

Use of magnetic resonance imaging to diagnose common wrist disorders

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Magnetic resonance imaging is being used more frequently to diagnose and plan treatment of wrist disorders. This article reviews the common pathologic lesions of the wrist: avascular necrosis, triangular fibrocartilage complex tears, ligamentous tears, ganglion cysts, carpal tunnel syndrome, and osteoarthritis. The typical magnetic resonance imaging characteristics of these lesions is discussed.

(Key words: magnetic resonance imaging, wrist disorders)

Magnetic resonance imaging (MRI) is an excellent noninvasive modality currently used to evaluate wrist pain and other symptomatology. The clinical entities discussed in this article are avascular necrosis, triangular fibrocartilage disorders, ligamentous tears, ganglion cysts, carpal tunnel syndrome, and osteoarthritis.

Avascular necrosis

Two areas of the wrist most commonly affected by avascular necrosis (AVN) are the scaphoid and lunate bones.¹ The distribution of blood supply from the radial artery is to the distal pole of the scaphoid with retrograde flow to its proximal portion. This renders the proximal scaphoid vulnerable to ischemia and

resultant AVN subsequent to a fracture in the region of the scaphoid wrist² (*Figure 1*). AVN of the proximal pole fragment, therefore, usually follows trauma, accompanying 30% of all scaphoid wrist fractures and the majority of fractures within the proximal scaphoid pole.¹ Non-traumatic avascular necrosis of the scaphoid is known as Preiser's disease.²

AVN with associated deformity of the lunate bone, or Kienböck's disease, is seen most frequently in 18- to 40-year-old males with a history of heavy manual labor. It occurs most often in the dominant wrist and has been suggested by some researchers to have an association with negative ulnar variance. This is a condition in which the ulna is shortened relative to the radius.¹ Repetitive microtrauma has been implicated as the most likely cause of Kienböck's disease.¹

AVN is first visualized as minimal early distortion of the trabecular pattern of bone caused by transverse microfractures. This appearance is followed by marrow edema, seen as decreased marrow signal intensity on T1-weighted images. Loss of signal intensity on T2-weighted images is regarded as less sensitive but more specific for AVN. In Kienböck's disease, lunate collapse may ensue with proximal migration of the capitate bone and disorganization of the normal carpal relationships.²

Chronic AVN presents on MRI with diminished signal intensity on all pulse sequences whether or not trabecular collapse is present. MRI with contrast enhancement may be of value in establishing the presence of viable tissue. Enhancement suggests the presence of viable tissue with intact blood supply.²

Triangular fibrocartilage complex tears

Triangular fibrocartilage tears are a frequent cause of ulnar-sided wrist pain. The triangular fibrocartilage complex (TFC) is composed of a central fibrocartilaginous cushioning articular disc with associated ligamentous structures. The TFC functions in suspending the ulnar carpus and distal radius from the distal ulna, diffusing the axial loading forces across the radiocarpal joint.^{3,4} It appears as a thick band of low signal intensity on all pulse sequences, extending from the hyaline cartilage of the ulnar aspect of the radius to the ulna from the region of the fovea to the styloid process.² Its components include the triangular fibrocartilage proper or articular disc, the meniscus homologue, the dorsal and volar radioulnar ligaments, the ulnar collateral ligament, and the extensor carpi ulnaris sheath.³

TFC tears may be traumatic or degenerative, and the incidence of asymptomatic TFC perforations escalates with increasing age of the patient.⁵ TFC tears are typically depicted on MRI as high signal intensity within the cartilage band on T1, proton density, and gradient echo sequences with brighter signal intensity on T2-weighted echo images.⁴ Fluid may be seen to extend between the radiocarpal joint compartment through the defect and into the distal radioulnar joint (*Figure 2*). Partial tears communicate with one articular surface.⁵ The TFC may become irregularly shaped and may exhibit inhomogeneous signal intensity. Coronal images may facilitate differentiation between central and peripheral tears.³

