



Magnetic Resonance Imaging in Ulnar-Sided Wrist Pain: Diagnostic Contributions, Limitations, and Imaging Pitfalls

Dalia Salah El-Deen Anwer ¹, Ayman Fathy Ahmed Amer ², Malek Hamada Ahmed Refaat³, Ibrahim Mahmoud Mohamed Eladl ⁴, Islam Hamada Ahmed Refaat ⁵

1. Assistant Professor of Radio-diagnosis, Faculty of Medicine, Zagazig University,
2. Professor of Radio-diagnosis, Faculty of Medicine, Zagazig University,
3. Resident of Radio-diagnosis, Faculty of Medicine, Zagazig University,
4. Lecturer of Radio-diagnosis, Faculty of Medicine, Zagazig University,
5. Lecturer of Orthopedic Surgery, Faculty of Medicine, Zagazig University

Corresponding Author: Malek Hamada Ahmed Refaat

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Abstract

Background: Ulnar-sided wrist pain represents a frequent and diagnostically challenging clinical problem because of the compact arrangement and functional interdependence of the osseous, ligamentous, tendinous, cartilaginous, neural, and vascular structures along the ulnar aspect of the wrist. Clinical manifestations are often nonspecific, and several disorders may coexist or produce overlapping symptoms. Conventional radiography remains the initial imaging modality for assessment of alignment, fracture, degenerative change, and ulnar variance; however, it provides limited evaluation of the triangular fibrocartilage complex, intrinsic and extrinsic ligaments, articular cartilage, tendons, bone marrow, and neurovascular structures. Magnetic resonance imaging has therefore become an important noninvasive tool in the investigation of persistent or unexplained ulnar-sided wrist pain.

This review aims to evaluate the diagnostic contributions of magnetic resonance imaging in patients with ulnar-sided wrist pain, with emphasis on relevant anatomy, technical considerations, major pathologic entities, limitations, and common interpretive pitfalls. Particular attention is given to triangular fibrocartilage complex injuries, ulnar impaction and impingement syndromes, distal radioulnar joint abnormalities, lunotriquetral ligament injuries, extensor carpi ulnaris tendon disorders, occult fractures, pisotriquetral abnormalities, and lesions affecting Guyon's canal. The role of optimized high-resolution imaging, multiplanar assessment, and magnetic resonance arthrography is also considered.

Magnetic resonance imaging contributes substantially to diagnosis by depicting soft-tissue structures directly, detecting bone marrow edema and occult osseous injury, characterizing tendon and ligament abnormalities, identifying associated chondral damage, and demonstrating secondary signs of instability or impaction. Nevertheless, diagnostic accuracy is influenced by spatial resolution, magnet strength, coil selection, imaging plane, observer experience, and the presence of normal anatomical variants or age-related changes. Central triangular fibrocartilage degeneration, ligamentum subcruentum signal, prestyloid recess fluid, partial-volume effects, and asymptomatic tendon or ligament abnormalities may mimic clinically relevant disease. In selected patients, magnetic resonance arthrography may improve visualization of small communicating defects, although its added benefit must be balanced against invasiveness and cost.

In conclusion, magnetic resonance imaging is a central component of the diagnostic work-up of ulnar-sided wrist pain when interpreted within an anatomy-based and clinically correlated framework. Its greatest value lies not in isolated lesion detection, but in comprehensive assessment of the multiple structures that may contribute to pain, while careful recognition of technical limitations and imaging pitfalls is essential to avoid overdiagnosis and inappropriate management.

Keywords: *Ulnar-sided wrist pain; Magnetic resonance imaging; Triangular fibrocartilage complex; Imaging pitfalls*



Introduction

Ulnar-sided wrist pain is a common but diagnostically demanding clinical presentation because numerous osseous, chondral, ligamentous, tendinous, neural, and vascular structures are concentrated within a small anatomical region. Disorders involving these structures frequently produce similar symptoms, including localized tenderness, painful forearm rotation, reduced grip strength, clicking, and restricted wrist motion. Moreover, more than one abnormality may coexist, particularly after trauma or in the presence of altered wrist biomechanics. For these reasons, the ulnar aspect of the wrist has often been regarded as a diagnostic “black box,” in which clinical examination alone may not reliably identify the principal pain generator [1].

Initial imaging generally includes posteroanterior and lateral radiographs, with additional views selected according to the suspected disorder. Radiography is valuable for detecting fractures, malalignment, degenerative changes, ulnar variance, and abnormalities of the distal radioulnar joint. Nevertheless, many clinically important causes of ulnar-sided wrist pain are radiographically occult. Ultrasonography provides dynamic and high-resolution evaluation of superficial tendons, particularly the extensor carpi ulnaris tendon, and may guide diagnostic or therapeutic injections. Computed tomography offers excellent assessment of cortical fractures and osseous alignment. However, MRI provides the most comprehensive noninvasive evaluation because it simultaneously depicts bone marrow, articular cartilage, fibrocartilage, ligaments, tendons, synovium, nerves, and adjacent soft tissues [2].

MRI is particularly valuable for assessment of the triangular fibrocartilage complex, which represents a major stabilizer of the distal radioulnar joint and an important load-transmitting structure of the ulnocarpal compartment. It also facilitates detection of lunotriquetral ligament injury, occult fractures, marrow edema, ulnar impaction-related changes, pisotriquetral arthropathy, tendon abnormalities, and space-occupying lesions within Guyon’s canal. Multiplanar imaging and fluid-sensitive sequences permit evaluation of both the primary lesion and associated secondary findings, such as synovitis, chondral damage, subchondral cyst formation, and reactive bone marrow edema. Consequently, MRI can narrow the differential diagnosis and may influence whether patients undergo conservative management, arthroscopy, tendon stabilization, ulnar shortening, or other surgical procedures [3].

