness	Serious	Selective patient population
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Low	
Other Considerations	No	
Overall Effect of Bias on Initial QOE Grade: No Change		
Final QOE Grade for Outcome Across Studies: **VERY 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 4A.2c—Evidence to Recommendations

PICO #2: In adults presenting with hip pain, what clinical predictors warrant conventional radiography (XR) imaging for optimal management?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Walker et al., 2019 Effect of initial emergency room imaging choice on time to hip reduction and repeat imaging	Initial trauma radiography (XR) of the pelvis, prior to CT imaging, could reduce both time to surgical reduction and radiation exposure but prospective, randomized trials are needed to confirm this.	Very Low	Very Low (4)	Consensus (B)
Blum et al., 2015 Strategy and optimization of diagnostic imaging in painful hip in adults	Diagnostic imaging strategy in painful hip depends on many factors, but in all cases, conventional X-ray is the first investigation.	Very Low		
Wilson & Furukawa, 2014 Evaluation of the Patient with Hip Pain	Radiography (XR) of the hip should be performed if acute fracture, dislocation, or stress fracture are suspected. Initial XR of the hip should include an anteroposterior (AP) view of the pelvis and a frog-leg lateral view of the symptomatic hip.	Very Low		
Altman et al., 1991 The American College of Rheumatology criteria for the classification and reporting of osteoarthritis of the hip	Hip Pain plus 2 of the following features: -ESR < 20 mm/hour -Femoral or acetabular osteophytes -Joint space narrowing provides 89% sensitivity and 91% specificity for hip osteoarthritis	Moderate		

Recommendation Rating: 4B—Recommendation from panel member consensus for the intervention based on very low-quality evidence
Justification: No trial-based literature addresses which clinical predictors require initial imaging thus warranting a consensus recommendation.

Rating Definitions:

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

Conclusion: Conventional radiography (XR) remains the cornerstone of initial diagnostic assessment of hip pain. A careful history and physical can identify patients who would benefit from XR imaging (obvious deformity, inability to bear weight, decreased range of motion). XR is used as the initial imaging study for the hip, particularly when hip symptoms are associated with trauma (and there is concern for fracture, dislocation, avulsion), sports injury, arthritis, or as a screening tool for infection or tumor. XR can also help in delineating causes of chronic hip pain such as dysplasia or impingement (Ruiz-Santiago, 2016; Tannast, 2007). However, XR has limited capability to detect early changes of joint infection, subtle stress or insufficiency fractures and intraarticular or other soft tissue structures.

Final Recommendation: 4B— In adults presenting with hip pain, X-ray imaging is recommended for initial evaluation of:

- Pain as the result of trauma (suspected fracture or dislocation)
- Deformity
- Inability to bear weight
- Restricted range-of-motion (ROM)
- Persistent discomfort despite an appropriate trial of conservative therapy

PICO #3: In adults with hip pain when arthrography is indicated, should MR arthrography be performed compared to CT arthrography for optimal diagnostic accuracy?

SEMPI Grading QOE—Table 4A.3a—Summary of Findings						
PICO #3: In adults with hip pain when arthrography is indicated, should MR arthrography be performed compared to CT arthrography for optimal diagnostic accuracy?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Lee et al., 2019 Accuracy of Magnetic Resonance Imaging and Computed Tomography Arthrography in Diagnosing Acetabular Labral Tears and Chondral Lesions	Retrospective Assess diagnostic accuracy of magnetic resonance (MR) and computed tomographic arthrography (CTA) for labral tears, chondral lesions	N=36, all had groin pain and positive impingement sign on physical exam All had MR, followed by CTA and arthroscopy 2 radiologist readers	MR versus CT arthrography Arthroscopy=ref standard Reliability-labral tears and chondral lesion: Intra-observer **MR**: κ= 0.756 and κ= 0.693, respectively; **CTA**: κ= 0.832 and κ= 0.774, respectively	**Acetabular Tears**: **MR**—2 readers Sensitivity—60%, 65% Specificity—80%, 70% Accuracy—64%, 69% **CTA**—2 readers Sensitivity—85%, 92% Specificity—90%, 80% Accuracy—86%, 89% **Chondral Lesions**: **MR**—2 readers Sensitivity—36%, 46% Specificity—84%, 88% **CTA**—2 readers Sensitivity—46%, 64% Specificity—84%, 88%	CT arthrography is comparable to magnetic resonance (MR) imaging of the hip in identifying acetabular labral tears. Neither MR imaging nor CT arthrography is highly reliable in identifying chondral lesions.	Low
Tian et al., 2014 3.0 T conventional hip MR and hip MR arthrography for the acetabular labral tears confirmed by arthroscopy	Retrospective	N=34 Patients (aged 14-64 years) with mixed clinical diagnoses, subset had MR-a and arthroscopy confirmation	MR arthrography and surgical confirmation (n=34)	Hip MR-a Sensitivity:(90.5–95.2%) Specificity: (84.6%) for Acetabular labral tear diagnosis	Hip MR arthrography is recommended for diagnosing acetabular labral tears.	Low
Perdikakis et al., 2011 Comparison of MR-arthrography and MDCT-arthrography for detection of labral and articular cartilage hip pathology	Prospective Blinded radiologists MR arthrography (MR-a) CT arthrography (CT-a)	N=14 Adults with surgical diagnosis of acetabular-labrum tear or chondral pathology of hip/acetabular cartilage	MRA and CTA with operative confirmation all had CT-a, MR-a, and Surgical confirmation	MRA / CTA for **Acetabular labral tear**: %Sens, Spec, Accuracy, PPV— 100/15, 50/13, 90/14, 90/13, (p<0.05) **Femoral/acetabular cartilage abnormalities**: 63/66, 33/40, 50/57, 55/66, (p>0.05-not statistically significant)	MR arthrography better than CT arthrography in acetabular labral tear detection. CT arthrography may demonstrate better hip and acetabular articular cartilage abnormalities than MRA. CTA may be alternative to MRA if MRA not feasible.	Moderate

Smith et al., 2011 The diagnostic accuracy of acetabular labral tears using magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis	Meta-analysis	15 studies	N/A	MR arthrography Pooled sensitivity-- 87% (95% CI, 84 to 90) Pooled specificity--64% (95% CI, 54 to 74) For acetabular labral tears	MR arthrography can be used to diagnose acetabular labral tears.	Moderate
Wyler et al., 2009 Comparison of MR-arthrography and CT-arthrography in hyaline cartilage-thickness measurement in radiographically normal cadaver hips with anatomy as gold standard	Prospective Blinded radiologists	N=12 cadavers with radiographically NORMAL hips Multiple planes used for MR-arthrography (MR-a) and Multidector spiral CT-arthrography (MDSCT-a) e.g., sagittal, coronal, transverse	MR arthrography (MR-a) and Multidetector spiral CT arthrography (MDSCTa) compared to anatomic tissue slices as "gold standard"	By MRA, cartilage was not measurable in 50% of points on sagittal and transverse sections, compared to <6% of the points by MDSCT-a. In the coronal plane, the difference between MDSCT arthrographic and MR arthrographic measurement errors was not significant (P = 0.93)	MR arthrography and CT arthrography are similarly accurate for measuring hip cartilage thickness. In the sagittal and transverse planes, cartilage thickness is not accurately measured by MR arthrography compared to CT arthrography.	Moderate
Initial QOE Score Across Studies for PICO #3: **Moderate (2)**						

