

**American College of Radiology  
ACR Appropriateness Criteria®  
Chronic Hand and Wrist Pain**

**Variant 1:                   Adult. Chronic hand or wrist pain. Initial imaging.**

Procedure	Appropriateness Category	Relative Radiation Level
Radiography area of interest	Usually Appropriate	Varies
US area of interest	May Be Appropriate	○
Radiographic arthrography area of interest	Usually Not Appropriate	Varies
MR arthrography area of interest	Usually Not Appropriate	○
MRI area of interest without and with IV contrast	Usually Not Appropriate	○
MRI area of interest without IV contrast	Usually Not Appropriate	○
Bone scan area of interest	Usually Not Appropriate	☼☼☼
CT area of interest with IV contrast	Usually Not Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
CT area of interest without IV contrast	Usually Not Appropriate	Varies
CT arthrography area of interest	Usually Not Appropriate	Varies

**Variant 2:                   Adult. Chronic wrist pain. Radiographs normal or remarkable for nonspecific arthritis. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MR arthrography wrist	Usually Appropriate	○
MRI wrist without IV contrast	Usually Appropriate	○
US wrist	May Be Appropriate	○
Radiography wrist additional views	May Be Appropriate	☼
CT arthrography wrist	May Be Appropriate	☼
CT wrist without IV contrast	May Be Appropriate	☼
Radiographic arthrography wrist	Usually Not Appropriate	☼
MRI wrist without and with IV contrast	Usually Not Appropriate	○
CT wrist with IV contrast	Usually Not Appropriate	☼
CT wrist without and with IV contrast	Usually Not Appropriate	☼
Bone scan wrist	Usually Not Appropriate	☼☼☼

**Variant 3:****Adult. Chronic hand pain. Radiographs normal or remarkable for nonspecific arthritis. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI hand without IV contrast	Usually Appropriate	○
US hand	May Be Appropriate	○
MRI hand without and with IV contrast	May Be Appropriate	○
Radiographic arthrography hand	Usually Not Appropriate	☢
MR arthrography hand	Usually Not Appropriate	○
CT hand with IV contrast	Usually Not Appropriate	☢
CT hand without and with IV contrast	Usually Not Appropriate	☢
CT hand without IV contrast	Usually Not Appropriate	☢
CT arthrography hand	Usually Not Appropriate	☢☢
Bone scan hand	Usually Not Appropriate	☢☢☢

**Variant 4:****Adult. Chronic wrist pain. Radiographs show old scaphoid fracture. Evaluate for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
MRI wrist without IV contrast	Usually Appropriate	○
CT wrist without IV contrast	Usually Appropriate	☢
MRI wrist without and with IV contrast	May Be Appropriate	○
US wrist	Usually Not Appropriate	○
Radiographic arthrography wrist	Usually Not Appropriate	☢
MR arthrography wrist	Usually Not Appropriate	○
CT arthrography wrist	Usually Not Appropriate	☢
CT wrist with IV contrast	Usually Not Appropriate	☢
CT wrist without and with IV contrast	Usually Not Appropriate	☢
Bone scan wrist	Usually Not Appropriate	☢☢☢

**Variant 5:**                    **Adult. Chronic hand or wrist pain. Radiographs normal or indeterminate. Symptoms suspicious for carpal tunnel syndrome. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
US area of interest	May Be Appropriate	○
MRI area of interest without IV contrast	May Be Appropriate	○
Radiography wrist additional views	Usually Not Appropriate	⊕
Radiographic arthrography area of interest	Usually Not Appropriate	Varies
MR arthrography area of interest	Usually Not Appropriate	○
MRI area of interest without and with IV contrast	Usually Not Appropriate	○
Bone scan area of interest	Usually Not Appropriate	⊕⊕⊕
CT area of interest with IV contrast	Usually Not Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
CT area of interest without IV contrast	Usually Not Appropriate	Varies
CT arthrography area of interest	Usually Not Appropriate	Varies

**Variant 6:**                    **Adult. Chronic hand or wrist pain. Radiographs normal or show nonspecific arthritis. Suspect tendon injury, tenosynovitis, or tendon pathology. Next imaging study.**

Procedure	Appropriateness Category	Relative Radiation Level
US area of interest	Usually Appropriate	○
MRI area of interest without IV contrast	Usually Appropriate	○
MRI area of interest without and with IV contrast	May Be Appropriate	○
Radiographic arthrography area of interest	Usually Not Appropriate	Varies
MR arthrography area of interest	Usually Not Appropriate	○
Bone scan area of interest	Usually Not Appropriate	⊕⊕⊕
CT area of interest with IV contrast	Usually Not Appropriate	Varies
CT area of interest without and with IV contrast	Usually Not Appropriate	Varies
CT area of interest without IV contrast	Usually Not Appropriate	Varies
CT arthrography area of interest	Usually Not Appropriate	Varies

## CHRONIC HAND AND WRIST PAIN

Expert Panel on Musculoskeletal Imaging: J. Derek Stensby, MD<sup>a</sup>; Michael G. Fox, MD, MBA<sup>b</sup>; Nicholas Nacey, MD<sup>c</sup>; Donna G. Blankenbaker, MD<sup>d</sup>; Matthew A. Frick, MD<sup>e</sup>; Shari T. Jawetz, MD<sup>f</sup>; Noah M. Raizman, MD<sup>g</sup>; Nicholas Said, MD, MBA<sup>h</sup>; Luke A. Stephens, MD, MSPH<sup>i</sup>; Naveen Subhas, MD, MPH<sup>j</sup>; Eric A. Walker, MD, MHA<sup>k</sup>; Chadwick L. Wright, MD, PhD<sup>l</sup>; Eric Y. Chang, MD.<sup>m</sup>

### **Summary of Literature Review**

#### **Introduction/Background**

The intricate anatomy and the complex biomechanics of the hand and wrist makes the evaluation of patients with chronic pain a diagnostic challenge. The International Association for the Study of Pain defines chronic pain as pain that persists or recurs for 3 months or longer. Appropriate use of imaging supplements the clinician's physical examination, patient history, and electrophysiology studies in establishing the proper diagnosis and treatment plan. This document covers the distal radioulnar joint (DRUJ), radiocarpal joint, intercarpal joints, carpometacarpal joints, metacarpophalangeal joints, interphalangeal joints, supporting soft tissues, and the tendons, nerves, and muscles of the hand and wrist. There are numerous causes of chronic hand and wrist pain including osteoarthritis, nonunited fractures, ligament insufficiency and instability, and nerve compression. Soft tissue masses, including ganglion cysts, are a common cause of chronic wrist pain and are covered in the ACR Appropriateness Criteria<sup>®</sup> topic on "[Soft Tissue Masses](#)" [1]. Imaging evaluation of inflammatory arthritis is covered in the ACR Appropriateness Criteria<sup>®</sup> topic on "[Chronic Extremity Joint Pain-Suspected Inflammatory Arthritis, Crystalline Arthritis, or Erosive Osteoarthritis](#)," [2] and the evaluation of infection is covered in the ACR Appropriateness Criteria<sup>®</sup> topic on "[Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection \(Excluding Spine and Diabetic Foot\)](#)" [3]. Evaluation of osteonecrosis, specifically Kienböck disease, is covered in the ACR Appropriateness Criteria<sup>®</sup> topic on "[Osteonecrosis](#)" [4]. Finally, imaging assessment of occult or stress fractures of the hand and wrist are covered in the ACR Appropriateness Criteria<sup>®</sup> topic on "[Stress \(Fatigue/Insufficiency\) Fracture, Including Sacrum, Excluding Other Vertebrae](#)" [5].

