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Ulnar-sided wrist pain: Diagnosis and treatment

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ULNAR-SIDED WRIST PAIN

DIAGNOSIS AND TREATMENT

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Ulnar-sided wrist pain has often been equated with low back pain because of its insidious onset, vague and chronic nature, intermittent symptoms, and frustration that it induces in patients. Chronic ulnar-sided wrist pain may be accompanied by a history of Workers' Compensation claims and unrelenting and irresolvable pain, and it may occur in patients with difficult personalities. Despite these issues, many patients with ulnar-sided wrist pain do have pathologic lesions that may be amenable to surgical treatment.

The anatomy of the ulnar side of the wrist is complex, with many overlapping areas that may be a cause of pain. A clear understanding of the normal anatomy of the ulnar side of the wrist in addition to a systematic evaluation with both physical examination and radiographic imaging can often elucidate the etiology, and thus the treatment, of ulnar-sided wrist pain.

The differential diagnosis of ulnar-sided wrist pain can be divided into six elements: osseous, ligamentous, tendinous, vascular, neurologic, and miscellaneous. Osseous injuries include the sequelae of fractures (i.e., nonunion or malunion) and degenerative processes. Fracture nonunions of the hamate[1-4], pisiform[5-10], triquetrum[11-13], base of the fifth metacarpal[14-17], ulnar styloid process, and distal part of the ulna or radius have been reported to cause ulnar-sided wrist pain. Degenerative processes at the pisotriquetral joint[18], midcarpal (triquetrohamate) articulation, fifth carpometacarpal joint[14-17], or distal radioulnar joint can also result in substantial ulnar-sided wrist pain. Ulnar impaction or abutment into the radius or carpus has been reported as well[19-21]. Ligamentous injuries can occur in any of the ulnar-sided intrinsic (lunotriquetral or capitohamate) or extrinsic (ulnolunate, triquetrocapitate, or triquetrohamate) ligaments as well as the triangular fibrocartilage complex[1,18,19,22-27]. Tendinopathies of the extensor carpi ulnaris[18,28-30] or flexor carpi ulnaris[31-34] as well as vascular lesions such as ulnar artery thrombosis or hemangiomas can also cause ulnar-sided wrist pain[35-38]. Neurologic processes such as entrapment of the ulnar nerve in Guyon's canal, neuritis of the dorsal sensory branch of the ulnar nerve, and complex regional pain syndromes may be present[39,40]. Finally, the miscellaneous group includes the very unusual etiologies such as tumors, including osteoid osteomas, chondroblastomas, and aneurysmal bone cysts.

The focus of this article is to provide a clear understanding of the anatomy of the ulnar side of the wrist and to discuss physical examination, imaging techniques, and treatment of some of the more common causes of ulnar-sided wrist pain.

Anatomy of the Ulnar Side of the Wrist
Extrinsic and Intrinsic Carpal Ligaments

The ulnar portion of the carpus has several intrinsic and extrinsic ligaments that are important to the stability of the wrist. The intrinsic ligaments include the capitohamate and lunotriquetral ligaments (Fig. 1). The lunotriquetral ligament is a c-shaped ligament with three parts: the dorsal, volar, and intramembranous portions. Histologically, the dorsal and volar ligaments are true ligaments, and the volar portion is substantially thicker than the dorsal portion. The intramembranous ligament is not a true ligament histologically, and it has little mechanical strength. The capitohamate ligament complex is formed by three distinct ligaments: the dorsal, volar, and deep components.