SEMPI Grading QOE—Table 4A.3b—Risk of Bias		
PICO #3: In adults with hip pain when arthrography is indicated, should MR arthrography be performed compared to CT arthrography 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	Subgroup analysis, highly selected, not all blinded, small sample size, no contrast in MR images versus CT arthrography
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	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 4A.3c—Evidence to Recommendations

PICO #3: In adults with hip pain when arthrography is indicated, should MR arthrography be performed compared to CT arthrography for optimal diagnostic accuracy?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Lee et al., 2019 Accuracy of Magnetic Resonance Imaging and Computed Tomography Arthrography in Diagnosing Acetabular Labral Tears and Chondral Lesions	CT arthrography is comparable to magnetic resonance (MR) imaging of the hip in identifying acetabular labral tears. Neither MR imaging nor CT arthrography is highly reliable in identifying chondral lesions.	Low	Moderate (2)	Strong (A)
Tian et al., 2014 3.0 T conventional hip MR and hip MR arthrography for the acetabular labral tears confirmed by arthroscopy	Hip MR Arthrography is recommended for diagnosing acetabular labral tears.	Low		
Perdikakis et al., 2011 Comparison of MR-arthrography and MDCT-arthrography for detection of labral and articular cartilage hip pathology	MR arthrography is better than CT arthrography for detection of acetabular labral tears.	Moderate		
Smith et al., 2011 The diagnostic accuracy of acetabular labr al tears using magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis	MR arthrography can be used to diagnose acetabular labral tears.	Moderate		
Wyler et al., 2009 Comparison of MR-arthrography and CT-arthrography in hyaline cartilage-thickness measurement in radiographically normal cadaver hips with anatomy as gold standard	MR arthrography and CT arthrography are similarly accurate for measuring hip cartilage thickness. In the sagittal and transverse planes, cartilage thickness is not accurately measured by MR arthrography compared to CT arthrography.	Moderate		

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

Justification: Risk of bias insufficient to downgrade the QOE. Prospective studies (although majority in literature were retrospective) and surgical confirmation support rating.

Rating Definitions: **Quality of Evidence:** High quality =**1**; Moderate quality = **2**; Low quality = **3**; Very low quality = **4** **Strength of Recommendation: A** = Strength of Recommendation from Consistent Evidence; **B**=Strength of Recommendation from Panel Consensus
Conclusion: The overall diagnostic accuracy between magnetic resonance (MR) imaging and computer tomography (CT) arthrography modalities are comparable. The literature specifically recommends MR arthrography for the assessment of pathology involving the acetabular labrum such as tears. Advantages of MR arthrography include absence of radiation risk and more comprehensive imaging of soft tissue structure surrounding the hip that could potentially be contributing to pain.
Final Recommendation: 2A—In adults with hip pain for whom arthrography is indicated, magnetic resonance (MR) arthrography is recommended. CT arthrography is an acceptable alternative when MR arthrography is contraindicated or unavailable.

PICO #4: In adults with hip pain, what clinical scenarios warrant magnetic resonance (MR) imaging for optimal patient assessment?

SEMPI Grading QOE—Table 4A.4a—Summary of Findings						
PICO #4: In adults with hip pain, what clinical scenarios warrant magnetic resonance (MR) imaging for optimal patient assessment?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Saied et al., 2017 Accuracy of magnetic resonance studies in the detection of chondral and labral lesions in femoroacetabular impingement: systematic review and meta-analysis	Systematic review and meta-analysis Assess test accuracy of imaging to diagnose labral and chondral lesions of the hip joint in femoro-acetabular impingement	N=12 studies for quantitative analysis (828 cases)	Magnetic resonance imaging (MRI) MR arthrography (MRA)	In **labral** lesions, pooled sensitivity, specificity and AUC: MRI— 0.86, 0.83 and 0.88 MRA—0.91, 0.58 and 0.92 In **chondral** lesions, pooled sensitivity, specificity and AUC: MRI— 0.76, 0.72 and 0.75 MRA--0.75, 0.79 and 0.83	Although conventional magnetic resonance (MR) imaging and MR arthrography are diagnostically reliable tools to identify acetabular **labral lesions** in patients with symptomatic femoroacetabular impingement, they are less accurate in identifying **chondral lesions**.	Moderate
Sadozai et al., 2016 The sensitivity of CT scans in diagnosing occult femoral neck fractures	Retrospective cohort	N=78 CT scans	CT for occult hip fractures using MR as 'gold standard'	Sensitivity of CT for occult fractures 86%	Magnetic resonance (MR) is the imaging modality of choice for occult hip fractures. CT imaging can be done when MR is unavailable/contraindicated.	Low
Naraghi & White, 2015 MRI of labral and chondral lesions of the hip	Systematic review Magnetic resonance arthrography (MRA)	30 studies included (6 studies comparing MR to MRA (direct and indirect) vs Arthroscopy/surgical confirmation	MR vs MRA (direct and indirect) vs Arthroscopy/surgical confirmation	Sensitivity/Specificity Range **MR**: Labral Byrd: 25%/50% Czerny:30%/100% Sundberg: 100%/N/A Sutter: 77-89%/50% Tian: 61-66%/74/77% Toomayan: 8%,25%/100% Chondral Byrd: 18%/100% Czerny: N/A	Magnetic resonance (MR) arthrography is more accurate for identification of labral tears and chondral lesions of the hip compared to unenhanced MR imaging.	Moderate

				Sundberg: N/A Sutter: 50-83%/50-100% Tian: N/A Toomayan: N/A **MRA:** <u>Labral</u> Byrd: 72%/13% Czerny:90%/100% Sundberg: 80%/N/A Sutter: 85-89%/50-100% Tian: 90-95%/85% Toomayan: 92%/100% <u>Chondral</u> Byrd: 41%/94% Czerny: N/A Sundberg: N/A Sutter: 50-92%/25-100% Tian: N/A Toomayan: N/A		
Murphey et al., 2014 From the radiologic pathology archives imaging of osteonecrosis: radiologic-pathologic correlation	Review study	N/A	Imaging for osteonecrosis	MR imaging can detect osteonecrosis within one week of vascular injury. Diagnostic accuracy for hip osteonecrosis (97% -100%). A thick physeal scar and early conversion to yellow marrow are indicative of osteonecrosis on MR imaging	Magnetic resonance (MR) imaging demonstrates high diagnostic accuracy for osteonecrosis of the hip.	Low
Hakkarinen et al., 2012 Magnetic resonance imaging identifies occult hip fractures missed by 64-slice computed tomography	Retrospective chart review	N=235 fractures	MR in some, CT in some, Both in only 4 Surgical follow-up in some	90% + initial XR 10% -XR (occult) Of the 24 occult fractures, 4 had both CT and MR and MR identified all 4 CT + for occult fracture 19/24 (80%) no comparison MR	CT can identify the majority of occult hip fractures but when negative, occult hip fracture cannot be excluded, follow-up is warranted.	Low