Other related findings include extensor carpi ulnaris tendon subluxation, indicative of subsheath injury, and dorsal or volar radioulnar ligament tears

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Figure 1. A coronal T1-weighted image demonstrates evidence of a fracture through the waist of the scaphoid (arrowhead). The distal pole fragment (arrow) exhibits normal increased signal visualized also in the other carpal bones. However, the proximal pole fragment (open arrow) has diminished signal intensity, signifying avascular necrosis. ►



Figure 2. A coronal T2-weighted image (without fat saturation) discloses separation of the scapholunate articulation (arrowhead). The normally low-signal scapholunate ligament has been disrupted, and high-signal synovial fluid extends between the radiocarpal and midcarpal joints. The triangular fibrocartilage (large open arrow) reveals a defect (small open arrow). ►



with distal radioulnar joint instability and subluxation.³ Degenerative perforation is represented by thinning of the disc or as a large oval defect in the central avascular region of the triangular fibrocartilage.²

Ligamentous tears

Intercarpal ligamentous tears are also implicated as a cause of wrist pain and instability.¹ The main intrinsic ligaments

of the wrist are the scapholunate and lunatotriquetral ligaments.³ They are normally seen as delta-shaped or linear structures with low to intermediate signal intensity on gradient echo sequences.¹ Tears are seen as areas of fragmentation or discontinuity within the ligament accompanied by hyperintensity on T2-weighted images, significant distortion of the morphology of the ligament, or complete absence of the ligament on all pulse

sequences, often with synovial fluid occupying the expected position of the ligament^{1,3} (Figure 2). The scapholunate ligament, seen best in the coronal plane, contributes to joint and wrist stability. Most characteristic of tears is complete absence of ligament or an area of ligament discontinuity interrupted by hyperintense fluid.² The lunatotriquetral ligament is a linear or U-shaped structure of low signal intensity that spans the proximal lunate and triquetrum. Tears are commonly seen as disruption of the ligament by high signal intensity fluid.²

Ganglion cysts

Ganglion cysts represent the most common soft tissue lesions of the wrist,¹ comprising 50% to 70% of all wrist masses. Women are affected more often than men (3:1), typically between the second and fourth decades. Seventy percent of ganglia are on the dorsum of the wrist, adjacent to the scapholunate articulation, and may result in dorsal wrist pain.¹ They may also be seen in the volar region of the trapeziotrapezoid joint, where they are often occult and nonpalpable, sometimes causing carpal tunnel syndrome¹ (Figure 3).

Ganglion cysts arise from joints, tendons, or tendon sheaths² and consist of a fibrous capsule filled with mucinous material,² without a synovial lining.⁶ Their cause is not known, but is suspected to be related to trauma, chronic herniation, or myxomatous degeneration of periarticular connective tissue.¹ They are well demarcated, round or lobulated homogeneous cystic masses that may be multiloculated or septated. Ganglia may be evaluated by use of ultrasonography.⁶ They demonstrate low to intermediate signal intensity on T1-weighted magnetic resonance images (isointense or hypointense to muscle) with a low signal periphery. They are hyperintense on T2-weighted images and do not enhance with gadolinium. Septations, if present, are of low signal intensity.^{1,2} Ganglion cysts can be located intraosseously in the carpus and may predispose to pathologic fracture. Such cysts manifest marrow replacement with intermediate signal on T1-weighted