Despite these advantages, MRI is not an infallible substitute for clinical assessment or arthroscopy. Diagnostic performance is affected by magnet strength, dedicated coil use, field of view, slice thickness, imaging plane, pulse sequence, wrist position, and radiologist experience. Small peripheral TFCC tears and partial-thickness ligament injuries may remain difficult to identify, while normal structures such as the ligamentum subcruentum and prestyloid recess may simulate disease. Degenerative central TFCC defects and mild tendon or ligament signal abnormalities can also occur in asymptomatic individuals. Direct MR arthrography may improve visualization of some communicating TFCC and intrinsic ligament defects, but its diagnostic improvement over optimized conventional MRI is generally modest and must be balanced against invasiveness, procedural discomfort, cost, and the possibility of contrast leakage producing false-positive interpretations [4].

A further limitation in the available literature is that many publications focus on individual lesions, particularly TFCC tears, rather than assessing MRI within the complete differential diagnosis of ulnar-sided wrist pain. There is also substantial variability among studies regarding imaging protocols, reference standards, patient selection, tear classification, and definitions of diagnostic accuracy. This heterogeneity limits direct comparison between studies and may encourage overreliance on isolated MRI abnormalities without sufficient correlation with the patient’s symptoms, physical examination, radiographs, and mechanism of injury.

Accordingly, this review aims to present an anatomy-based assessment of MRI in ulnar-sided wrist pain, emphasizing its principal diagnostic contributions across traumatic, degenerative, tendinous, osseous, and neurovascular disorders. It also examines protocol-related limitations, the relative role of conventional MRI and MR arthrography, and the normal variants and artifacts that commonly lead to misinterpretation. The central objective is to define where MRI provides meaningful added diagnostic value and where its findings should be interpreted cautiously within a combined clinical and



multimodality imaging approach [5].

MRI-Relevant Anatomy of the Ulnar Wrist

The ulnar aspect of the wrist is formed by closely related osseous, fibrocartilaginous, ligamentous, tendinous, and neurovascular structures. Accurate MRI interpretation requires understanding of their normal relationships because many pathological conditions produce overlapping findings. The principal structures include the distal ulna, sigmoid notch of the radius, distal radioulnar joint, triangular fibrocartilage complex, lunate, triquetrum, pisiform, hamate, lunotriquetral ligament, ulnocarpal ligaments, extensor carpi ulnaris tendon, flexor carpi ulnaris tendon, pisotriquetral joint, and Guyon canal [6].

Distal Radioulnar and Ulnocarpal Joints

The distal radioulnar joint is formed by the ulnar head and sigmoid notch of the distal radius. It permits pronation and supination while maintaining congruity through the coordinated action of the triangular fibrocartilage complex, joint capsule, interosseous membrane, pronator quadratus, and extensor carpi ulnaris subsheath. MRI can demonstrate joint effusion, synovitis, cartilage loss, incongruity, and associated TFCC injury, although dynamic instability is better assessed clinically or with position-dependent imaging [7].

The ulnocarpal compartment lies between the distal ulna and the proximal carpal row. Direct contact between the ulna and carpus is normally prevented by the triangular fibrocartilage disc. Load transmission across this compartment depends strongly on ulnar variance. Positive ulnar variance increases loading across the TFCC, lunate, and triquetrum and predisposes to ulnar impaction, whereas negative variance reduces ulnocarpal load and has been associated with other disorders, including Kienböck disease [8].

Ulnar Variance

Ulnar variance represents the relative distal length of the ulna compared with the radius. It is classified as neutral, positive, or negative and is most accurately measured on a standardized posteroanterior radiograph with the shoulder abducted, elbow flexed, and forearm in neutral rotation. MRI may provide an approximate assessment on coronal images, but wrist position and forearm rotation can alter the measurement. Therefore, radiographic correlation remains important when surgical planning depends on the degree of variance [9].

Positive ulnar variance may be constitutional or acquired after distal radius malunion, premature physeal closure, or radial shortening. It increases mechanical stress on the TFCC and ulnar-sided carpal bones. Negative ulnar variance may be normal but can influence carpal loading patterns. Dynamic ulnar variance should also be considered because the ulna may become functionally more positive during pronation and power grip, which may explain symptoms despite neutral variance on static imaging [10].

Triangular Fibrocartilage Complex

The triangular fibrocartilage complex is the principal stabilizer of the distal radioulnar joint and an important load-bearing structure. It includes the triangular fibrocartilage disc, dorsal and volar radioulnar ligaments, meniscal homologue, ulnolunate ligament, ulnotriquetral ligament, and extensor carpi ulnaris subsheath. Its radial attachment lies at the sigmoid notch, while its ulnar attachment is divided into proximal fibers inserting at the ulnar fovea and distal fibers inserting at the ulnar styloid [11].

The central disc is relatively avascular, thin, and vulnerable to degenerative perforation. In contrast, the peripheral ulnar portion is vascularized and has greater healing potential. On MRI, the disc normally appears as a low-signal triangular or bow-tie structure on coronal images. Increased internal signal may reflect degeneration, partial tearing, magic-angle effect, or partial-volume averaging; therefore, a tear should be diagnosed only when abnormal signal or discontinuity reaches an articular surface or when convincing morphological disruption is present [12].

The ligamentum subcruentum is a normal vascularized connective tissue structure located between the proximal and distal ulnar attachments of the TFCC. It frequently demonstrates intermediate or high signal on fluid-sensitive sequences and can mimic a peripheral tear. The prestyloid recess is another



normal structure that may contain fluid adjacent to the ulnar styloid. Recognition of these features is essential to avoid false-positive diagnosis [13].

Lunotriquetral Ligament and Ulnocarpal Ligaments

The lunotriquetral ligament connects the lunate and triquetrum and consists of volar, dorsal, and proximal membranous components. The volar component is the strongest, whereas the dorsal component contributes substantially to rotational stability. The proximal membranous portion may show age-related degeneration or perforation without clinically significant instability. Coronal MRI best demonstrates the proximal component, while axial images better depict the dorsal and volar bands [14]. The ulnolunate and ulnotriquetral ligaments arise from the volar aspect of the TFCC and attach to the lunate and triquetrum. They contribute to ulnocarpal stability and may be injured in association with peripheral TFCC tears. Because these ligaments are small and obliquely oriented, thin-section imaging in multiple planes is required. Direct MR arthrography may improve visualization of partial tears, but small defects can remain difficult to distinguish from normal capsular irregularity [15].