Smith et al., 2011 The diagnostic accuracy of acetabular labral tears using magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis	Meta-analysis MRA=magnetic resonance arthrography	N= 19 studies (872 patients; 881 hips) Conventional MRI = 13 studies and MRA = 16 studies	MR vs MRA (compared to reference standard of arthroscopic or open surgical findings)	Pooled estimates for detecting acetabular labral tears: **MR (8 studies):** Sensitivity: 66% (95% CI 59 to 73) Specificity: 79% (95% CI 67 to 91) **MRA (15 studies):** Sensitivity: 87% (95% CI 84 to 90) Specificity: 64% (95% CI 54 to 74)	Magnetic resonance (MR) imaging and MR arthrography are comparable diagnostic imaging studies for identifying acetabular labral tears.	Moderate
Mintz et al., 2005 Magnetic Resonance Imaging of the Hip: Detection of Labral and Chondral Abnormalities Using Noncontrast Imaging	Retrospective (consecutive sample)	N= 92 patients (patients who had MRI followed by subsequent arthroscopy) 2 radiologists blinded to initial MRI and surgical findings, independentl y interpreted the studies	MR followed by Hip arthroscopy	Labral Tears: 83 and 84 of the 88 labral tears identified by 2 radiologists respectively • 92% inter-observer agreement • Articular cartilage abnormalities: • Femoral cartilage- Agreement of MRI and Arthroscopy--Was 92% and 86% for 2 radiologists respectively • Acetabular cartilage- 88% and 85% for 2 radiologists respectively	MR is an accurate noninvasive diagnostic tool to screen patients for labral tears and cartilage lesions and facilitate in deciding about surgical intervention thus preserving arthroscopy for therapeutic purposes.	Low
James et al., 2006 MRI Findings of Femoroacetabular Impingement	Prospective (Consecutive patients)	N=46 patients With history of chronic hip pain or groin pain and clinical findings consistent with femoral impingement	MRI vs Surgical findings (all patients had preoperative MRI) 2 radiologists independently reviewed MRI Blinded to surgical findings	7 cases of labral tears identified and confirmed surgically 37/38 cases (97%) of chondral lesions identified Acetabular chondral lesions identified in 89-94% of the cases	MR is accurate in preoperative assessment of patients with impingement who require arthroscopy/surgery.	Low
Initial QOE Score Across Studies for PICO #4**: Low (3)**						

SEMPI Grading QOE—Table 4A.4b—Risk of Bias		
PICO #4: In adults with hip pain, what clinical scenarios warrant magnetic resonance (MR) imaging for optimal patient assessment?		
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	Retrospective, selection criteria not identified, unblinded, incomplete data, no control groups; Review articles
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Surgical confirmation
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 4A.4c—Evidence to Recommendations				
PICO #4: In adults with hip pain, what clinical scenarios warrant magnetic resonance (MR) imaging for optimal patient assessment?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Saied et al., 2017 Accuracy of magnetic resonance studies in the detection of chondral and labral lesions in femoroacetabular impingement: systematic review and meta-analysis	Although conventional magnetic resonance (MR) imaging and MR arthrography are diagnostically reliable tools to identify acetabular **labral lesions** in patients with symptomatic femoroacetabular impingement; they are less accurate in identifying **chondral lesions.**	Moderate	Low (3)	Strong (A)
Sadozai et al., 2016 The sensitivity of CT scans in diagnosing occult femoral neck fractures	CT does not offer sufficient sensitivity to detect occult hip fractures. MR is imaging modality of choice for occult hip fractures and if CT is done when MR unavailable/contraindicated, further follow-up after negative CT is indicated.	Low		
Naraghi & White, 2015 MRI of labral and chondral lesions of the hip	Magnetic resonance (MR) arthrography is more accurate for identification of labral tears and chondral lesions of the hip compared to unenhanced MR imaging.	Moderate		
Murphey et al., 2014 From the radiologic pathology archives imaging of osteonecrosis: radiologic-pathologic correlation	Magnetic resonance (MR) imaging demonstrates high diagnostic accuracy for osteonecrosis of the hip.	Low		
Hakkarinen et al., 2012 Magnetic resonance imaging identifies occult hip fractures missed by 64-slice computed tomography	CT can identify the majority of occult hip fractures but when negative, occult hip fracture cannot be excluded, follow-up is warranted.	Low		
Smith et al., 2011 The diagnostic accuracy of acetabular labral tears us ing magnetic resonance imaging and magnetic resonance arthrography: a meta-analysis	MR imaging and MRA are comparable diagnostic studies for identifying acetabular labral tears.	Moderate		
Mintz et al., 2005 Magnetic Resonance Imaging of the Hip: Detection of Labral and Chondral Abnormalities Using Noncontrast Imaging	MR is a noninvasive diagnostic tool to screen patients for labral tears and cartilage lesions and facilitate in deciding about surgical intervention thus preserving arthroscopy for therapeutic purposes.	Low		
James et al., 2006 MRI Findings of Femoroacetabular Impingement	MR is useful in preoperative assessment of patients with impingement who require arthroscopy/surgery.	Low		

Recommendation Rating: 3A—Strong recommendation for the intervention based on low quality evidence
Justification: Overall risk of bias is offset by surgical confirmation and consistency of findings, thus QOE not downgraded.

Rating Definitions:

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

Conclusion: Magnetic resonance (MR) is the modality of choice for characterizing the articular cartilage of the hip and underlying subchondral bone because of good tissue delineation. It depicts soft tissue injury and abnormalities with greater sensitivity and surpasses surgical visualization in its ability to reveal the underlying femoral and acetabular anatomy. In addition, MR arthrography has greater diagnostic accuracy for labral/muscle tears and is the preferred modality for perioperative evaluation. Although computed tomography (CT) is generally sensitive for the assessment of osseous (bony) structures, when negative for suspected occult hip fracture or stress fracture, MR imaging is warranted. The blood supply to the femoral head of the hip joint is vulnerable to both direct traumatic injury as well as venous stasis-related compartment syndrome. This, combined with the hip's role as a major weight-bearing joint, makes it a common site of avascular necrosis (AVN)/osteonecrosis, resulting in chronic hip pain and best identified by MR imaging which detects bone marrow edema (Baig & Baig, 2018; Pierce et al., 2015). Conversely, idiopathic AVN also occurs where no etiology or risk factors can be identified.

Final Recommendation: 3A—In adults with hip pain, magnetic resonance (MR) imaging is recommended for optimal management in the following scenarios:

- Suspected labral and chondral abnormalities of the hip joint
  - With contrast
- Exclude occult hip fracture when CT is negative
  - Without contrast
- Suspected osteonecrosis
  - Without contrast
- Impingement syndrome
  - Without contrast
- Inconclusive initial imaging (XR, US) and persistence of symptoms
  - Without contrast (unless concern for labral/chondral lesion high in which case contrast warranted)

If MR is unavailable/contraindicated, CT imaging may be used.