images and high signal on T2-weighted images, without contrast enhancement.²

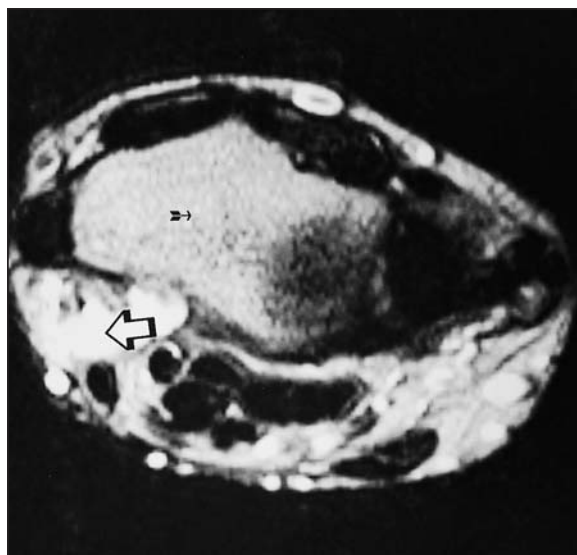
Carpal tunnel syndrome

Carpal tunnel syndrome (CTS) is a chronic debilitating disorder that results from compression of the median nerve at the carpal tunnel due to narrowing or increased pressure with resultant ischemia of the nerve. It is the most common of the peripheral nerve entrapment syndromes, affecting women 3 to 5 times more often than men, with 78% of patients between the ages of 40 and 70 years old.⁷

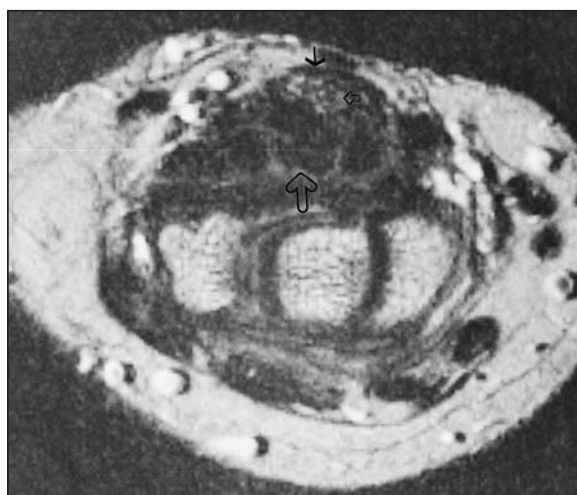
The diagnosis of CTS is rendered clinically. Patients present with paresthesias or hyperesthesias of the fingers along the course of the median nerve, radiating into the forearm. The second digit is most frequently involved. Unreliability or weakness of the grip is a usual clinical feature. Exacerbation of symptoms tends to occur nocturnally and during repetitive daily activity. Muscular weakness and atrophy of the thenar eminence are late findings. Patients may have intermittent relief of symptoms with shaking of the hand.⁸ Diagnosis is aided by eliciting Tinel's and Phalen's signs, by electromyography of the thenar muscles, and by nerve conduction studies of the median nerve. Electromyographic studies are greater than 90% accurate.¹

Causes of CTS have been placed into acute and chronic categories. The most common acute etiologic factor is a severe Colle's fracture, with other less-frequent causes including infections, intraneural hemorrhage, and thrombosis of a persistent median artery.⁷ Chronic causes are more frequent, with chronic repetitive microtrauma being the most common. CTS may also be a complication of tenosynovitis, ganglion cysts, lipomas, trauma, osteoarthritis, rheumatoid arthritis, chronic infections such as tuberculosis, systemic diseases (diabetes mellitus, amyloidosis, lupus erythematosus, acromegaly, hypothyroidism, or gout), pregnancy, and work-related hypertrophy of muscles and tendons.⁷

The carpal tunnel is bounded by the concave volar surface of the carpus in continuity with the tough transverse carpal ligament and extends from the



◀ **Figure 3.** An axial T2-weighted image, at the level of the distal radius (arrow), shows a bright fluid collection along the volar soft tissue (open arrow). This finding represents a ganglion cyst with internal septations.