There are multiple imaging studies to evaluate chronic hand and wrist pain. The need for imaging and the choice of the appropriate imaging modality are best determined by the patient's presentation, physical examination, and the clinician's working diagnosis. Noninvasive imaging modalities of the hand and wrist include radiography, ultrasound (US), CT, MRI, and bone scan. Minimally invasive imaging options include arthrography, CT arthrography, CT with intravenous (IV) contrast, MR arthrography, and MRI with IV contrast. US is unique in that it can be used in dynamic assessment of the hand and wrist with the added benefit of imaging the contralateral side for comparison without an additional cost to the patient.

#### **Initial Imaging Definition**

Initial imaging is defined as imaging at the beginning of the care episode for the medical condition defined by the variant. More than one procedure can be considered usually appropriate in the initial imaging evaluation when:

- There are procedures that are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care)

OR

- There are complementary procedures (ie, more than one procedure is ordered as a set or simultaneously where each procedure provides unique clinical information to effectively manage the patient's care).

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The American College of Radiology seeks and encourages collaboration with other organizations on the development of the ACR Appropriateness Criteria through representation of such organizations on expert panels. Participation on the expert panel does not necessarily imply endorsement of the final document by individual contributors or their respective organization.

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## **Discussion of Procedures by Variant**

### **Variant 1: Adult. Chronic hand or wrist pain. Initial imaging.**

#### **Bone Scan Area of Interest**

There is no relevant literature to support the use of bone scan as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **CT Area of Interest With IV Contrast**

There is no relevant literature to support the use of CT with IV contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **CT Area of Interest Without and With IV Contrast**

There is no relevant literature to support the use of CT without and with IV contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **CT Area of Interest Without IV Contrast**

There is no relevant literature to support the use of CT without IV contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **CT Arthrography Area of Interest**

There is no relevant literature to support the use of CT arthrography as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **MR Arthrography Area of Interest**

There is no relevant literature to support the use of MR arthrography as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **MRI Area of Interest Without and With IV Contrast**

There is no relevant literature to support the use of MRI without and with IV contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **MRI Area of Interest Without IV Contrast**

There is no relevant literature to support the use of MRI without IV contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **Radiographic Arthrography Area of Interest**

There is no relevant literature to support the use of radiographic arthrography contrast as the first imaging study in the evaluation of chronic hand or wrist pain.

#### **Radiography Area of Interest**

The imaging evaluation of chronic hand or wrist pain should begin with radiographs [6-12]. In many cases, radiographs may be the only imaging examination needed to establish a diagnosis or confirm a clinically expected diagnosis. The standard radiographic evaluation of both the hand and wrist includes 3 views: posteroanterior, lateral, and oblique [9]. The standard projections allow assessment of alignment including ulnar variance, joint spaces, impaction syndromes, static instability, chronic healed and nonunited fractures, soft tissue mineralization, erosions, and soft tissue swelling.

#### **US Area of Interest**

Given the superficial location of the joints, ligaments, muscles, tendons, and nerves of the hand and wrists, US is a useful tool in the assessment of chronic hand and wrist pain bolstered by the ability to readily perform and dynamic examination and evaluate the contralateral side [9,13]. US is optimally performed using high-frequency (10-15 MHz) linear transducers [11,13].

US can be used to identify synovitis, joint effusion, tenosynovitis, tendinopathy and tendon injury, pulley injury, carpal tunnel syndrome (CTS), and retained foreign body [6,13-16]. The American College of Rheumatology has concluded there is reasonable evidence to support the use of musculoskeletal US in patients without definitive diagnosis presenting with pain, swelling, or mechanical symptoms of the wrist, metacarpophalangeal, and interphalangeal joints; US is reasonable to evaluate tendon and soft tissue pathology of the hand and wrist and to assess for entrapment of the median or ulnar nerves [14]. In a study of patients referred from hand surgeons, US of the hand and wrist was contributory to the clinical assessment, defined as confirming the clinical suspicion or modifying the diagnostic/therapeutic plan in 76% of all patients and 67% of patient who presented without a history

of trauma [17]. Although there are many advantages to US evaluation for chronic hand and wrist pain, an interdisciplinary group of hand surgeons and radiologists recommended against the inclusion of US in the standard evaluation of scapholunate instability [18].

**Variant 2: Adult. Chronic wrist pain. Radiographs normal or remarkable for nonspecific arthritis. Next imaging study.**

This variant is a guide on appropriate imaging use early in the assessment of chronic wrist pain, when standard radiographic projections are normal or show nonspecific arthritis. For purposes of this variant, a nonspecific arthritis is defined as articular changes at a single joint and/or a pattern of arthritis throughout the hand and wrist that, when combined with the appropriate clinical history, does not allow distinction between degenerative or post-traumatic osteoarthritis, inflammatory arthritis, and crystalline arthritis.

**Bone Scan Wrist**

There is no relevant literature discussing routine use of bone scan in the assessment of nonspecific chronic wrist pain. Bone scans offer the ability to differentiate metabolically active abnormalities, which may be the cause of pain, from those that are inactive [19]. Bone scans can reliably detect chronic or occult scaphoid fracture with a sensitivity and specificity of 97% and 89%, respectively [20]. Although bone scans are sensitive for the detection of bone abnormalities, the findings may be nonspecific [19]. There are established imaging patterns for fracture, osteonecrosis, nonunited fracture, arthritis, and complex regional pain syndrome [19]. Bone scan of the wrist offers improved specificity when single-photon emission CT is performed [19].

**CT Arthrography Wrist**

Performing arthrography before a CT scan of the wrist aids in the detection of ligament injuries and cartilage abnormalities. CT arthrography allows direct visualization of full thickness ligament tears and visualization of partial thickness tears of the appropriate compartment [6,21]. An interdisciplinary group of hand surgeons and radiologists supports the use of CT arthrography for the assessment of clinically suspected scapholunate instability and cartilage defects [18]. CT arthrography has demonstrated a sensitivity, specificity, and accuracy between 92% and 94% for triangular fibrocartilage (TFC) complex tears, between 80% and 100% for intrinsic ligament tears located within the proximal carpal compartment, and between 94% and 100% for articular cartilage abnormalities [22]. In a study assessing the diagnostic performance of CT arthrography in cadavers, CT arthrography was more sensitive for the diagnosis of scapholunate and lunotriquetral tears when compared with MRI at 1.5T and performed particularly well in assessment of the dorsal segment of the scapholunate ligament [23].