PICO #5: In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reactions), should ultrasound (US) be performed compared to magnetic resonance (MR) for optimal assessment?

SEMPI Grading QOE—Table 4A.5a—Summary of Findings						
PICO #5: In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reactions), should sonography (US) be performed compared to magnetic resonance (MR) for optimal assessment?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Frisch et al., 2017 Ultrasound findings in asymptomatic patients with modular metal on metal total hip arthroplasty	Prospective, consecutive enrollment Determine prevalence of pseudotumor in symptom-free recipients of metal-on-metal hip prosthesis after 5+ years by US	N=36 asymptomatic patients with metal-on-metal total hip arthroplasty (THA) from 2004-2010	US (performed in 2015)	7/36 (19.4%) asymptomatic patients had pseudotumor identified on US	One in five asymptomatic patients with metal-on-metal hip prosthetic implants can develop a periarticular pseudotumor; routine ultrasound (US) imaging, in experienced hands, is warranted to identify pseudotumor in this population.	Low
Kwon et al., 2016 Is Ultrasound as Useful as Metal Artifact Reduction Sequence Magnetic Resonance Imaging in Longitudinal Surveillance of Metal-on-Metal Hip Arthroplasty Patients?	Prospective study	N= 35 patients (42 hips) 2 follow up scans for detecting adverse local tissue reactions	Ultrasound vs. MARS-MRI (reference standard)	Ultrasound vs. MARS-MRI **Initial imaging:** Sensitivity: 81% Specificity 92% PPV:86 % NPV: 88% **Repeat imaging (follow up post one year):** Sensitivity:86% Specificity 88 % PPV:75 % NPV: 94% Ultrasound able to detect the "change" in the lesions size with -0.3 cm^2 average bias from the MARS MRI (agreement; k = 0.85)	Ultrasound demonstrates comparable accuracy and agreement with MARS MRI in detecting adverse tissue reaction and change in lesion size on follow-up imaging of hip arthroplasty.	Low

Matharu et al., 2016 Which imaging modality is most effective for identifying pseudotumours in metal-on-metal hip resurfacings requiring revision-ultrasound or MARS-MRI or both?	Retrospective study	N= 39 patients Underwent imaging with both ultrasound and MARS-MRI	US vs. MARS-MRI (metal artefact reduction sequence MRI) vs. intra-operative & histopathologic confirmation	**Agreement with intra-operative findings:** US: 82.5% MARS-MRI: 87.5% US+MARS-MRI:92.5% Identification of a pseudo-tumor: agreement for ultrasound and MARS-MRI combined (κ = 0.69), moderate for MARS-MRI alone (κ = 0.54), fair for ultrasound alone (κ = 0.36). **US vs MARS MRI** Sensitivity:90.9% vs 93.9% Specificity: 57.1% vs 42.9% Positive predictive values: 88.2% vs 91.2% Negative predictive value: 66.7% vs 50.0% **US +MARS-MRI** Sensitivity: 100% NPV: 100%	Ultrasound (US) and magnetic resonance (MR) imaging are comparable in assessing intraoperatively-proven pseudotumours in metal-on-metal hip resurfacing (MoMHR).	Moderate
Madanat et al., 2016 Early Lessons from a Worldwide, Multicenter, Follow-up Study of the Recalled Articular Surface Replacement Hip System	Prospective Multicenter	N=288 patients (333 hips) Procedures included 166 hips (50%) with ASR resurfacing and 167 hips (50%) with ASR XL THA performed ALTRs were classified using the Anderson ALTR grading system, and the location, synovial thickness, and diameter of the ATLRs were assessed	MR of the hip performed at a mean time of 6 years post-surgery (ALTR for ASR and ASRXL)	Moderate or severe ALTRs were identified in 79 hips (24%); No differences in patient-reported outcome measures between patients with moderate-to-severe ALTRs and those with no ALTR findings on MR (p > 0.09)	MR should be used as a screening measure for ALTRs in patients with ASR XL as they are more likely to develop moderate-to-severe ALTRs.	Moderate

Lainiala et al., 2015 Good sensitivity and specificity of ultrasound for detecting pseudotumors in 83 failed metal-on-metal hip replacements	Prospective, pre-selected group with known pseudotumor based on MR then sent for revision surgery for failed THA	N=82, THA pts part of large 'recall'; MR to establish pseudotumor. Then they had pre-revision US to identify and classify type of pseudotumor found in OR	US vs OR (revision of failed THA)	US sensitivity/specificity: 79-83/92-94	US is reliable tool to predict pseudotumor in failed THA.	Moderate
Nishii et al., 2014 Is ultrasound screening reliable for adverse local tissue reaction after hip arthroplasty?	Retrospective study	N=105 patients (131 hips)	Ultrasound vs. MARS-MRI (reference standard)	Metal on metal (MoM) tissue reaction: Sensitivity: 74% Specificity :92% Accuracy: 84% Highly cross-linked polyethylene (HXLPE bearings): Sensitivity: 90% Specificity :83% Accuracy: 85%	Ultrasound is a reliable screening tool for detecting clinically important lesions in the anterior region around MoM or polyethylene bearings.	Low
Garbuz et al., 2014 The John Charnley Award: Diagnostic accuracy of MRI versus ultrasound for detecting pseudotumors in asymptomatic metal-on-metal THA	Prospective (Enrolled on average 54 months post THA)	N=40 All asymptomatic THA pts, followed with both US and MRI to detect pseudotumor, blind radiologists	MR and US (if both US and MR were positive that was concordant and 'gold standard')	Concordance=93% Prevalence of pseudo tumor=31% US sensitivity/specificity=100/96 MR Sensitivity/Specificity=92/100	US should be initial screen for pseudotumor after THA as it can exclude pseudotumor in asymptomatic patients.	Moderate
Nam et al., 2014 What are the advantages and disadvantages of imaging modalities to diagnose wear-related corrosion problems?	Systematic Literature Review (40 articles reviewed)	To evaluate the advantages and disadvantages of (1) US; (2) CT; and (3) MRI as diagnostic tools in the assessment of wear-related corrosion problems after hip arthroplasty	US, MR, CT	US is accessible and relatively inexpensive yet has not been used to report synovial thicknesses in the setting of wear-related corrosion. CT scans are highly sensitive and provide information regarding component positioning but are limited in providing enhanced soft tissue contrast and require ionizing radiation. MRI has shown promise in predicting both the presence and severity of adverse local tissue reactions but is more expensive.	US may serve as a screening technique for the detection of larger periprosthetic collections. MRI has been shown to predict the severity of tissue destruction found at revision and correlate to the degree of tissue necrosis at histologic evaluation.	Moderate