Extensor Carpi Ulnaris Tendon

The extensor carpi ulnaris tendon occupies the sixth dorsal extensor compartment and lies within a fibro-osseous groove along the distal ulna. Its subsheath is anatomically related to the TFCC and contributes to distal radioulnar joint stability. The tendon changes position during forearm rotation, moving relatively volar and ulnar during supination. Mild positional displacement can therefore be physiological, especially when the wrist is imaged in supination [16].

MRI can demonstrate tendinosis, tenosynovitis, partial tearing, complete rupture, and subsheath injury. However, dynamic ECU subluxation may not be visible during static MRI, particularly when the wrist is examined in neutral position. Ultrasound is often superior for demonstrating real-time instability, while MRI is more useful for identifying associated marrow, ligamentous, and TFCC abnormalities [17].

Pisotriquetral Joint and Flexor Carpi Ulnaris Tendon

The pisiform is a sesamoid bone within the flexor carpi ulnaris tendon and articulates with the volar surface of the triquetrum. The pisotriquetral joint is a synovial articulation that may develop osteoarthritis, synovitis, instability, or chondral injury. MRI may show cartilage loss, subchondral edema, cyst formation, effusion, and surrounding soft-tissue inflammation. These findings should be correlated with focal tenderness because degenerative changes may be asymptomatic [18].

The flexor carpi ulnaris tendon inserts primarily on the pisiform, with distal extensions through the pisohamate and pisometacarpal ligaments. Tendinopathy is less common than ECU pathology but may produce pain at the volar-ulnar wrist. MRI findings include tendon thickening, increased intratendinous signal, peritendinous edema, and associated pisiform marrow reaction [19].

Guyon Canal

Guyon canal is a fibro-osseous tunnel extending from the pisiform proximally to the hook of the hamate distally. It contains the ulnar nerve and artery, which divide into superficial sensory and deep motor branches within the canal. MRI can identify mass lesions, anomalous muscles, ganglion cysts, vascular abnormalities, and nerve enlargement. Because the canal is small and anatomically variable, high-resolution axial imaging is essential [20].

Ulnar nerve compression may occur from ganglion cysts, hook of hamate fracture, repetitive trauma, tumors, or ulnar artery thrombosis. MRI findings of neuropathy may include nerve enlargement, increased T2-weighted signal, loss of fascicular pattern, and denervation edema in the hypothenar muscles. These findings are supportive but should be interpreted with clinical and electrophysiological correlation [21].

MRI Technique and Protocol Optimization

High-quality wrist MRI depends on appropriate patient positioning, use of a dedicated surface coil, a small field of view, thin sections, and multiplanar imaging. The patient is usually examined with the wrist in a neutral position, either with the arm alongside the body or in the “superman” position above the head. The latter may improve centering of the wrist within the magnet but can be uncomfortable. Motion should be minimized because even slight displacement can substantially degrade visualization



of the small ligaments and fibrocartilaginous structures [22].

A dedicated multichannel wrist coil is preferable because it improves signal-to-noise ratio and spatial resolution. Imaging at 3 T generally provides higher signal than 1.5 T and can facilitate thinner sections and smaller fields of view. However, higher field strength may increase susceptibility artifacts, chemical shift, and image inhomogeneity. Diagnostic quality therefore depends not only on field strength but also on coil design, sequence optimization, and radiologist familiarity with normal wrist anatomy [23].

The routine protocol should include coronal, axial, and sagittal planes. Coronal images are essential for evaluation of the triangular fibrocartilage disc, ulnar variance, lunotriquetral ligament, articular cartilage, and marrow abnormalities of the lunate and triquetrum. Axial images are particularly useful for assessing the dorsal and volar radioulnar ligaments, ECU tendon and subsheath, distal radioulnar joint congruity, Guyon canal, and peripheral TFCC attachments. Sagittal images provide additional assessment of carpal alignment, cartilage, tendon position, and dorsal or volar soft-tissue abnormalities [24].

A combination of T1-weighted and fluid-sensitive sequences is generally required. T1-weighted images provide excellent anatomical detail and are useful for evaluating marrow replacement, fracture lines, cortical anatomy, and fatty muscle changes. Proton-density or intermediate-weighted fat-suppressed sequences provide high contrast for ligaments, cartilage, tendons, and fibrocartilage, while T2-weighted or short tau inversion recovery sequences are sensitive to edema, fluid, synovitis, and occult osseous injury. Thin-section three-dimensional isotropic sequences may permit multiplanar reformations and improve evaluation of obliquely oriented structures [25].

Slice thickness should generally be kept between approximately 2 and 3 mm, with minimal interslice gap. A field of view of about 8 to 12 cm is commonly used, depending on patient size and coil configuration. Excessively large fields of view reduce spatial resolution and may obscure small TFCC or ligament tears. Conversely, extremely small fields may exclude clinically relevant structures such as the distal ulna, proximal metacarpals, or Guyon canal. Protocol selection should therefore reflect the suspected pathology rather than follow a rigid uniform approach [26].

Fat suppression must be homogeneous because incomplete suppression can mimic marrow edema or obscure subtle pathology. Frequency-selective fat suppression may be affected by magnetic field inhomogeneity, especially at 3 T, whereas inversion recovery techniques offer more uniform suppression but lower signal-to-noise ratio. Dixon-based methods may provide more reliable fat-water separation and can be particularly useful in postoperative wrists or when metallic susceptibility is present [27].

Intravenous gadolinium is not routinely required for uncomplicated ulnar-sided wrist pain. Contrast-enhanced MRI may be useful when infection, inflammatory synovitis, tumor, vascular lesion, postoperative complication, or active neuropathy is suspected. Enhancement can help distinguish solid tissue from simple fluid and may demonstrate hypervascular synovium or inflammatory change. However, enhancement alone is nonspecific and should not be interpreted without correlation with morphology and noncontrast sequences [28].