**CT Wrist With IV Contrast**

There is no relevant literature to support the use of CT wrist with IV contrast in the setting of chronic wrist pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Wrist Without and With IV Contrast**

There is no relevant literature to support the use of CT wrist without and with IV contrast in the setting of chronic wrist pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Wrist Without IV Contrast**

CT of the wrist provides a detailed assessment of the cortical and trabecular bone with a high spatial resolution. CT is the ideal modality to assess fracture healing, malunion, and articular surface incongruity [6,24]. CT is particularly useful in assessment of the DRUJ. When there is clinical concern for DRUJ instability, CT can be used to image the symptomatic and contralateral wrist simultaneously in the neutral, supinated, and pronated positions to assess for instability [24-26].

CT without IV contrast has been shown to be beneficial in operative planning for scaphoid fracture [27,28].

A disadvantage of CT compared with both MRI and US is its decreased contrast resolution and lower sensitivity in the detection of soft tissue abnormalities.

**MR Arthrography Wrist**

Direct MR arthrography is performed following the intra-articular injection of gadolinium and improves the detection and interobserver agreement for abnormalities of the wrist. MR arthrography is a minimally invasive imaging examination that may be appropriate for cases of suspected intrinsic ligament injury, TFC complex injury, cartilage abnormality, or surgical planning. Injection of any combination of the 3 compartments (DRUJ, radiocarpal, midcarpal) can be performed depending on the clinical question [13]. If the injection is performed with fluoroscopy,

comparison of the MR images with the fluoroscopic images is an essential step in image interpretation [13]. In most cases, a radiocarpal injection is performed; however, if there is concern for an ulnar sided detachment of the TFC, an additional DRUJ injection should be considered [7]. With single, radiocarpal injection, the sensitivity for TFC tears, intrinsic ligament injury, and cartilage lesions of the radiocarpal joint ranged from 63% to 100%, with specificity ranging from 89% to 97% [29].

MR arthrography has a higher sensitivity and specificity for the detection of scapholunate ligament injury, lunotriquetral ligament injury, and TFC injury [30-33]. Wrist traction improves detection of cartilage, TFC, and intrinsic ligament injuries [34]. An interdisciplinary group of hand surgeons and radiologists consensus statements concluded “MR arthrography provides better diagnostic accuracy for the determination of scapholunate interosseous ligament tears than MRI” and “MR arthrography or CT arthrography are generally recommended for the diagnostic workup for ligamentous and early cartilage defects” [18].

### **MRI Wrist Without and With IV Contrast**

There is no relevant literature discussing the routine use of MRI wrist without and with IV contrast for the evaluation of chronic wrist pain and normal or nonspecific radiographs. The addition of postcontrast imaging to wrist MRI aids in distinguishing synovitis from joint effusion and ganglion cysts [9,35]. Similarly, postcontrast MRI aids in the detection of tenosynovitis [35]. For these reasons, MRI without and with IV contrast is usually appropriate in the evaluation of chronic joint pain with clinical suspicion of rheumatoid arthritis or seronegative spondyloarthropathy [2] and in cases of suspected septic arthritis or soft tissue infection [3].

### **MRI Wrist Without IV Contrast**

MRI without IV contrast is useful in the assessment of wrist pain. MRI is useful in assessing abnormalities of the bones, including bone marrow, and soft tissues, including the ligaments, TFC, tendons, and nerves. When using arthroscopy as the reference standard, the sensitivity and specificity of 3.0T MRI in the evaluation of scapholunate tear range from 70% to 87% and 90% to 97%, respectively, for lunotriquetral tear range from 50% to 63% and 94% to 97% respectively, and for TFC tear range from 63% to 100% and 42% to 100%, respectively [32,36-40]. A study of 18 patients demonstrated good correlation between cartilage lesions at 3.0T MRI and arthroscopy [37]. If a study is specifically performed to assess the intrinsic ligaments or TFC, MR arthrography has been demonstrated to be superior to MRI without IV contrast [30-32,41].

MRI is helpful in the diagnosis of tendon abnormalities including tendinopathy, tenosynovitis, and intersection syndromes [12,13,42,43]. In a retrospective review of 316 consecutive patients referred to a hand surgeon with MRI of the hand or wrist, MRI changed clinical management in 69.5% of cases [44]. MRI was particularly useful in reassuring patients that no further follow-up was necessary in 70% of cases [44].

### **Radiographic Arthrography Wrist**

There is no relevant literature to support the use of radiographic arthrography of the wrist in the setting of chronic wrist pain and normal or nonspecific radiographs. Although a meta-analysis has demonstrated a pooled sensitivity of 76.2% and a specificity of 92.5% for the detection of complete TFC complex tear, radiographic arthrography is not routinely performed in isolation [45]. In current practice it is infrequently performed as a standalone imaging examination; rather, it is typically performed in conjunction with CT or MR arthrography.

### **Radiography Wrist Additional Views**

A variety of additional radiographic projections of the wrist may be obtained to supplement the standard 3-view series depending on the specific clinical indication. However, there is no recent literature to support obtaining additional views in the setting of chronic wrist pain and normal or nonspecific radiographs. An interdisciplinary group of hand surgeons and radiologists consensus statements concluded stress views are indicated for the diagnosis of scapholunate instability [18].

### **US Wrist**

US can be used to identify synovitis, joint effusion, tenosynovitis, tendinopathy and tendon injury, CTS, metacarpophalangeal joint collateral ligament injury, extensor hood injury, and retained foreign body [6,13,14,16,46]. The American College of Rheumatology has concluded there is reasonable evidence to support the use of musculoskeletal US in patients without definitive diagnosis presenting with pain, swelling, or mechanical symptoms of the wrist; US is reasonable to evaluate tendon and soft tissue pathology of the wrist and to assess for entrapment of the median or ulnar nerves [14]. In a study of patients referred from hand surgeons, US of the hand and wrist was contributory to the clinical assessment, defined as confirming the clinical suspicion or modifying the diagnostic/therapeutic plan, in 76% of all patients and 67% of patients who presented without a history of trauma

[17]. Although there are many advantages to US evaluation for chronic hand and wrist pain, an interdisciplinary group of hand surgeons and radiologists recommended against the inclusion of US in the standard evaluation of scapholunate instability [18].