Siddiqui et al., 2014 A comparison of the diagnostic accuracy of MARS MRI and ultrasound of the painful metal-on-metal hip arthroplasty	Prospective study	N=19 consecutive patients with unilateral Metal on metal hips 3 Blind MSK radiologists (2 for US and 1 for MARS-MRI)	Ultrasound vs. MARS-MRI (reference standard) detection of soft tissue lesions (pseudotumor), muscle atrophy, tendon abnormalities, and joint effusions	Pseudotumor detection: Sensitivity:69% (CI: 39-91) Specificity: 83% (CI: 36-97) PPV: 90% NPV: 56% sensitivity of detection of abductor muscle atrophy :47% (CI: 24-71). Joint effusion detected in 10 cases by US and none by MARS MRI	US is inferior to MARS MRI for detection of pseudotumors and muscle atrophy, but it is superior for detection of joint effusion and tendinous pathologies.	Low
Initial QOE Score across studies for PICO #5**: Moderate (2)**						

SEMPI Grading QOE—Table 4A.5b—Risk of Bias		
PICO #5: In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reactions), should ultrasound (US) be performed compared to magnetic resonance (MR) for optimal assessment?		
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	Incomplete blinding, selection criteria not always clear
Inconsistency	Not Serious	
Indirectness	Not Serious	Generalizable to THA population
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Surgical/histopathologic 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 4A.5c—Evidence to Recommendations				
PICO #5: In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reactions), should ultrasound (US) be performed compared to magnetic resonance (MR) for optimal assessment?				
SEMPI Quality of Evidence (QOE) & Recommendation Strength				
Author/Year/Title	Highlights	SEMPI QOE Category	Final QOE Category	Recommendation Strength
Frisch et al., 2017 Ultrasound findings in asymptomatic patients with modular metal on metal total hip arthroplasty	One in five asymptomatic patients with metal-on-metal hip prosthetic implants can develop a periarticular pseudotumor; routine ultrasound (US) imaging, in experienced hands, is warranted to identify pseudotumor in this population.	Low	Moderate (2)	Strong (A)
Kwon et al., 2016 Is Ultrasound as Useful as Metal Artifact Reduction Sequence Magnetic Resonance Imaging in Longitudinal Surveillance of Metal on Metal Hip Arthroplasty Patients?	Ultrasound demonstrates comparable accuracy and agreement with MARS MRI in detecting adverse tissue reaction and change in lesion size on follow-up imaging of hip arthroplasty.	Low		
Matharu et al., 2016 Which imaging modality is most effective for identifying pseudotumours in metal-on-metal hip resurfacings requiring revision-ultrasound or MARS-MRI or both?	Ultrasound (US) and magnetic resonance (MR) imaging are comparable in assessing intraoperatively proven pseudotumors in metal-on-metal hip resurfacing (MoMHR).	Moderate		
Madanat et al., 2016 Early Lessons from a Worldwide, Multicenter, Followup Study of the Recalled Articular Surface Replacement Hip System	MRI should be used as a screening measure for ALTRs in patients with ASR XL as they are more likely to develop moderate-to-severe ALTRs.	Moderate		
Lainiala et al., 2015 Good sensitivity and specificity of ultrasound for detecting pseudotumors in 83 failed metal-on-metal hip replacements	US is reliable tool to predict pseudotumor in failed THA.	Moderate		
Nishii et al., 2014 Is ultrasound screening reliable for adverse local tissue reaction after hip arthroplasty?	Ultrasound is a reliable screening tool for detecting clinically important lesions in the anterior region around MoM or polyethylene bearings.	Low		

Garbuz et al., 2014 The John Charnley Award: Diagnostic accuracy of MRI versus ultrasound for detecting pseudotumors in asymptomatic metal-on-metal THA	US should be initial screen for pseudotumor after THA as it can exclude pseudotumor in asymptomatic patients. It is readily available and inexpensive	Moderate		
Nam et al., 2014 What are the advantages and disadvantages of imaging modalities to diagnose wear-related corrosion problems?	US may serve as a screening technique for the detection of larger periprosthetic collections. MRI has been shown to predict the severity of tissue destruction found at revision and correlate to the degree of tissue necrosis at histologic evaluation.	Moderate		
Siddiqui et al., 2014 A comparison of the diagnostic accuracy of MARS MRI and ultrasound of the painful metal-on-metal hip arthroplasty	US is inferior to MARS MRI for detection of pseudotumors and muscle atrophy, but it is superior for detection of joint effusion and tendinous pathologies.	Low		

Recommendation Rating: 2A—Strong recommendation for the intervention based on moderate quality evidence
Justification: Risk of bias insufficient to downgrade QOE given prospective trial data, surgical/histopathologic and direct applicability to hip arthroplasty population

Rating Definitions:

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

Strength of Recommendation: A = Strength of Recommendation from Consistent Evidence; **B**=Strength of Recommendation from Panel Consensus

Conclusion: Pseudotumor, a localized tissue reaction to metal debris, is a known post-operative complication following metal -on-metal prosthetic hip implants which has resulted in high-volume "recalls" of prosthetic hip joints. Although magnetic resonance (MR) imaging to detect pseudotumor has been considered the 'reference standard' and is used for revision surgical planning, sonography (US) demonstrates acceptable sensitivity in detection of pseudotumor, particularly as a screening tool, and can also be used to monitor the size of a known pseudotumor. Compared with Metal Artifact Reduction Sequence-Magnetic Resonance (MARS-MR), the main advantages of ultrasound include lower cost, efficiency, no impact of prosthetic artifact, and fewer patient contraindications such as metallic implants and claustrophobia (Siddiqui et al., 2014). The main disadvantages of US include operator dependence, unavailability, and obesity-related limitations (Kwon et al., 2016; Siddiqui et al., 2014).

Final Recommendation: 2A—In adults with suspected hip arthroplasty complications (pseudotumor/local soft tissue reaction), ultrasound (US) is recommended as an initial imaging modality for optimal assessment.
Metal Artifact Reduction Sequence Magnetic Resonance (MARS- MR) imaging is recommended for operative planning when revision of a hip prosthesis is necessary.

PICO #6: In adults with suspected infection (osteomyelitis) is magnetic resonance (MR) imaging the modality of choice for optimal diagnostic accuracy?