◀ **Figure 4.** An axial T2-weighted scan, performed with the arm in supination, was conducted to evaluate the carpal tunnel (large open arrow shows multiple low-signal tendons in the carpal tunnel). The flexor retinaculum (arrow) is bulging, and the median nerve (small open arrow) is thickened and edematous with moderately bright signal intensity.

scaphoid tubercle to the hook of the hamate. Eight flexor digitorum tendons and the flexor pollicis longus tendon course through the carpal tunnel along with the median nerve. Being of limited volume, any process that reduces the cross-sectional area of the tunnel can inflict mechanical compression of the median nerve, leading to the ischemia that elicits the symptoms.²

The carpal tunnel is imaged to best advantage in the true axial plane with T1- and T2-weighted spin echo pulse sequences and proton density images with the wrist in neutral position.¹ Abnormal findings of the carpal tunnel on MRI include the following:

■ Increased girth of the median nerve proximal to the transverse carpal ligament and proximal to the carpal tunnel

(Figure 4). This widening is best evaluated at the level of the pisiform bone. In patients with CTS, the nerve is 1.6 to 3.5 times larger at the level of the pisiform than at the level of the distal radioulnar joint.^{1,7}

■ Flattening of the median nerve in the carpal tunnel, which is best evaluated at the level of the hamate. The ratio of the nerve's major axis to minor axis is recorded, with flattening ratios averaging 1.8 at the distal radius and 3.8 at the hamate in patients with CTS, compared with average ratios of 2.5 and 2.9, respectively, in clinically normal patients.^{1,7}

■ Volar bowing or bulging of the flexor retinaculum. Palmar bowing of the flexor retinaculum is seen at the distal carpal tunnel between the hook of the

hamate and the tubercle of the trapezium where the flexor retinaculum is thickest and the carpal tunnel is narrowest. The normally straight or concave flexor retinaculum becomes bowed with a palmar convexity by increasing pressure in the carpal tunnel. The amount of palmar displacement is determined by deviation from a straight line drawn between the hooks of the hamate and the trapezium to ascertain a ratio. Bowing ratios in patients with CTS range from 14% to 20%, compared with 0% to 15% in normal subjects.^{1,7}

■ Abnormal increased signal intensity within the median nerve on T2-weighted images. Increased T2 signal may be noted within the substance of the swollen part of the nerve at the proximal end of the carpal tunnel to as far distally as the metacarpal bases. The normal median nerve is bright relative to tendons.^{1,7}

Osteoarthritis

Osteoarthritis exhibits focal irregular thinning or loss of the fine layer of hyaline articular cartilage at the cortical surface viewed on T2-weighted images. The areas of cartilage denudation may be outlined by joint effusion, which has high signal intensity on T2-weighted images. Subchondral replacement of fatty marrow by granulation tissue and fibrosis is seen as replacement of the normally high T1 signal intensity of fat by intermediate signal. Marrow edema may also be seen as decreased signal on T1 sequences. Subchondral sclerosis or eburnation appears as low signal on all pulse sequences. Minute marginal osteophytes have a low signal intensity on T1-weighted images. However, prominent osteophytes demonstrate a high signal intensity on T1-

weighted images due to the presence of fatty marrow centrally. Joint space narrowing and subchondral cysts are other features of osteoarthritis.⁹

Rheumatoid arthritis is manifested by inflamed synovium, which appears as thick, edematous tissue (pannus) in the joint capsule, bursa, and tendon sheath. Inflamed synovium has an intermediate signal on T1- and a high signal intensity on T2-weighted sequences. Periarticular enhancement following intravenous administration of gadolinium suggests active synovitis and may allow earlier detection of rheumatoid arthritis. Joint effusion is often present and can be confused with synovitis. The administration of contrast demonstrating enhancement of the synovium on T1 sequences or the use of gradient recalled acquisition in a steady state magnetic resonance imaging and magnetization transfer subtraction technique may help to discriminate between the two entities.⁹ Chronic synovitis is characterized by fibrotic synovium, which has intermediate to low signal intensity on both T1- and T2-weighted images.⁹

Comment

MRI has advanced medical diagnosis in the area of wrist pathology. It is a highly sensitive technique, and in most cases has a relatively high specificity for various wrist disorders. MRI is of particular diagnostic value when the clinical examination is ambiguous.

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