**Variant 3: Adult. Chronic hand pain. Radiographs normal or remarkable for nonspecific arthritis. Next imaging study.**

**Bone Scan Hand**

There is no relevant literature to support the use of bone scan in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Arthrography Hand**

There is no relevant literature to support the use of CT arthrography in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Hand With IV Contrast**

There is no relevant literature to support the use of CT hand with IV contrast in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Hand Without and With IV Contrast**

There is no relevant literature to support the use of CT hand with IV contrast in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**CT Hand Without IV Contrast**

There is no relevant literature to support the use of CT hand without IV contrast in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**MR Arthrography Hand**

There is no relevant literature to support the use of MR arthrography in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**MRI Hand Without and With IV Contrast**

There is no relevant literature discussing routine use of MRI hand without and with IV contrast in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis. In the research setting, contrast-enhanced MRI can identify synovitis, periarticular bone marrow edema, and tenosynovitis, which correlates with patient pain in the setting of hand osteoarthritis [47,48].

**MRI Hand Without IV Contrast**

MRI hand without IV contrast is of limited benefit in the setting of nonspecific pain. A study evaluating hand MRI in the setting of erosive osteoarthritis showed no difference in the assessment of joint space narrowing, bone erosion, and malalignment compared with radiographs [49]. MRI can demonstrate many abnormalities that result in chronic pain including arthritis, carpal boss, tendinopathy, tenosynovitis, pulley injury, extensor hood injury, sagittal band injury, volar plate injury, chondral injury, and ligament injury [13,50-54]. In a retrospective review of 316 consecutive patients referred to a hand surgeon with MRI of the hand or wrist, MRI changed clinical management in 69.5% of cases [44]. MRI was particularly useful in reassuring patients that no further follow-up was necessary in 70% of cases [44].

**Radiographic Arthrography Hand**

There is no relevant literature to support the use of radiographic arthrography in the setting of chronic hand pain and normal radiographs or radiographs remarkable for nonspecific arthritis.

**US Hand**

US can be used to identify synovitis, joint effusion, tenosynovitis, tendinopathy and tendon injury, pulley injury, CTS, and retained foreign body [6,13-16]. The American College of Rheumatology has concluded there is reasonable evidence to support the use of musculoskeletal US in patients without definitive diagnosis presenting with pain, swelling, or mechanical symptoms of the metacarpophalangeal and interphalangeal joints, and US is reasonable to evaluate tendon and soft tissue pathology of the hand [14]. In a study of patients referred from hand surgeons, US of the hand and wrist was contributory to the clinical assessment, defined as confirming the clinical suspicion or modifying the diagnostic/therapeutic plan, in 76% of all patients and 67% of patient who presented without a history of trauma [17].



**Variant 4: Adult. Chronic wrist pain. Radiographs show old scaphoid fracture. Evaluate for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis. Next imaging study.**

#### **Bone Scan Wrist**

There is no relevant literature to support the use of bone scan in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis.

#### **CT Arthrography Wrist**

There is no relevant literature to support the use of CT arthrography in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, or osteonecrosis. If the specific clinical concern requires assessment of the articular cartilage in post-traumatic osteoarthritis, the spatial resolution of CT when combined with intra-articular contrast makes CT arthrography an ideal study. CT arthrography has demonstrated a sensitivity, specificity, and accuracy between 94% and 100% for articular cartilage injury [22].

#### **CT Wrist With IV Contrast**

CT wrist with IV contrast is not routinely performed in clinical practice, although there is an isolated report of dual-energy CT with IV contrast used to assess scaphoid osteonecrosis. In addition to the benefits afforded by the high spatial resolution of CT in the assessment of scaphoid fracture, the addition of contrast has been shown to be beneficial in the determination of proximal pole viability. A study of 19 wrists in 18 patients with dual-energy contrast-enhanced CT showed promising results in the assessment of proximal pole osteonecrosis in the setting of scaphoid fracture [55]. When compared with intraoperative assessment or histologic analysis, in a series of 18 patients who underwent dual-energy contrast-enhanced CT of the wrist there was a sensitivity of 100% and a specificity of 94% for the assessment of osteonecrosis of the proximal pole of the scaphoid following fracture [55].

#### **CT Wrist Without and With IV Contrast**

There is no relevant literature to support the use of CT with IV contrast in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis.

#### **CT Wrist Without IV Contrast**

The spatial resolution obtained with CT makes it well suited to assess for any trabecular bridging at the fracture site, nonunion, malunion, and the sclerosis and fragmentation of avascular necrosis. The isotropic acquisition and the ability to create 3-D models assists in surgical planning [27,28].

#### **MR Arthrography Wrist**

There is no relevant literature to support the use of MR arthrography in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, or osteonecrosis. If the specific clinical concern requires assessment of the articular cartilage in post-traumatic osteoarthritis, the addition of arthrography to MRI improves the assessment of the articular cartilage [31]. However, CT arthrography has a higher sensitivity and specificity for articular cartilage defect compared with MR arthrography [31,56].

#### **MRI Wrist Without and With IV Contrast**

MRI wrist without and with IV contrast can demonstrate both nonunited and malunited scaphoid fractures. Although 3.0T MRI without IV contrast falls behind MR and CT arthrography in the assessment of the articular cartilage, it has demonstrated a modest sensitivity of 48% to 52% and a good specificity of 82% compared with visual inspection in a cadaver study [57]. The added benefit of MRI comes in the assessment for osteonecrosis in the proximal pole scaphoid following scaphoid fracture. Whether contrast-enhanced MRI is superior to noncontrast MRI for assessment of scaphoid osteonecrosis is controversial. In a study comparing the addition of postcontrast images with the unenhanced MRI in 30 patients, the addition of contrast increased the sensitivity (66% versus 36%), specificity (88% versus 78%), and accuracy (83% versus 68%) when compared with the noncontrast images alone [58].

#### **MRI Wrist Without IV Contrast**

MRI wrist without IV contrast can demonstrate both nonunited and malunited scaphoid fractures. Although 3.0T MRI without IV contrast falls behind MR and CT arthrography in the assessment of the articular cartilage, it has demonstrated a modest sensitivity of 48% to 52% and a good specificity of 82% compared with visual inspection in a cadaver study [57]. The added benefit of MRI comes in the assessment for osteonecrosis in the proximal pole scaphoid following scaphoid fracture. Whether contrast-enhanced MRI is superior to noncontrast MRI for assessment of scaphoid osteonecrosis is controversial. A study of noncontrast MRI in 29 patients with scaphoid

nonunion demonstrated a sensitivity of 55%, a specificity of 94%, and an accuracy of 79% for the diagnosis of osteonecrosis compared with intraoperative assessment [59].

### **Radiographic Arthrography Wrist**

There is no relevant literature to support the use of radiographic arthrography in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis.

### **US Wrist**

There is no relevant literature to support the use of US in the setting of chronic wrist pain, remote scaphoid fracture, and clinical concern for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis.