SEMPI Grading QOE—Table 4A.6a—Summary of Findings						
PICO #6: In adults with suspected infection (osteomyelitis) is magnetic resonance (MR) imaging the modality of choice for optimal diagnostic accuracy?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Glaudemans et al., 2019 Consensus document for the diagnosis of peripheral bone infection in adults: a joint paper by the EANM, EBJIS, and ESR (with ESCMID endorsement)	Professional society (EBJIS, ESR, ESCMID, EANM) guidelines from evidence-based systematic review MR=magnetic resonance	N/A EBJIS=European Bone and Joint Infection Society, ESR=European Society of Radiology ESCMID=European Society of Microbiology and Infectious Disease EANM = European Association of Nuclear Medicine	N/A	MR imaging performance for peripheral bone osteomyelitis MR Sensitivity: 88-98% MR Specificity: 70-96% MR Accuracy: 81-86% Advantages of MR: -early diagnosis (x-ray negative) -contrast not required unless soft tissue involvement -no radiation risk	Magnetic resonance (MR) imaging without contrast demonstrates high diagnostic performance in detecting peripheral bone infection. Contrast can be added when soft tissue involvement is suspected.	Moderate
Zalavras et al., 2009 Magnetic Resonance Imaging Findings in Hematogenous Osteomyelitis of the Hip in Adults	Retrospective	N=11 patients (12 hips) with hematogenous osteomyelitis of femoral head 10/11 had one or more co morbidities	MR All patients received surgical debridement	7/12 hips had osteomyelitis distal to femoral head 10 /12 had femoral head erosions 11/12 had acetabulum osteomyelitis 6/12 had acetabular erosions 8/12 hips had infection extended into soft tissues	MR determines the extent of spread of infection and is useful in preoperative planning to treat all infected regions.	Low
Huang et al., 1998 Osteomyelitis of the pelvis/hips in paralyzed patients: accuracy and clinical utility of MRI	Prospective	N = 44 paralyzed patients Total MR exams= 59 Follow up = 3 years Extent of infection identified by MR compared with surgical findings	MR vs Surgical confirmation	Sensitivity = 98% Specificity = 89% Accuracy = 97% 21 patients had limited surgical resection guided by MR findings	MR accurately identifies osteomyelitis and associated soft tissue pathologies. It also determines the extent of infection and hence helps in appropriate surgical resection.	Moderate

Unger et al., 1988 Diagnosis of Osteomyelitis by MR Imaging	Prospective Consecutive enrollment MR imaged sites- Feet, Ankles, Tibia, Knees, pelvis, Hips, spine, Hands, elbows and Skull	N= 35 patients (incudes pediatric population) clinically suspected to have osteomyelitis Age 1-84 years (Mean =52 years) 14 patients had diabetes 38 MR exams on 35 patients 33 patients had scintigraphy MR and bone scan interpreted by two radiologists to rule out osteomyelitis	MR, Scintigraphy (Imaging Diagnosis surgically confirmed in 21 patients)	Sensitivity: MR =92% Scintigraphy =82% Specificity: MR =96% Scintigraphy =65% Accuracy: MR =94% Scintigraphy =71%	MR is superior to bone scan for diagnosis of osteomyelitis.	Low
Tang et al., 1988 Musculoskeletal infection of the Extremities: Evaluation with MR Imaging	Prospective Consecutive enrollment (referral population) MR imaged sites- Shoulder, Hip, Humerus, Femur, Knee, Tibia, Fibula, Ankle and Foot	N=17 11-84 years (average =44 years) All patients had standard XR 3 patients had CT 10 had bone scan 2 had leukocyte scan 12 patients had surgery Histopathologic confirmation of surgical samples	XR, CT, Bone-scan, MR, Surgery and Histopathologic confirmation	10 patients with osteomyelitis identified: Acute = 4 Subacute with Brodie abscess =2 Chronic =2 Acute with septic arthritis =2 4 cases of cellulitis in absences of osteomyelitis identified 3 cases with no osteomyelitis identified	MR provides accurate and detailed information about the extent of infection with surgically confirmed results.	Low
Initial QOE Score across studies for PICO #6: **Low (3)**						

SEMPI Grading QOE—TTable 4A.6b—Risk of Bias		
PICO #6: In adults with suspected infection (osteomyelitis) is magnetic resonance MR imaging the modality of choice for optimal diagnostic accuracy?		
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 bias, Non-randomized studies, Small sample size
Inconsistency	Not Serious	
Indirectness	Serious	Selective population-- surgical populations
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Surgical/histopathologic confirmation
Other Considerations	Yes	Professional society guidelines
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 4A.6c—Evidence to Recommendations

PICO #6: In adults with suspected infection (osteomyelitis) is magnetic resonance (MR) imaging the modality of choice for optimal diagnostic accuracy?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Category	Final QOE Category	Recommendation Strength
Glaudemans et al., 2019 Consensus document for the diagnosis of peripheral bone infection in adults: a joint paper by the EANM, EBJIS, and ESR (with ESCMID endorsement)	Magnetic resonance (MR) imaging without contrast demonstrates high diagnostic performance in detecting peripheral bone infection. Contrast can be added when soft tissue involvement is suspected.	Moderate	Low (3)	Strong (A)
Zalavras et al., 2009 Magnetic Resonance Imaging Findings in Hematogenous Osteomyelitis of the Hip in Adults	MR determines the extent of spread of infection and is useful in preoperative planning to treat all infected regions.	Low		
Huang et al., 1998 Osteomyelitis of the pelvis/hips in paralyzed patients: accuracy and clinical utility of MRI	MR accurately identifies osteomyelitis and associated soft tissue pathologies. It also determines the extent of infection and hence helps in appropriate surgical planning.	Moderate		
Unger et al., 1988 Diagnosis of Osteomyelitis by MR Imaging	MR has ability to differentiate soft tissue disease from bone marrow processes and this leads to improved specificity and accuracy of osteomyelitis diagnosis.	Low		
Tang et al., 1988 Musculoskeletal infection of the Extremities: Evaluation with MR Imaging	MR provides accurate and detailed information about the extent of infection compared to XR, CT or bone scan. It reliably identifies infection foci and differentiates osteomyelitis from other soft tissue pathologies.	Low		

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

Justification: Risk of bias insufficient to downgrade QOE given surgical/histopathology and professional society guidelines systematic reviews

Rating Definitions:

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

Strength of Recommendation: A = Strength of Recommendation from Consistent Evidence; **B**=Strength of Recommendation from Panel Consensus

Conclusion: Magnetic resonance (MR) imaging demonstrates high diagnostic accuracy for osteomyelitis of the hip, particularly early in the infectious process when conventional radiography (XR) is generally negative. MR imaging provides anatomic details regarding the extent of infection and assists in pre-op planning (debridement) and management of osteomyelitis. Contrast is not required when infection is limited to the bone but can be used when soft tissue involvement is suspected. A further advantage of MR imaging is the absence of radiation exposure.

Final Recommendation: 3A- In adults with suspected hip infection, magnetic resonance (MR) imaging without and with contrast is recommended in the following scenarios:

- XR is negative and clinical presentation suspicious for infection
- Soft tissue involvement is suspected in addition to osseous involvement/osteomyelitis
- Osteomyelitis diagnosed and pre-operative mapping for extent of debridement desired

PICO #7: In adults who require aspiration or injection of the hip joint, should imaging guidance be performed by ultrasound (US) or fluoroscopy (FL) for optimal patient management?