Direct MR arthrography involves injection of diluted gadolinium into one or more wrist compartments before imaging. It can improve delineation of small full-thickness TFCC defects and intrinsic ligament tears by demonstrating contrast passage through abnormal communications. Nevertheless, contrast leakage may occur through degenerative perforations or iatrogenic needle injury, and absence of leakage does not exclude a partial-thickness tear. MR arthrography is therefore most useful when conventional MRI is inconclusive and clinical suspicion remains high [29].

Indirect MR arthrography uses intravenous gadolinium followed by wrist exercise to promote contrast diffusion into the joint. It avoids intra-articular injection but provides less joint distension and lower spatial contrast than direct arthrography. Its role is limited, and it is not routinely preferred for evaluation of small TFCC or interosseous ligament defects. Optimized conventional high-resolution MRI remains the first-line examination in most patients [30].

Wrist position can influence interpretation. Forearm rotation changes distal radioulnar joint congruity



and ECU tendon position, while gripping can increase functional ulnar variance. Static neutral-position MRI may therefore underestimate dynamic instability, ECU subluxation, or load-dependent ulnar impaction. In selected cases, dynamic ultrasonography, stress radiographs, fluoroscopy, or imaging in alternative positions may provide complementary information [31].

The MRI examination should be planned according to the clinical pain location and suspected structure. Dorsal-ulnar pain may direct attention to the ECU tendon, dorsal TFCC, and distal radioulnar joint. Volar-ulnar symptoms may suggest pisotriquetral disease, flexor carpi ulnaris tendinopathy, or Guyon canal pathology. Deep pain during pronation, supination, or axial loading raises suspicion for TFCC injury, ulnar impaction, or distal radioulnar joint abnormality. Accurate clinical information substantially improves targeted image interpretation [32].

Triangular Fibrocartilage Complex Abnormalities

The triangular fibrocartilage complex is one of the most important structures evaluated in patients with ulnar-sided wrist pain because it contributes to distal radioulnar joint stability, ulnocarpal load transmission, and smooth forearm rotation. TFCC abnormalities may result from acute trauma, repetitive loading, degeneration, positive ulnar variance, distal radius malunion, or chronic instability. Patients commonly present with deep ulnar pain, clicking, reduced grip strength, and pain during pronation, supination, or axial loading [33].

Traumatic TFCC injuries are commonly classified according to the Palmer system. Class 1A lesions involve the central disc, class 1B lesions affect the peripheral ulnar attachment, class 1C lesions involve the distal ulnocarpal ligamentous attachment, and class 1D lesions occur at the radial attachment. Although this system remains widely used, modern MRI interpretation should also describe the exact site, depth, morphology, associated instability, and presence of secondary osseous or chondral abnormalities [34].

Central TFCC tears usually appear as linear or focal fluid-signal defects extending through the articular disc. Because the central portion is relatively avascular, these tears have limited healing potential and are generally treated by debridement when symptomatic. MRI is most reliable when a defect is clearly demonstrated on more than one image or plane. Internal increased signal that does not reach an articular surface should be interpreted cautiously because it may represent degeneration rather than a true tear [35].

Peripheral ulnar-sided tears are clinically important because they may involve the foveal attachment of the radioulnar ligaments and produce distal radioulnar joint instability. MRI findings include fiber discontinuity, abnormal fluid signal at the ulnar insertion, detachment from the fovea or styloid, and associated soft-tissue edema. Indirect signs include distal radioulnar joint effusion, synovitis, marrow edema or cystic change at the ulnar fovea, and associated ulnar styloid fracture [36].

Peripheral TFCC tears are among the most difficult lesions to diagnose on conventional MRI. The ligamentum subcruentum normally contains vascular tissue and may appear hyperintense on fluid-sensitive sequences, mimicking a tear. A true lesion is more likely when there is complete fiber disruption, abnormal morphology, contrast extension on MR arthrography, or associated distal radioulnar joint instability. Correlation with symptoms and physical examination remains essential [37]. Radial-sided TFCC tears occur near the attachment of the disc to the sigmoid notch. They may be associated with a small avulsion fracture or cartilage injury and can appear as focal detachment, irregularity, or fluid-signal cleft at the radial insertion. Because the radial attachment is relatively broad, partial-volume averaging may simulate pathology. Thin coronal and axial sections improve evaluation of this region [38].

Distal TFCC injuries involve the ulnolunate and ulnotriquetral ligaments and may produce ulnocarpal instability. These lesions are less common and often occur with more extensive trauma. MRI may show ligament discontinuity, surrounding edema, abnormal widening, or associated carpal malalignment. Small partial tears can be difficult to identify because of the oblique course and variable thickness of the ulnocarpal ligaments [39].

Degenerative TFCC lesions are classified as Palmer class 2 abnormalities. Early degeneration consists



of disc thinning and internal signal change, followed by chondromalacia of the lunate, triquetrum, or distal ulna. More advanced disease includes central perforation, lunotriquetral ligament involvement, and eventually ulnocarpal or distal radioulnar osteoarthritis. These findings usually reflect chronic mechanical overload, particularly in patients with positive ulnar variance [40].

MRI should not evaluate the TFCC in isolation. Associated findings may determine the clinical importance of a tear and influence treatment. Bone marrow edema and subchondral cystic change in the proximal ulnar lunate or triquetrum support ulnar impaction, while distal radioulnar joint incongruity suggests instability. Cartilage loss, synovitis, and lunotriquetral ligament injury indicate more advanced degenerative disease [41].

MR arthrography may improve detection of small full-thickness TFCC defects by showing contrast passage between the radiocarpal and distal radioulnar joints. However, communicating central perforations may be degenerative and asymptomatic, particularly in older individuals. Partial-thickness tears may also remain occult because they do not permit contrast passage. Therefore, arthrographic findings should be interpreted together with morphology and clinical symptoms [42].