**Variant 5: Adult. Chronic hand or wrist pain. Radiographs normal or indeterminate. Symptoms suspicious for carpal tunnel syndrome. Next imaging study.**

### **Bone Scan Area of Interest**

There is no relevant literature to support the use of bone scan in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **CT Area of Interest With IV Contrast**

There is no relevant literature to support the use of CT with IV contrast in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **CT Area of Interest Without and With IV Contrast**

There is no relevant literature to support the use of CT without and with IV contrast in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **CT Area of Interest Without IV Contrast**

There is no relevant literature to support the use of CT without IV contrast in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **CT Arthrography Area of Interest**

There is no relevant literature to support the use of CT arthrography in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **MR Arthrography Area of Interest**

There is no relevant literature to support the use of MR arthrography in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **MRI Area of Interest Without and With IV Contrast**

There is no relevant literature to support the use of MR without and with IV contrast in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **MRI Area of Interest Without IV Contrast**

MRI can identify enlargement and flattening of the median nerve, bowing of the flexor retinaculum, space occupying lesions, anatomic variants including bifid median nerve and persistent median artery, and tendon pathology in the carpal tunnel [60-62]. When compared with clinical assessment and nerve conduction studies, MRI can diagnose CTS with a high accuracy and stage severity with moderate accuracy [62,63]. There is good correlation between the cross-sectional area of the median nerve as assessed by both US and MRI [63,64]. However, MRI of the wrist is typically not indicated in the setting of suspected CTS [60-62].

### **Radiographic Arthrography Area of Interest**

There is no relevant literature to support the use of radiographic arthrography in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **Radiography Wrist Additional Views**

There is no relevant literature to support the use of additional radiographic views in the setting of chronic hand and wrist pain with clinical concern for CTS.

### **US Area of Interest**

When compared with clinical assessment and electrophysiologic studies, multiple systematic reviews and meta-analyses have demonstrated US to be highly sensitive and specific for the diagnosis of CTS [65-69]. The measurements and calculations used in the literature for US evaluation of the median nerve are heterogeneous;

cross-sectional area measurements of the median nerve at multiple locations in the forearm and wrist and ratios or differences in cross-sectional area comparing the various measurements have been reported. Some authors have advocated for the use of US as the confirmatory test of choice or as a complementary test for the suspected diagnosis of CTS due to the ability to identify space occupying lesions, anatomic variants including bifid median nerve and persistent median artery, and tendon pathology in the carpal tunnel and the false-positive rate of electrodiagnostic studies [70-73]. Despite evidence supporting the diagnostic capabilities of US in the setting of CTS, there is disagreement among hand surgeons regarding the necessity of diagnostic tests [73,74]. The 2016 American Academy of Orthopedic Surgeons guidelines reports limited evidence supports not routinely using US for the diagnosis of CTS [60].

**Variant 6: Adult. Chronic hand or wrist pain. Radiographs normal or show nonspecific arthritis. Suspect tendon injury, tenosynovitis, or tendon pathology. Next imaging study.**

#### **Bone Scan Area of Interest**

There is no relevant literature to support the use of bone scan in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **CT Area of Interest With IV Contrast**

There is no relevant literature to support the use of CT with IV contrast in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **CT Area of Interest Without and With IV Contrast**

There is no relevant literature to support the use of CT without and with IV contrast in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **CT Area of Interest Without IV Contrast**

There is no relevant literature to support the use of CT without IV contrast in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **CT Arthrography Area of Interest**

There is no relevant literature to support the use of CT arthrography in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **MR Arthrography Area of Interest**

There is no relevant literature to support the use of MR arthrography in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **MRI Area of Interest Without and With IV Contrast**

The inclusion of postcontrast images to MRI of the wrist improves detection of tenosynovitis [43,75].

#### **MRI Area of Interest Without IV Contrast**

The contrast resolution of MRI makes it ideal to assess soft tissue abnormalities in the hand and wrist. MRI of the hand or wrist without IV contrast can diagnose or confirm a multitude of tendon abnormalities including tendinopathy, tendon tear, intersection syndrome, tenosynovitis, stenosing tenosynovitis, pulley injuries, sagittal band, and palmar fibromatosis [13,43,76,77].

#### **Radiographic Arthrography Area of Interest**

There is no relevant literature to support the use of MR arthrography in the setting of chronic hand and wrist pain with clinical concern for tendon injury, tenosynovitis, or tendon pathology.

#### **US Area of Interest**

Tendon injuries of the hand and wrist are well suited to US evaluation due to their superficial location and the ability to dynamically assess the tendons. US of the hand or wrist can diagnose or confirm a multitude of tendon abnormalities including tendinopathy, tendon tear, intersection syndrome, tenosynovitis, stenosing tenosynovitis, pulley injuries, sagittal band, and palmar fibromatosis [6,13,46,77,78]. US assists in operative and injection planning in patients with De Quervain tenosynovitis with accurate identification of an intracompartmental septum [79]. In a study of 50 injured tendons of the hand and wrist in 35 patients, 25 with surgical comparison, US demonstrated high accuracy in the setting of complete tears, partial tears, and tenosynovitis [80].

## Summary of Recommendations

- **Variation 1:** Radiography is usually appropriate as the initial imaging study in the evaluation of chronic hand or wrist pain.
- **Variation 2:** MR arthrography or MRI without IV contrast is usually appropriate as the next imaging study for chronic wrist pain following normal radiographs or radiographs remarkable for nonspecific arthritis. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variation 3:** MRI without IV contrast is usually appropriate as the next imaging study for chronic hand pain following normal radiographs or radiographs remarkable for nonspecific arthritis.
- **Variation 4:** In the setting of chronic wrist pain diagnosed with remote scaphoid fracture by radiographs, MRI without IV contrast or CT without IV contrast is usually appropriate as the next imaging study when there is concern for nonunion, malunion, osteonecrosis, or post-traumatic osteoarthritis. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variation 5:** In the setting of chronic wrist pain with normal or indeterminate radiographs, US area of interest or MRI area of interest without IV contrast may be appropriate as the next imaging study when there is concern for CTS. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).
- **Variation 6:** In the setting of chronic hand or wrist pain with normal radiographs or radiographs remarkable for nonspecific arthritis, US area of interest or MRI area of interest without IV contrast is usually appropriate as the next imaging study when there is concern for tendon injury, tenosynovitis, or tendon pathology. These procedures are equivalent alternatives (ie, only one procedure will be ordered to provide the clinical information to effectively manage the patient's care).

## Supporting Documents

The evidence table, literature search, and appendix for this topic are available at <https://acsearch.acr.org/list>. The appendix includes the strength of evidence assessment and the final rating round tabulations for each recommendation.

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

## Appropriateness Category Names and Definitions

Appropriateness Category Name	Appropriateness Rating	Appropriateness Category Definition
Usually Appropriate	7, 8, or 9	The imaging procedure or treatment is indicated in the specified clinical scenarios at a favorable risk-benefit ratio for patients.
May Be Appropriate	4, 5, or 6	The imaging procedure or treatment may be indicated in the specified clinical scenarios as an alternative to imaging procedures or treatments with a more favorable risk-benefit ratio, or the risk-benefit ratio for patients is equivocal.
May Be Appropriate (Disagreement)	5	The individual ratings are too dispersed from the panel median. The different label provides transparency regarding the panel's recommendation. "May be appropriate" is the rating category and a rating of 5 is assigned.
Usually Not Appropriate	1, 2, or 3	The imaging procedure or treatment is unlikely to be indicated in the specified clinical scenarios, or the risk-benefit ratio for patients is likely to be unfavorable.

## Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Patients in the pediatric age group are at inherently higher risk from exposure, because of both organ sensitivity and longer life expectancy (relevant to the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared with those specified for adults (see Table below). Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® [Radiation Dose Assessment Introduction](#) document [81].

Relative Radiation Level Designations		
Relative Radiation Level*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
○	0 mSv	0 mSv
⊕	<0.1 mSv	<0.03 mSv
⊕⊕	0.1-1 mSv	0.03-0.3 mSv
⊕⊕⊕	1-10 mSv	0.3-3 mSv
⊕⊕⊕⊕	10-30 mSv	3-10 mSv
⊕⊕⊕⊕⊕	30-100 mSv	10-30 mSv

\*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as "Varies."

## References

1. Kransdorf MJ, Murphey MD, Wessell DE, et al. ACR Appropriateness Criteria® Soft-Tissue Masses. J Am Coll Radiol 2018;15:S189-S97.

2. Subhas N, Wu F, Fox MG, et al. ACR Appropriateness Criteria® Chronic Extremity Joint Pain-Suspected Inflammatory Arthritis, Crystalline Arthritis, or Erosive Osteoarthritis: 2022 Update. *J Am Coll Radiol* 2023;20:S20-S32.
3. Pierce JL, Perry MT, Wessell DE, et al. ACR Appropriateness Criteria® Suspected Osteomyelitis, Septic Arthritis, or Soft Tissue Infection (Excluding Spine and Diabetic Foot): 2022 Update. *J Am Coll Radiol* 2022;19:S473-S87.
4. Ha AS, Chang EY, Bartolotta RJ, et al. ACR Appropriateness Criteria® Osteonecrosis: 2022 Update. *J Am Coll Radiol* 2022;19:S409-S16.
5. Bencardino JT, Stone TJ, Roberts CC, et al. ACR Appropriateness Criteria® Stress (Fatigue/Insufficiency) Fracture, Including Sacrum, Excluding Other Vertebrae. *J Am Coll Radiol* 2017;14:S293-S306.
6. DaSilva MF, Goodman AD, Gil JA, Akelman E. Evaluation of Ulnar-sided Wrist Pain. *J Am Acad Orthop Surg* 2017;25:e150-e56.
7. Daun M, Rudd A, Cheng K, Rezai F. Magnetic Resonance Imaging of the Triangular Fibrocartilage Complex. *Top Magn Reson Imaging* 2020;29:237-44.
8. Faucher GK, Moody MC. LT Ligament Tears. *Hand Clin* 2021;37:537-43.
9. Gulati A, Wadhwa V, Ashikyan O, Cerezal L, Chhabra A. Current perspectives in conventional and advanced imaging of the distal radioulnar joint dysfunction: review for the musculoskeletal radiologist. *Skeletal Radiol* 2019;48:331-48.
10. Jens S, Luijckx T, Smithuis FF, Maas M. Diagnostic modalities for distal radioulnar joint. *J Hand Surg Eur Vol* 2017;42:395-404.
11. Taljanovic MS, Goldberg MR, Sheppard JE, Rogers LF. US of the intrinsic and extrinsic wrist ligaments and triangular fibrocartilage complex--normal anatomy and imaging technique. *Radiographics* 2011;31:e44.
12. Zanetti M, Saupe N, Nagy L. Role of MR imaging in chronic wrist pain. *Eur Radiol* 2007;17:927-38.
13. Tiegs-Heiden CA, Howe BM. Imaging of the Hand and Wrist. *Clin Sports Med* 2020;39:223-45.
14. McAlindon T, Kissin E, Nazarian L, et al. American College of Rheumatology report on reasonable use of musculoskeletal ultrasonography in rheumatology clinical practice. *Arthritis Care Res (Hoboken)* 2012;64:1625-40.
15. Schoffl I, Hugel A, Schoffl V, Rascher W, Jungert J. Diagnosis of Complex Pulley Ruptures Using Ultrasound in Cadaver Models. *Ultrasound Med Biol* 2017;43:662-69.
16. Fjellstad CM, Mathiessen A, Slatkowsky-Christensen B, Kvien TK, Hammer HB, Haugen IK. Associations Between Ultrasound-Detected Synovitis, Pain, and Function in Interphalangeal and Thumb Base Osteoarthritis: Data From the Nor-Hand Cohort. *Arthritis Care Res (Hoboken)* 2020;72:1530-35.
17. Tagliafico A, Bignotti B, Rossi F, Rubino M, Civani A, Martinoli C. Clinical Contribution of Wrist and Hand Sonography: Pilot Study. *J Ultrasound Med* 2019;38:141-48.
18. Dietrich TJ, Toms AP, Cerezal L, et al. Interdisciplinary consensus statements on imaging of scapholunate joint instability. *Eur Radiol* 2021;31:9446-58.
19. Al-Janabi M. Imaging modalities of the painful wrist: the role of bone scintigraphy. *Rheumatology (Oxford)* 2002;41:1085-7.
20. Yin ZG, Zhang JB, Kan SL, Wang XG. Diagnosing suspected scaphoid fractures: a systematic review and meta-analysis. *Clin Orthop Relat Res* 2010;468:723-34.
21. Moser T, Dosch JC, Moussaoui A, Buy X, Gangi A, Dietemann JL. Multidetector CT arthrography of the wrist joint: how to do it. *Radiographics* 2008;28:787-800; quiz 911.
22. De Filippo M, Pogliacomini F, Bertellini A, et al. MDCT arthrography of the wrist: diagnostic accuracy and indications. *Eur J Radiol* 2010;74:221-5.
23. Schmid MR, Schertler T, Pfirrmann CW, et al. Interosseous ligament tears of the wrist: comparison of multi-detector row CT arthrography and MR imaging. *Radiology* 2005;237:1008-13.
24. Szabo RM. Distal radioulnar joint instability. *J Bone Joint Surg Am* 2006;88:884-94.
25. Wijffels M, Stomp W, Krijnen P, Reijniers M, Schipper I. Computed tomography for the detection of distal radioulnar joint instability: normal variation and reliability of four CT scoring systems in 46 patients. *Skeletal Radiol* 2016;45:1487-93.
26. Carr LW, Adams B. Chronic Distal Radioulnar Joint Instability. *Hand Clin* 2020;36:443-53.
27. Ten Berg PW, Dobbe JG, Horbach SE, Gerards RM, Strackee SD, Streekstra GJ. Analysis of deformity in scaphoid non-unions using two- and three-dimensional imaging. *J Hand Surg Eur Vol* 2016;41:719-26.
28. Schweizer A, Mauler F, Vlachopoulos L, Nagy L, Furnstahl P. Computer-Assisted 3-Dimensional Reconstructions of Scaphoid Fractures and Nonunions With and Without the Use of Patient-Specific Guides:

- Early Clinical Outcomes and Postoperative Assessments of Reconstruction Accuracy. *J Hand Surg Am* 2016;41:59-69.
29. Asaad AM, Andronic A, Newby MP, Harrison JWK. Diagnostic accuracy of single-compartment magnetic resonance arthrography in detecting common causes of chronic wrist pain. *J Hand Surg Eur Vol* 2017;42:580-85.
  30. Scheck RJ, Romagnolo A, Hierner R, Pfluger T, Wilhelm K, Hahn K. The carpal ligaments in MR arthrography of the wrist: correlation with standard MRI and wrist arthroscopy. *J Magn Reson Imaging* 1999;9:468-74.
  31. Lee RK, Ng AW, Tong CS, et al. Intrinsic ligament and triangular fibrocartilage complex tears of the wrist: comparison of MDCT arthrography, conventional 3-T MRI, and MR arthrography. *Skeletal Radiol* 2013;42:1277-85.
  32. Hafezi-Nejad N, Carrino JA, Eng J, et al. Scapholunate Interosseous Ligament Tears: Diagnostic Performance of 1.5 T, 3 T MRI, and MR Arthrography-A Systematic Review and Meta-analysis. *Acad Radiol* 2016;23:1091-103.
  33. Petsatodis E, Pilavaki M, Kalogera A, Drevelegas A, Agathangelidis F, Ditsios K. Comparison between conventional MRI and MR arthrography in the diagnosis of triangular fibrocartilage tears and correlation with arthroscopic findings. *Injury* 2019;50:1464-69.
  34. Lee RK, Griffith JF, Ng AW, Nung RC, Yeung DK. Wrist Traction During MR Arthrography Improves Detection of Triangular Fibrocartilage Complex and Intrinsic Ligament Tears and Visibility of Articular Cartilage. *AJR Am J Roentgenol* 2016;206:155-61.
  35. Anderson SE, Steinbach LS, Stauffer E, Voegelin E. MRI for differentiating ganglion and synovitis in the chronic painful wrist. *AJR Am J Roentgenol* 2006;186:812-8.
  36. Anderson ML, Skinner JA, Felmlee JP, Berger RA, Amrami KK. Diagnostic comparison of 1.5 Tesla and 3.0 Tesla preoperative MRI of the wrist in patients with ulnar-sided wrist pain. *J Hand Surg Am* 2008;33:1153-9.
  37. Ochman S, Wieskotter B, Langer M, Vieth V, Raschke MJ, Stehling C. High-resolution MRI (3T-MRI) in diagnosis of wrist pain: is diagnostic arthroscopy still necessary? *Arch Orthop Trauma Surg* 2017;137:1443-50.
  38. Boer BC, Vestering M, van Raak SM, van Kooten EO, Huis In 't Veld R, Vochteloo AJH. MR arthrography is slightly more accurate than conventional MRI in detecting TFCC lesions of the wrist. *Eur J Orthop Surg Traumatol* 2018;28:1549-53.
  39. Zhan H, Bai R, Qian Z, Yang Y, Zhang H, Yin Y. Traumatic injury of the triangular fibrocartilage complex (TFCC)-a refinement to the Palmer classification by using high-resolution 3-T MRI. *Skeletal Radiol* 2020;49:1567-79.
  40. Eladawi S, Balamoody S, Amerasekera S, Choudhary S. 3T MRI of wrist ligaments and TFCC using true plane oblique 3D T2 Dual Echo Steady State (DESS) - a study of diagnostic accuracy. *Br J Radiol* 2022;95:20210019.
  41. Skalski MR, White EA, Patel DB, Schein AJ, RiveraMelo H, Matcuk GR, Jr. The Traumatized TFCC: An Illustrated Review of the Anatomy and Injury Patterns of the Triangular Fibrocartilage Complex. *Curr Probl Diagn Radiol* 2016;45:39-50.
  42. Parellada AJ, Gopez AG, Morrison WB, et al. Distal intersection tenosynovitis of the wrist: a lesser-known extensor tendinopathy with characteristic MR imaging features. *Skeletal Radiol* 2007;36:203-8.
  43. Plotkin B, Sampath SC, Sampath SC, Motamedi K. MR Imaging and US of the Wrist Tendons. *Radiographics* 2016;36:1688-700.
  44. Ratasvuori MS, Lindfors NC, Sormala MJ. The clinical significance of magnetic resonance imaging of the hand: an analysis of 318 hand and wrist images referred by hand surgeons. *J Plast Surg Hand Surg* 2022;56:69-73.
  45. Smith TO, Drew BT, Toms AP, Chojnowski AJ. The diagnostic accuracy of X-ray arthrography for triangular fibrocartilaginous complex injury: a systematic review and meta-analysis. *J Hand Surg Eur Vol* 2012;37:879-87.
  46. Kichouh M, De Maeseneer M, Jager T, et al. Ultrasound findings in injuries of dorsal extensor hood: correlation with MR and follow-up findings. *Eur J Radiol* 2011;77:249-53.
  47. Liu R, Damman W, Reijnierse M, Bloem JL, Rosendaal FR, Kloppenburg M. Bone marrow lesions on magnetic resonance imaging in hand osteoarthritis are associated with pain and interact with synovitis. *Osteoarthritis Cartilage* 2017;25:1093-99.
  48. van Beest S, Damman W, Liu R, Reijnierse M, Rosendaal FR, Kloppenburg M. In finger osteoarthritis, change in synovitis is associated with change in pain on a joint-level; a longitudinal magnetic resonance imaging study. *Osteoarthritis Cartilage* 2019;27:1048-56.