SEMPI Grading QOE—Table 4A.7a—Summary of Findings						
PICO #7: In adults who require aspiration or injection of the hip joint, should imaging guidance be performed by ultrasound (US) or fluoroscopy (FL) for optimal patient management?						
Author/Year/Title	Study Design	Population	Intervention Vs Comparator	Results	Conclusion Summary	SEMPI QOE Rating
Randelli et al., 2018 Fluoroscopy-vs ultrasound-guided aspiration techniques in the management of periprosthetic joint infection: which is the best?	Retrospective cohort study	52 hip aspirations in 49 patients suspected of PJI FL – N = 26 US – N = 26 FL = Fluoroscopy guided US – Ultrasound guided PJI – Periprosthetic joint infection	Comparing diagnostic characteristics (sensitivity, specificity and cost) of FL vs US-guided joint aspiration Intraoperative cultures (reference standard)	**US vs FL:** Sensitivity: 89% vs 60%, p=0.73 Specificity: 94% vs 81%, p=0.80 Cost: 125 € vs 343 €	Ultrasound-guided aspiration, in well-trained hands, can provide an appropriate alternative to fluoroscopy - guided aspiration in the diagnosis/management of periprosthetic hip joint infection.	Low
Balog et al., 2017 Accuracy of ultrasound-guided intra-articular hip injections performed in the orthopedic clinic	Observational study	N = 50 US guided hip injection (43 patients with 7 having bilateral injections)	N/A Contrast injected with injection and fluoroscopy performed to confirm intra-articular injection	96% accuracy with 46/48 injections confirmed as intra-articular Procedure time 2.6 mins (avg) Visual analog pain score=1.9	Ultrasound-guided intra-articular hip injections has high accuracy and can be conveniently performed in the clinic with minimal patient discomfort.	Low :
Martínez-Martínez et al., 2016 Comparison of ultrasound and fluoroscopic guidance for injection in CT arthrography and MR arthrography of the hip	Retrospective US-or FL-guided contrast injection during arthroscopy	N=58 procedures 26-FL-guided 32-US-guided Measures: sufficient volume injected, extravasation, intra-articular bubbles	US-guided and FL-guided contrast injection during either MR- or CT-arthroscopy	**Contrast extravasation** 18/32 (56%) and 2/32 (6%) invalid of **US-guided injections** Contrast extravasation 14/26 (54%) and 1/26 (4%) invalid of **FL-guided procedures** **Intra-articular gas** 7/32 (22%) by **US-**, 10/26 (39%) by **FL-guidance**--NOT statistically significant (p > 0.05)	Ultrasound is as useful as fluoroscopy for injecting contrast material for CT- and MR-arthroscopy.	Moderate

Byrd et al., 2014 Ultrasound-guided hip injections: a comparative study with fluoroscopy-guided injections	Prospective, Consecutive enrollment	N=50 Ortho clinic patients had initial Fluoroscopy (FL)-guided hip injection then later US-guided; Both rated on 1-10 scale for pain and convenience	US-guided outpatient hip injection (by NP) versus FL-guided hip injection at radiology unit in hospital	US/FL-- Pain: 3/5.6 Convenience: 9.8/3.1 ($p < 0.01$) in favor of US Preference: 49 of 50 (98%) preferred US-guided injection	Outpatient ultrasound-guided injection of the hip is more convenient and less painful than fluoroscopy-guided hospital-based injections and preferred by patients who have had both.	Moderate
Initial QOE Score across studies for PICO #7: **Moderate (2)**						

SEMPI Grading QOE—Table 4A.7b—Risk of Bias		
PICO #7: In adults who require aspiration or injection of the hip joint, should imaging guidance be performed by ultrasound (US) or fluoroscopy (FL) for optimal patient management?		
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	Pre-selected patients; technique used not defined/controlled; no accounting for "operator-dependent" factor with US technique, Small N, lack of comparator
Inconsistency	Not Serious	
Indirectness	Serious	Varied populations; specific indications for intervention; "country of origin" affects availability of modality
Imprecision	Not Serious	Surrogates (qualitative extravasation, 'gas bubbles') not definitively tied to outcomes/disease process
Positive Bias		
Strength of Association	Moderate	Surgical confirmation in some studies (not all)
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 4A.7c—Evidence to Recommendations

PICO #7: In adults who require aspiration or injection of the hip joint, should imaging guidance be performed by ultrasound (US) or fluoroscopy (FL) for optimal patient management?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Category	Final QOE Category	Recommendation Strength
Randelli et al., 2018 Fluoroscopy-vs ultrasound-guided aspiration techniques in the management of periprosthetic joint infection: which is the best?	Ultrasound-guided aspiration, in well-trained hands, can provide an appropriate alternative to fluoroscopy - guided aspiration in the diagnosis/management of periprosthetic hip joint infection.	Low	Low (3)	Strong (A)
Balog et al., 2017 Accuracy of ultrasound-guided intra-articular hip injections performed in the orthopedic clinic	Ultrasound-guided intra-articular hip injections has a high accuracy and can be conveniently performed in the clinic with minimal patient discomfort.	Low		
Martínez-Martínez et al., 2016 Comparison of ultrasound and fluoroscopic guidance for injection in CT arthrography and MR arthrography of the hip	Ultrasound is as useful as fluoroscopy for injecting contrast material for CT and MR arthroscopy.	Moderate		
Byrd et al., 2014 Ultrasound-guided hip injections: a comparative study with fluoroscopy-guided injections	Outpatient ultrasound-guided injection of the hip is more convenient and less painful than fluoroscopy-guided hospital-based injections and preferred by patients who have had both.	Moderate		

Recommendation Rating: 3A—Strong recommendation for the intervention based on low quality evidence
Justification: Significant risk of bias due to preselected populations, small n, population heterogeneity is sufficient to downgrade QOE.

Rating Definitions:

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

Conclusion: Fluoroscopy guidance is the most commonly used imaging modality and a long-standing reference standard for aspiration/injection procedures involving the hip joint. It can be used with or without the injection of iodinated contrast to confirm needle placement. Ultrasound-guided imaging for these procedures is increasingly being used because it avoids radiation exposure and also provides direct visualization of fluid collections that add diagnostic value over fluoroscopy. Conversely, limitations associated with ultrasound guidance include significant operator-dependence and lack of widespread training/expertise in its use.

Final Recommendation: 3A—In adults who require aspiration or injection of the hip joint, either fluoroscopy (FL) or ultrasound (US) guidance is recommended for optimal management of hip joint-related processes.

PICO #8: In adults with hip pain, what clinical scenarios warrant computed tomography (CT) imaging for optimal diagnostic accuracy?

<table>
<tr><th colspan="7">SEMPI Grading QOE—Table 4A.8a—Summary of Findings</th></tr>
<tr><td colspan="7">PICO #8: In adults with hip pain, what clinical scenarios warrant computed tomography (CT) imaging for optimal diagnostic accuracy?</td></tr>
<tr><th>Author/Year/Title</th><th>Design</th><th>Population</th><th>Intervention Vs Comparator</th><th>Results</th><th>Conclusion Summary</th><th>SEMPI QOE Rating</th></tr>
<tr>
<td>Lanotte et al., 2020
Value of CT to detect radiographically occult injuries of the proximal femur in elderly patients after low-energy trauma: determination of non-inferiority margins of CT in comparison with MRI</td>
<td>Prospective, consecutive enrollment over 2-year period

2 centers, 4 radiologists</td>
<td>N=102 who met inclusion criteria = age >60, low energy trauma, suspicion of femur injury, negative X-ray