False-positive TFCC diagnoses may result from age-related degeneration, the prestyloid recess, the ligamentum subcruentum, magic-angle effects, motion, and partial-volume averaging. False-negative results may occur with small peripheral tears, insufficient spatial resolution, non-fluid-filled defects, and suboptimal imaging planes. Reviewing thin-section coronal and axial images together reduces the risk of misinterpretation [43].

The clinical relevance of an MRI-detected TFCC abnormality depends on patient age, trauma history, pain location, ulnar variance, and associated instability. Degenerative signal or small central perforations may be incidental, whereas complete foveal detachment with distal radioulnar joint instability is usually significant. MRI therefore contributes most effectively when it provides a structured description rather than simply reporting the presence or absence of a TFCC tear [44].

Ulnar Impaction and Related Impingement Syndromes

Ulnar impaction syndrome is a degenerative condition caused by repetitive loading between the distal ulna, triangular fibrocartilage complex, lunate, and triquetrum. It is most commonly associated with positive ulnar variance, although it may also occur in neutral or even negative variance when dynamic loading, pronation, or forceful grip increases functional ulnar length. Patients typically present with chronic ulnar-sided pain that worsens during forearm rotation, gripping, and ulnar deviation [45].

MRI is particularly valuable because it can demonstrate the complete spectrum of disease before advanced radiographic changes develop. Early findings include central TFCC thinning or degeneration, bone marrow edema in the proximal ulnar aspect of the lunate or triquetrum, and subtle chondral injury. More advanced cases show subchondral cyst formation, cartilage loss, lunotriquetral ligament degeneration or tearing, and secondary ulnocarpal or distal radioulnar osteoarthritis [46].

The distribution of marrow abnormalities is diagnostically useful. Ulnar impaction typically produces edema and cystic change at the proximal ulnar lunate and sometimes the adjacent triquetrum. This pattern should be differentiated from Kienböck disease, in which signal abnormality is centered more diffusely within the lunate and may be associated with sclerosis, collapse, and negative ulnar variance. Correlation with radiographs and the pattern of cartilage and TFCC injury improves diagnostic confidence [47].

MRI also helps determine the stage and mechanical consequences of ulnar impaction. A degenerative central TFCC perforation alone may represent an age-related finding, but when accompanied by focal lunate chondromalacia, subchondral edema, or lunotriquetral injury, it strongly supports clinically relevant ulnocarpal overload. This distinction is important because management may range from activity modification and arthroscopic debridement to ulnar shortening osteotomy or wafer resection [48].

Ulnar styloid impaction syndrome occurs when an elongated ulnar styloid repeatedly contacts the triquetrum or compresses the intervening TFCC and meniscal homologue. MRI may show an elongated styloid, marrow edema or sclerosis of the styloid and triquetrum, chondral injury, synovitis, and progressive TFCC degeneration. In early disease, soft-tissue impingement may occur without direct



osseous contact, whereas advanced cases may demonstrate true styloid–triquetral impaction [49].

A symptomatic ulnar styloid nonunion may produce a related form of impaction. The nonunited fragment can irritate the ECU sheath, impinge on the triquetrum, or remain attached to disrupted peripheral TFCC fibers. MRI can identify the fragment, marrow edema, cartilage injury, synovitis, and associated foveal or styloid TFCC detachment. Distinguishing an asymptomatic nonunion from a pain-generating lesion depends on the presence of adjacent reactive changes and clinical correlation [50].

Hamatolunate impingement is associated with a type II lunate, which has an additional medial distal facet articulating with the hamate. Repetitive contact may produce focal cartilage loss, marrow edema, and subchondral cystic change at the proximal pole of the hamate and the corresponding lunate facet. MRI is useful because the osseous morphology alone may be a normal variant, whereas associated chondral and marrow abnormalities suggest clinically significant impingement [51].

Pisotriquetral impingement and osteoarthritis are additional causes of volar ulnar-sided pain. MRI may demonstrate joint-space narrowing, cartilage loss, subchondral edema, cyst formation, effusion, and surrounding synovitis. Because pisotriquetral degeneration may be incidental, imaging findings should be correlated with focal tenderness over the pisiform and pain reproduced by pisotriquetral shear or compression [52].

Ulnocarpal impaction related to distal radius malunion may occur when radial shortening creates acquired positive ulnar variance. MRI depicts associated TFCC degeneration, carpal marrow changes, and chondral injury, while radiographs and computed tomography better quantify deformity and osseous alignment. Combined assessment is often necessary because surgical correction may require treatment of both the radius deformity and the ulnocarpal overload [53].

Several imaging pitfalls may lead to overdiagnosis. Mild lunate cysts, age-related TFCC thinning, and type II lunate morphology can be asymptomatic. Conversely, early impaction may produce only subtle marrow edema without obvious radiographic positive variance. MRI findings should therefore be interpreted as a pattern that integrates ulnar variance, TFCC morphology, cartilage status, marrow reaction, and the precise location of pain [54].

Distal Radioulnar Joint Disorders

The distal radioulnar joint is a pivot-type synovial articulation that permits pronation and supination through movement of the radius around the relatively fixed ulna. Its stability depends mainly on the dorsal and volar radioulnar ligaments of the triangular fibrocartilage complex, with additional support from the joint capsule, interosseous membrane, pronator quadratus, and extensor carpi ulnaris subsheath. Abnormalities of any of these structures may produce ulnar-sided pain, clicking, weakness, and limitation of forearm rotation [7].

Distal radioulnar joint instability may be acute after trauma or chronic following malunited distal radius fracture, TFCC injury, inflammatory arthropathy, or congenital deformity. MRI can demonstrate associated soft-tissue injuries, particularly foveal TFCC detachment, capsular disruption, synovitis, and ECU subsheath injury. However, static MRI may not reliably confirm dynamic instability, and findings should be correlated with clinical examination and comparison radiographs [36].

On axial MRI, joint congruity should be assessed at several levels because apparent subluxation may vary with forearm position. Mild dorsal displacement of the ulna relative to the sigmoid notch can occur in pronation, whereas volar displacement may occur in supination. Therefore, distal radioulnar malalignment should not be diagnosed solely from a single axial image without considering wrist position, symmetry, and associated structural injury [24].