49. Ramonda R, Favero M, Vio S, et al. A recently developed MRI scoring system for hand osteoarthritis: its application in a clinical setting. *Clin Rheumatol* 2016;35:2079-86.
50. Pfirrmann CW, Theumann NH, Botte MJ, Drape JL, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers: part II. Detection of simulated injuries in cadavers. *Radiology* 2002;222:447-52.
51. Theumann NH, Pessis E, Lecompte M, et al. MR imaging of the metacarpophalangeal joints of the fingers: evaluation of 38 patients with chronic joint disability. *Skeletal Radiol* 2005;34:210-6.
52. Nevalainen MT, Roedl JB, Morrison WB, Zoga AC. MRI of a painful carpal boss: variations at the extensor carpi radialis brevis insertion and imaging findings in regional traumatic and overuse injuries. *Skeletal Radiol* 2019;48:1079-85.
53. van Beest S, Kroon HM, Reijnierse M, Rosendaal FR, Kloppenburg M, Kroon FPB. Two-Year Changes in Magnetic Resonance Imaging Features and Pain in Thumb Base Osteoarthritis. *Arthritis Care Res (Hoboken)* 2021;73:1628-37.
54. Shin YE, Kim SJ, Kim JS, Kwak KY, Kim JH, Kim JP. Efficiency of magnetic resonance imaging for diagnosing unstable ligament injuries around the thumb metacarpophalangeal joint: A comparison to arthroscopy. *J Orthop Surg (Hong Kong)* 2020;28:2309499020978308.
55. Pianta M, McCombe D, Slavin J, Hendry S, Perera W. Dual-energy contrast-enhanced CT to evaluate scaphoid osteonecrosis with surgical correlation. *J Med Imaging Radiat Oncol* 2019;63:69-75.
56. Moser T, Dosch JC, Moussaoui A, Dietemann JL. Wrist ligament tears: evaluation of MRI and combined MDCT and MR arthrography. *AJR Am J Roentgenol* 2007;188:1278-86.
57. Saupe N, Pfirrmann CW, Schmid MR, Schertler T, Manestar M, Weishaupt D. MR imaging of cartilage in cadaveric wrists: comparison between imaging at 1.5 and 3.0 T and gross pathologic inspection. *Radiology* 2007;243:180-7.
58. Cerezal L, Abascal F, Canga A, Garcia-Valtuille R, Bustamante M, del Pinal F. Usefulness of gadolinium-enhanced MR imaging in the evaluation of the vascularity of scaphoid nonunions. *AJR Am J Roentgenol* 2000;174:141-9.
59. Fox MG, Gaskin CM, Chhabra AB, Anderson MW. Assessment of scaphoid viability with MRI: a reassessment of findings on unenhanced MR images. *AJR Am J Roentgenol* 2010;195:W281-6.
60. Graham B, Peljovich AE, Afra R, et al. The American Academy of Orthopaedic Surgeons Evidence-Based Clinical Practice Guideline on: Management of Carpal Tunnel Syndrome. *J Bone Joint Surg Am* 2016;98:1750-54.
61. Wipperfman J, Goerl K. Carpal Tunnel Syndrome: Diagnosis and Management. *Am Fam Physician* 2016;94:993-99.
62. Ng AWH, Griffith JF, Tong CSL, et al. MRI criteria for diagnosis and predicting severity of carpal tunnel syndrome. *Skeletal Radiol* 2020;49:397-405.
63. Bagga B, Sinha A, Khandelwal N, Modi M, Ahuja CK, Sharma R. Comparison of Magnetic Resonance Imaging and Ultrasonography in Diagnosing and Grading Carpal Tunnel Syndrome: A Prospective Study. *Curr Probl Diagn Radiol* 2020;49:102-15.
64. Hersh B, D'Auria J, Scott M, Fowler JR. A Comparison of Ultrasound and MRI Measurements of the Cross-Sectional Area of the Median Nerve at the Wrist. *Hand (N Y)* 2019;14:746-50.
65. Fowler JR, Gaughan JP, Ilyas AM. The sensitivity and specificity of ultrasound for the diagnosis of carpal tunnel syndrome: a meta-analysis. *Clin Orthop Relat Res* 2011;469:1089-94.
66. Descatha A, Huard L, Aubert F, Barbato B, Gorand O, Chastang JF. Meta-analysis on the performance of sonography for the diagnosis of carpal tunnel syndrome. *Semin Arthritis Rheum* 2012;41:914-22.
67. Torres-Costoso A, Martinez-Vizcaino V, Alvarez-Bueno C, Ferri-Morales A, Cavero-Redondo I. Accuracy of Ultrasonography for the Diagnosis of Carpal Tunnel Syndrome: A Systematic Review and Meta-Analysis. *Arch Phys Med Rehabil* 2018;99:758-65 e10.
68. Roomizadeh P, Eftekharsadat B, Abedini A, et al. Ultrasonographic Assessment of Carpal Tunnel Syndrome Severity: A Systematic Review and Meta-Analysis. *Am J Phys Med Rehabil* 2019;98:373-81.
69. Erickson M, Lawrence M, Lucado A. The role of diagnostic ultrasound in the examination of carpal tunnel syndrome: an update and systematic review. *J Hand Ther* 2022;35:215-25.
70. Fowler JR, Munsch M, Tosti R, Hagberg WC, Imbriglia JE. Comparison of ultrasound and electrodiagnostic testing for diagnosis of carpal tunnel syndrome: study using a validated clinical tool as the reference standard. *J Bone Joint Surg Am* 2014;96:e148.



71. Fowler JR, Byrne K, Pan T, Goitz RJ. False-Positive Rates for Nerve Conduction Studies and Ultrasound in Patients Without Clinical Signs and Symptoms of Carpal Tunnel Syndrome. *J Hand Surg Am* 2019;44:181-85.
72. Gervasio A, Stelitano C, Bollani P, Giardini A, Vanzetti E, Ferrari M. Carpal tunnel sonography. *J Ultrasound* 2020;23:337-47.
73. Ratasvuori M, Sormaala M, Kinnunen A, Lindfors N. Ultrasonography for the diagnosis of carpal tunnel syndrome: correlation of clinical symptoms, cross-sectional areas and electroneuromyography. *J Hand Surg Eur Vol* 2022;47:369-74.
74. Sears ED, Lu YT, Wood SM, et al. Diagnostic Testing Requested Before Surgical Evaluation for Carpal Tunnel Syndrome. *J Hand Surg Am* 2017;42:623-29 e1.
75. Tehranzadeh J, Ashikyan O, Anavim A, Tramma S. Enhanced MR imaging of tenosynovitis of hand and wrist in inflammatory arthritis. *Skeletal Radiol* 2006;35:814-22.
76. Clavero JA, Golano P, Farinas O, Alomar X, Monill JM, Esplugas M. Extensor mechanism of the fingers: MR imaging-anatomic correlation. *Radiographics* 2003;23:593-611.
77. Llopis E, Restrepo R, Kassarian A, Cerezal L. Overuse Injuries of the Wrist. *Radiol Clin North Am* 2019;57:957-76.
78. Kazmers NH, Gordon JA, Buterbaugh KL, Bozentka DJ, Steinberg DR, Khoury V. Ultrasonographic Evaluation of Zone II Partial Flexor Tendon Lacerations of the Fingers: A Cadaveric Study. *J Ultrasound Med* 2018;37:941-48.
79. Kwon BC, Choi SJ, Koh SH, Shin DJ, Baek GH. Sonographic Identification of the intracompartmental septum in de Quervain's disease. *Clin Orthop Relat Res* 2010;468:2129-34.
80. Bekhet CNH, Ghaffar MKA, Nassef MA, Khattab RT. Role of Ultrasound in Flexor Tendon Injuries of the Hand: A New Insight. *Ultrasound Med Biol* 2021;47:2157-66.
81. American College of Radiology. ACR Appropriateness Criteria® Radiation Dose Assessment Introduction. Available at: <https://www.acr.org/-/media/ACR/Files/Appropriateness-Criteria/RadiationDoseAssessmentIntro.pdf>. Accessed September 29, 2023.

The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.