MR=magnetic resonance
CT=computed tomography</td>
<td>CT vs MR proximal femur (Both completed on all study participants)</td>
<td>Sensitivity/specificity of CT and MR by 4 different readers for detection of occult femoral fracture after low energy trauma
<table>
<tr><td></td><td>CT</td><td>CT</td><td>MR</td><td>MR</td></tr>
<tr><td></td><td>SE</td><td>SP</td><td>SE</td><td>SP</td></tr>
<tr><td>R1</td><td>83%</td><td>99%</td><td>100%</td><td>100%</td></tr>
<tr><td>R2</td><td>93%</td><td>100%</td><td>97%</td><td>99%</td></tr>
<tr><td>R3</td><td>90%</td><td>100%</td><td>97%</td><td>100%</td></tr>
<tr><td>R4</td><td>90%</td><td>100%</td><td>97%</td><td>100%</td></tr>
</table>
P value range: 0.1250—0.3750</td>
<td>Computed tomography (CT) to identify femur fracture is an accepted alternative if magnetic resonance (MR) imaging is unavailable or contraindicated; CT is significantly better than x-ray imaging for evaluation of femur fractures in elderly patients following low-energy trauma.</td>
<td>Moderate</td>
</tr>
<tr>
<td>Eggenberger et al., 2019
Use of CT Vs. MRI for Diagnosis of Hip or Pelvic Fractures in Elderly Patients After Low Energy Trauma</td>
<td>Retrospective chart review

Determine if CT imaging can be alternative to magnetic resonance (MR) imaging for detection of occult hip/pelvis fractures in adults over 50</td>
<td>N=218

Patients >50 presenting to Emergency Department at single facility with hip pain after low energy fall with negative XR who also had an MR or CT or MR and CT</td>
<td>CT vs MR hip/pelvis</td>
<td>Fracture detection after low energy trauma:
CT only group: 41/132 (31%)
MR only group: 24/78 (32%)

Average emergency department time
CT: 430 minutes
MR: 502 minutes
p < 0.0001</td>
<td>The detection rate of occult hip/pelvic fractures following low impact trauma in older adults is similar between computed tomography (CT) and magnetic resonance (MR) imaging.</td>
<td>Low</td>
</tr>
</table>

Haubro et al., 2015 Sensitivity and specificity of CT-and MRI-scanning in evaluation of occult fracture of the proximal femur	Prospective, consecutive enrollment cohort, hip pain after low energy fall and negative x-ray	N=67 (40-female, 27-male)	CT, MR on all (MR reference standard)	15 fractures found in 67 patients Detection of occult femoral fracture after low energy trauma: Computed Tomography (CT): Sensitivity—0.87; 95% CI [0.60-0.98] Specificity—1.00; 95% CI [0.93-1.00]	Computed tomography (CT) is not as sensitive as magnetic resonance (MR) imaging in detecting occult fractures of the proximal femur.	Low
Initial QOE Score Across Studies for PICO #8: **Low (3)**						

SEMPI Grading QOE—Table 4A.8b—Risk of Bias		
PICO #8: In adults with hip pain, what clinical scenarios warrant computed tomography (CT) imaging for optimal diagnostic accuracy?		
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	Small N, use of reference standard as comparator, retrospective and/or incomplete data reported
Inconsistency	Not Serious	
Indirectness	Not Serious	
Imprecision	Not Serious	
Positive Bias		
Strength of Association	Moderate	Surgical confirmation
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 4A.8c—Evidence to Recommendations

PICO #8: In adults with hip pain, what clinical scenarios warrant computed tomography (CT) imaging for optimal diagnostic accuracy?

SEMPI Quality of Evidence (QOE) & Recommendation Strength

Author/Year/Title	Highlights	SEMPI QOE Rating	Final QOE Category	Recommendation Strength
Lanotte et al., 2020 Value of CT to detect radiographically occult injuries of the proximal femur in elderly patients after low-energy trauma: determination of non-inferiority margins of CT in comparison with MRI	Computed tomography (CT) to identify femur fracture is an accepted alternative if magnetic resonance (MR) imaging is unavailable or contraindicated; CT is significantly better than x-ray imaging for evaluation of femur fractures in elderly patients following low-energy trauma.	Moderate	Low (3)	Consensus(B)
Eggenberger el al., 2019 Use of CT Vs. MRI for Diagnosis of Hip or Pelvic Fractures in Elderly Patients After Low Energy Trauma	The detection rate of occult hip/pelvic fractures following low impact trauma in older adults is similar between computed tomography (CT) and magnetic resonance (MR) imaging.	Low		
Haubro et al., 2015 Sensitivity and specificity of CT-and MRI-scanning in evaluation of occult fracture of the proximal femur	Computed tomography (CT) is not as sensitive as magnetic resonance (MR) imaging in detecting occult fractures of the proximal femur.	Low		

Recommendation Rating: 3B--Recommendation from panel members is Consensus for the intervention based on low quality evidence
Justification: Risk of bias insufficient to warrant downgrade of QOE given consistency of findings.

Rating Definitions:

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

Conclusion: While magnetic resonance (MR) imaging is consistently more accurate in detecting occult fractures of the femur in patients with hip pain after low energy trauma, CT imaging has a relatively high degree of accuracy for detecting such fractures and is often more readily available, has fewer contraindications, and is less costly. CT is significantly better than radiographs (XR) for evaluation of femur fractures in elderly patients following low energy trauma. CT imaging is also used following reduction following a hip dislocation. Generally, an x-ray (XR) is first used to confirm reduction, and once confirmed, CT must be done to assess for concentric reduction, articular fractures, or bony fragments incarcerated within the joint. CT should be considered for preoperative evaluation prior to surgery for fixation of femoral neck fractures. CT is often used for evaluation in the setting of a painful or potentially loose hip replacement (Blum et al., 2016). CT is also frequently utilized for evaluation of bone stock prior to undergoing a revision hip replacement to determine, for example, extent of osteolysis which will dictate the type of prosthesis that will be needed for revision reconstruction. CT is also used for evaluation in the setting of a suspected osteoid osteoma, of which the hip is a common

location (Allen et al., 2003). Of note, CT is considered more accurate than MR imaging at detecting subchondral fractures in patients with osteonecrosis of the femoral head; and CT may offer improved evaluation of cartilage injuries as such injuries often involve, to some degree, the subchondral bone whereby small flecks of subchondral bone are easier to identify on CT than on MR imaging (Baig & Baig, 2018; Hu et al., 2015; Yeh et al., 2009).

Final Recommendation: 3B— In adults with hip pain, CT imaging is recommended in the following scenarios:

- All articular fractures of the hip (all femoral head or acetabular fractures)
- Post reduction following a hip dislocation. Generally, XR is first used to confirm reduction, and once confirmed, CT must be done to assess for concentric reduction, articular fractures, or bony fragments incarcerated within the joint.
- Preoperative evaluation prior to surgery for fixation of femoral neck fractures.
- Evaluation in the setting of a painful or potentially loose hip replacement
- Evaluation of bone stock prior to undergoing a revision hip replacement to determine, for example, extent of osteolysis which will dictate the type of prosthesis that will be needed for revision reconstruction.
- Evaluation in the setting of a suspected osteoid osteoma, of which the hip is a common location**.**

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