Traumatic instability most commonly results from peripheral TFCC injury involving the foveal attachment of the radioulnar ligaments. MRI findings include discontinuity or detachment of the proximal TFCC lamina, surrounding edema, distal radioulnar joint effusion, and associated ulnar styloid fracture. Complete foveal tears are more likely to produce clinically significant instability than isolated central disc perforations [36].

Chronic instability may lead to joint incongruity, cartilage wear, subchondral sclerosis, cystic change, and secondary osteoarthritis. MRI is useful for evaluating cartilage loss, reactive marrow edema,



synovitis, and associated tendon or ligament abnormalities. Computed tomography may be more accurate for quantifying subtle rotational malalignment or sigmoid notch morphology, particularly when surgical reconstruction is considered [57].

Distal radioulnar joint osteoarthritis may occur after trauma, chronic instability, inflammatory disease, or ulnar impaction. MRI findings include cartilage thinning, joint-space narrowing, subchondral cyst formation, osteophytes, marrow edema, and synovitis. Associated TFCC degeneration is common and may be both a cause and consequence of altered joint mechanics [57].

Joint effusion is a nonspecific finding and should not be interpreted as evidence of instability by itself. Small amounts of fluid may be physiological, whereas a disproportionate distal radioulnar joint effusion may support associated TFCC injury, synovitis, or inflammatory arthropathy. The significance of effusion depends on its size, distribution, and accompanying structural abnormalities [46].

Inflammatory arthropathies can affect the distal radioulnar joint and produce synovial proliferation, erosions, cartilage loss, tendon sheath inflammation, and ligamentous weakening. Contrast-enhanced MRI may be useful when active synovitis is suspected, although the diagnosis should be integrated with clinical findings and laboratory data. Chronic inflammatory disease may ultimately cause instability and dorsal subluxation of the distal ulna [28].

Congenital or developmental abnormalities of the distal radius and ulna may alter joint mechanics and mimic post-traumatic instability. Variations in sigmoid notch depth, ulnar head shape, and radial inclination can predispose to abnormal translation. MRI contributes by identifying associated soft-tissue injury, but radiographs and computed tomography remain important for defining osseous morphology [10].

The main limitation of MRI in distal radioulnar joint assessment is that most examinations are performed in a static neutral position. Dynamic instability may therefore be underestimated. In patients with persistent clinical suspicion despite nondiagnostic MRI, stress radiographs, bilateral computed tomography in pronation and supination, dynamic ultrasound, or arthroscopic evaluation may provide additional information [31].

Conclusion

Magnetic resonance imaging plays a central role in the evaluation of ulnar-sided wrist pain by providing comprehensive assessment of the TFCC, distal radioulnar joint, intrinsic ligaments, tendons, cartilage, bone marrow, and neurovascular structures. Its greatest diagnostic value lies in detecting radiographically occult abnormalities, defining associated structural injuries, and distinguishing among overlapping causes of pain. However, MRI findings must be interpreted cautiously because normal variants, age-related degeneration, partial-volume effects, static positioning, and limited spatial resolution may produce false-positive or false-negative results. An anatomy-based, clinically correlated approach, supported by radiographs and selective use of ultrasound, CT, MR arthrography, or arthroscopy, remains essential for accurate diagnosis and appropriate management.

References

1. DaSilva MF, Goodman AD, Gil JA, Akelman E. Evaluation of ulnar-sided wrist pain. *J Am Acad Orthop Surg*. 2017;25(8). doi:10.5435/JAAOS-D-16-00407
2. Kreulen RT, Nayar SK, Alfaki Y, LaPorte DM, Demehri S. Advanced imaging of ulnar wrist pain. *Hand Clin*. 2021;37(4):477-486. doi:10.1016/j.hcl.2021.07.004
3. Lauder J, Younis F, Khan SHM. Imaging of ulnar-sided wrist pain. *Br J Hosp Med (Lond)*. 2019;80(8):461-465. doi:10.12968/hmed.2019.80.8.461
4. Vassa R, Garg A, Omar IM. Magnetic resonance imaging of the wrist and hand. *Pol J Radiol*. 2020;85. doi:10.5114/pjr.2020.99034
5. Vezeridis PS, Yoshioka H, Han R, Blazar P. Ulnar-sided wrist pain. Part I: anatomy and physical examination. *Skeletal Radiol*. 2010;39(8):733-745. doi:10.1007/s00256-009-0770-x



6. Porteous R, Harish S, Parasu N. Imaging of ulnar-sided wrist pain. *Can Assoc Radiol J*. 2012;63(1):18-29. doi:10.1016/j.carj.2010.04.003
7. Huang JI, Hanel DP. Anatomy and biomechanics of the distal radioulnar joint. *Hand Clin*. 2012;28(2):157-163. doi:10.1016/j.hcl.2012.03.002
8. Berger RA. The anatomy of the ligaments of the wrist and distal radioulnar joints. *Clin Orthop Relat Res*. 2001;(383):32-40. doi:10.1097/00003086-200102000-00006
9. Bae WC, Ruangchaijatuporn T, Chang EY, et al. MR morphology of the triangular fibrocartilage complex: correlation with quantitative MR and biomechanical properties. *Skeletal Radiol*. 2016;45(4):447-454. doi:10.1007/s00256-015-2311-1
10. Nöbauer-Huhmann IM, Pretterklieber M, Erhart J, et al. Anatomy and variants of the triangular fibrocartilage complex and its MR appearance at 3 and 7 T. *Semin Musculoskelet Radiol*. 2012;16(2):93-103. doi:10.1055/s-0032-1311768
11. 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(1):39-50. doi:10.1067/j.cpradiol.2015.05.004
12. Ng AWH, Griffith JF, Fung CSY, et al. MR imaging of the traumatic triangular fibrocartilaginous complex tear. *Quant Imaging Med Surg*. 2017;7(4):443-460. doi:10.21037/qims.2017.07.01
13. Burns JE, Tanaka T, Ueno T, Nakamura T, Yoshioka H. Pitfalls that may mimic injuries of the triangular fibrocartilage and proximal intrinsic wrist ligaments at MR imaging. *Radiographics*. 2011;31(1):63-78. doi:10.1148/rg.311105114
14. Ahn AK, Chang D, Plate AM. Triangular fibrocartilage complex tears: a review. *Bull NYU Hosp Jt Dis*. 2006;64(3-4):114-118.
15. Sachar K. Ulnar-sided wrist pain: evaluation and treatment of triangular fibrocartilage complex tears, ulnocarpal impaction syndrome, and lunotriquetral ligament tears. *J Hand Surg Am*. 2012;37(7):1489-1500. doi:10.1016/j.jhsa.2012.04.037
16. 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(8):1549-1553. doi:10.1007/s00590-018-2215-x
17. Squires JH, England E, Mehta K, Wissman RD. The role of imaging in diagnosing diseases of the distal radioulnar joint, triangular fibrocartilage complex, and distal ulna. *AJR Am J Roentgenol*. 2014;203(1):146-153. doi:10.2214/AJR.13.11589
18. Cerezal L, Llopis E, Canga A, del Piñal F. Postoperative imaging of ulnar wrist pain. *Semin Musculoskelet Radiol*. 2021;25(2):329-345. doi:10.1055/s-0041-1729968
19. Serfaty A, Costa HP, Foelker CE, Kochem Filho EN, Souza FF, Bordalo-Rodrigues M. Evaluation of ulnar variance on wrist MR imaging: is it a reliable measure? *Skeletal Radiol*. 2020;49(5):723-730. doi:10.1007/s00256-019-03334-0
20. Kox LS, Jens S, Lauf K, Smithuis FF, van Rijn RR, Maas M. Well-founded practice or personal preference: a comparison of established techniques for measuring ulnar variance in healthy children and adolescents. *Eur Radiol*. 2020;30(1):151-162. doi:10.1007/s00330-019-06347-2
21. Wang J, Yin Y, Sun C, et al. The association of three anatomical factors with ulnar-sided wrist pain: a radiological study. *Acta Radiol*. 2023;64(1):250-256. doi:10.1177/02841851211055858
22. Bateni CP, Bartolotta RJ, Richardson ML, Mulcahy H, Allan CH. Imaging key wrist ligaments: what the surgeon needs the radiologist to know. *AJR Am J Roentgenol*. 2013;200(5):1089-1095. doi:10.2214/AJR.12.9738
23. Rajan PV, Day CS. Scapholunate interosseous ligament anatomy and biomechanics. *J Hand Surg Am*. 2015;40(8):1692-1702. doi:10.1016/j.jhsa.2015.03.032
24. Mak WH, Szabo RM, Myo GK. Assessment of volar radiocarpal ligaments: MR arthrographic and arthroscopic correlation. *AJR Am J Roentgenol*. 2012;198(2):423-427. doi:10.2214/AJR.11.7306
25. Pérez AJ, Jethanandani RG, Vutescu ES, Meyers KN, Lee SK, Wolfe SW. Role of ligament stabilizers of the proximal carpal row in preventing dorsal intercalated segment instability. *J Bone Joint Surg Am*. 2019;101(15):1388-1396. doi:10.2106/JBJS.18.01109
26. Plotkin B, Sampath SC, Sampath SC, Motamedi K. MR imaging and US of the wrist tendons. *Radiographics*. 2016;36(6):1688-1700. doi:10.1148/rg.2016160011
27. Allende C, Le Viet D. Extensor carpi ulnaris problems at the wrist: classification, surgical treatment and results. *J Hand Surg Br*. 2005;30(3):265-272. doi:10.1016/j.jhsb.2004.12.003
28. Pang EQ, Yao J. Ulnar-sided wrist pain in the athlete: TFCC, distal radioulnar joint, and extensor carpi ulnaris. *Curr Rev Musculoskelet Med*. 2017;10(1):53-61. doi:10.1007/s12178-017-938 ulnar wrist.



29. Massaki AN, Tan J, Huang BK, Chang EY, Trudell DJ, Resnick DL. Extensor retinaculum of the wrist: gross anatomical correlation with MR imaging after ultrasound-guided tenography, with emphasis on anatomical features in wrist dorsiflexion responsible for tendon impingement. *Skeletal Radiol.* 2013;42(12):1727-1737. doi:10.1007/s00256-013-1706-8
30. Lee RP, Hatem SF, Recht MP. Extended MRI findings of intersection syndrome. *Skeletal Radiol.* 2009;38(2):157-163. doi:10.1007/s00256-008-0611-1
31. Fadel ZT, Samargandi OA, Tang DT. Variations in the anatomical structures of the Guyon canal. *Plast Surg (Oakv).* 2017;25(2):84-92. doi:10.1177/2292550317693814
32. Blum AG, Zabel JP, Kohlmann R, et al. Pathologic conditions of the hypothenar eminence: evaluation with multidetector CT and MR imaging. *Radiographics.* 2006;26(4):1021-1044. doi:10.1148/rg.264055021
33. Choi SJ, Ahn JH, Ryu DS, et al. Ultrasonography for nerve compression syndromes of the upper extremity. *Ultrasonography.* 2015;34(4):275-291. doi:10.14366/usg.14060
34. Goitz RJ, Fowler JR, Li ZM. The transverse carpal ligament: anatomy and clinical implications. *J Wrist Surg.* 2014;3(4):233-234. doi:10.1055/s-0034-1394133
35. Aguiar ROC, Gasparetto EL, Escuissato DL, et al. Radial and ulnar bursae of the wrist: cadaveric investigation of regional anatomy with ultrasonographically guided tenography and MR imaging. *Skeletal Radiol.* 2006;35(11):828-832. doi:10.1007/s00256-006-0155-1
36. Nealey EM, Petscavage-Thomas JM, Chew FS, Allan CH, Ha AS. Radiologic guide to surgical treatment of Kienböck disease. *Curr Probl Diagn Radiol.* 2018;47(2):103-109. doi:10.1067/j.cpradiol.2017.03.008
37. Arnaiz J, Piedra T, Cerezal L, et al. Imaging of Kienböck disease. *AJR Am J Roentgenol.* 2014;203(1):131-139. doi:10.2214/AJR.13.11606
38. Lichtman DM, Lesley NE, Simmons SP. The classification and treatment of Kienböck disease: the state of the art and a look at the future. *J Hand Surg Eur Vol.* 2010;35(7):549-554. doi:10.1177/1753193410374690
39. Zahiri H, Zahiri CA, Ravari FK. Ulnar styloid impingement syndrome. *Int Orthop.* 2010;34(8):1233-1237. doi:10.1007/s00264-009-0896-7
40. Levy SM, Reid M, Montgomery AM, et al. Do magnetic resonance imaging abnormalities of the nondominant wrist correlate with ulnar-sided wrist pain in elite tennis players? *Skeletal Radiol.* 2020;49(3):407-415. doi:10.1007/s00256-019-03293-6
41. Palmer AK. Triangular fibrocartilage complex lesions: a classification. *J Hand Surg Am.* 1989;14(4):594-606. doi:10.1016/0363-5023(89)90174-3
42. Palmer AK, Werner FW. The triangular fibrocartilage complex of the wrist: anatomy and function. *J Hand Surg Am.* 1981;6(2):153-162. doi:10.1016/S0363-5023(81)80170-0
43. Anderson ML, Skinner JA, Felmlee JP, Berger RA, Amrami KK. Diagnostic comparison of 1.5-T and 3.0-T preoperative MRI of the wrist in patients with ulnar-sided wrist pain. *J Hand Surg Am.* 2008;33(7):1153-1159. doi:10.1016/j.jhsa.2008.02.028
44. Potter HG, Asnis-Ernberg L, Weiland AJ, Hotchkiss RN, Peterson MGE, McCormack RR Jr. The utility of high-resolution magnetic resonance imaging in the evaluation of the triangular fibrocartilage complex of the wrist. *J Bone Joint Surg Am.* 1997;79(11):1675-1684. doi:10.2106/00004623-199711000-00009
45. Magee T. Comparison of 3-T MRI and arthroscopy of intrinsic wrist ligament and TFCC tears. *AJR Am J Roentgenol.* 2009;192(1):80-85. doi:10.2214/AJR.08.1089
46. Saupé N, Prüssmann KP, Luechinger R, Bösiger P, Marincek B, Weishaupt D. MR imaging of the wrist: comparison between 1.5- and 3-T MR imaging—preliminary experience. *Radiology.* 2005;234(1):256-264. doi:10.1148/radiol.2341031596
47. Treiser MD, Crawford K, Iorio ML. TFCC injuries: meta-analysis and comparison of diagnostic imaging modalities. *J Wrist Surg.* 2018;7(3):267-272. doi:10.1055/s-0038-1629911
48. De Santis S, Cozzolino R, Luchetti R, Cazzoletti L. Comparison between MRI and arthroscopy of the wrist for the assessment of posttraumatic lesions of intrinsic ligaments and the triangular fibrocartilage complex. *J Wrist Surg.* 2022;11(1):28-34. doi:10.1055/s-0041-1729757
49. Daunt N, Quayle J, Hacking C, et al. Accuracy of magnetic resonance imaging of the wrist for clinically important lesions of the major interosseous ligaments and triangular fibrocartilage complex: correlation with radiocarpal arthroscopy. *Skeletal Radiol.* 2021;50(9):1775-1783. doi:10.1007/s00256-020-03701-8
50. Van der Post AS, Jens S, Smithuis FF, Obdeijn MC, Oostra RJ, Maas M. The triangular fibrocartilage complex on high-



resolution 3-T MRI in healthy adolescents: the thin line between asymptomatic findings and pathology. *Skeletal Radiol.* 2021;50(11):2195-2204. doi:10.1007/s00256-021-03779-8

51. von Borstel D, Wang M, Small K, Nozaki T, Yoshioka H. High-resolution 3-T MR imaging of the triangular fibrocartilage complex. *Magn Reson Med Sci.* 2017;16(1):3-15. doi:10.2463/mrms.rev.2016-0011
52. Zhan HL, Bai RJ, Qian ZH, Yang Y, Zhang H, Yin YM. High-resolution 3-T magnetic resonance imaging of the triangular fibrocartilage complex in Chinese wrists. *Chin Med J (Engl).* 2017;130(7):817-822. doi:10.4103/0366-6999.202742
53. Tanaka T, Yoshioka H, Ueno T, Shindo M, Ochiai N. Comparison between high-resolution MRI with a microscopy coil and arthroscopy in triangular fibrocartilage complex injury. *J Hand Surg Am.* 2006;31(8):1308-1314. doi:10.1016/j.jhsa.2006.06.003
54. Lee YH, Choi YR, Kim S, Song HT, Suh JS. Intrinsic ligament and triangular fibrocartilage complex tears of the wrist: comparison of isovolumetric 3D-THRIVE sequence MR arthrography and conventional MR imaging at 3 T. *Magn Reson Imaging.* 2013;31(2):221-226. doi:10.1016/j.mri.2012.06.024
55. Lee RK, Griffith JF, Ng AWH, Nung RCH, Yeung DKW. 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(1):155-161. doi:10.2214/AJR.15.14948
56. Iordache SD, Rowan R, Garvin GJ, Osman S, Grewal R, Faber KJ. Prevalence of triangular fibrocartilage complex abnormalities on MRI scans of asymptomatic wrists. *J Hand Surg Am.* 2012;37(1):98-103. doi:10.1016/j.jhsa.2011.10.006
57. Zhao X, Yu A, Shao X, et al. Diagnostic value of MRI in traumatic triangular fibrocartilage complex injuries: a retrospective study. *BMC Musculoskelet Disord.* 2024;25(1):63. doi:10.1186/s12891-023-07140-z