The extrinsic ligaments on the ulnar side include the ulnotriquetral and ulnolunate ligaments (Fig. 2). These ligaments act as primary stabilizers of the relationship between the distal part of the ulna and the volar part of the carpus. The fibers originate from the volar margin of the triangular fibrocartilage complex, with a contribution from the base of the ulnar styloid, and insert onto the palmar aspect of the triquetrum, lunate, and lunotriquetral ligament (Fig. 3). The fibers are blended intimately with the volar margin of the triangular fibrocartilage complex. The meniscus homologue attaches proximally to the dorsal end of the distal margin of the sigmoid notch and the dorsal border of the triangular disk. It extends volarly and distally to insert at the ulnar aspects of the triquetrum, lu-
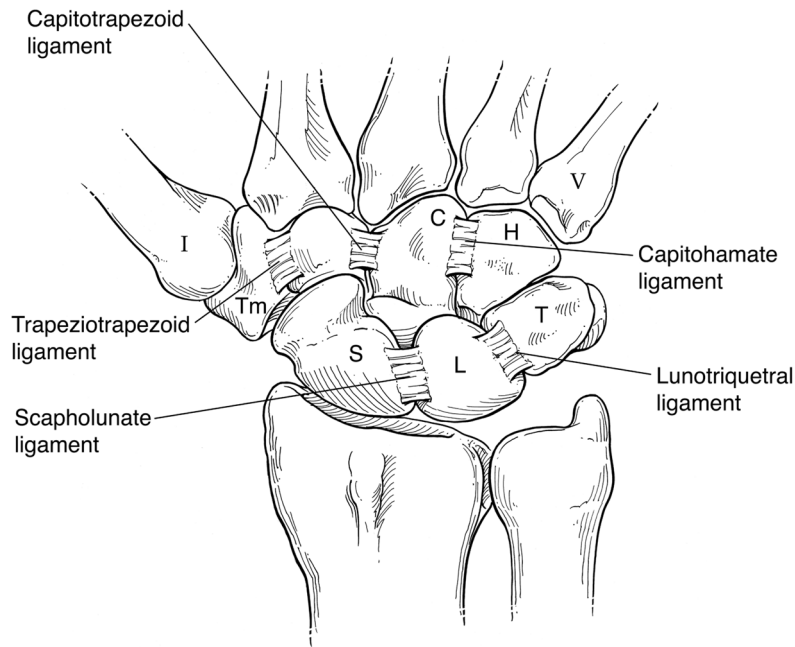
Fig. 1

The intrinsic ligaments of the wrist as viewed from the dorsal aspect of the carpus. C = capitate, H = hamate, L = lunate, S = scaphoid, T = triquetrum, Tm = trapezium, I = first metacarpal, and V = fifth metacarpal. (Reprinted with permission of the Mayo Foundation.)

oulnar joint, with supplemental stability being provided by the interosseous membrane, the extensor retinaculum, and the muscle-tendon units that cross the longitudinal axis of rotation of the forearm. The tendon of the extensor carpi ulnaris serves as a dynamic stabilizer. Static stability is provided by the subsheath of the extensor carpi ulnaris.

The volar and dorsal radioulnar ligaments originate from the dorsal and volar margins of the medial aspect of the radius adjacent to the sigmoid notch (Fig. 3). They conjoin just medial to the pole of the distal part of the ulna, forming a triangle that surrounds the articular disk. There are two separate sites of insertion on the distal part of the ulna, separated by a band of vascularized loose connective tissue: the deep fibers of the conjoined ligaments insert into the ulnar fovea as the ligamentum subcruentum, while the superficial fibers insert into the base of the ulnar styloid.

nate, and lunotriquetral ligament. The ulnar fibers commingle with those of the subsheath of the extensor carpi ulnaris and continue to the base of the fifth metacarpal.

Distal Radioulnar Joint

The curvature of the sigmoid notch of the radius is larger than the ulnar seat and therefore provides little osseous stability to the distal radioulnar joint. In addition, a dorsal-palmar translation occurs between the joint surfaces during forearm rotation.

It is understood that, with forearm rotation, motion occurs at the distal radioulnar joint in three planes: rotation about the longitudinal axis of the forearm, dorsal-palmar translation, and proximal-distal translation. The osseous architecture of the distal radioulnar joint affords decreasing stability with increasing forearm pronation or supination, as the ulnar head contacts only the volar margin of the sigmoid notch in full supination and the dorsal margin of the sigmoid notch in full pronation. The ligaments of the triangular fibrocartilage complex, therefore, provide the primary intrinsic stabilization of the distal radi-
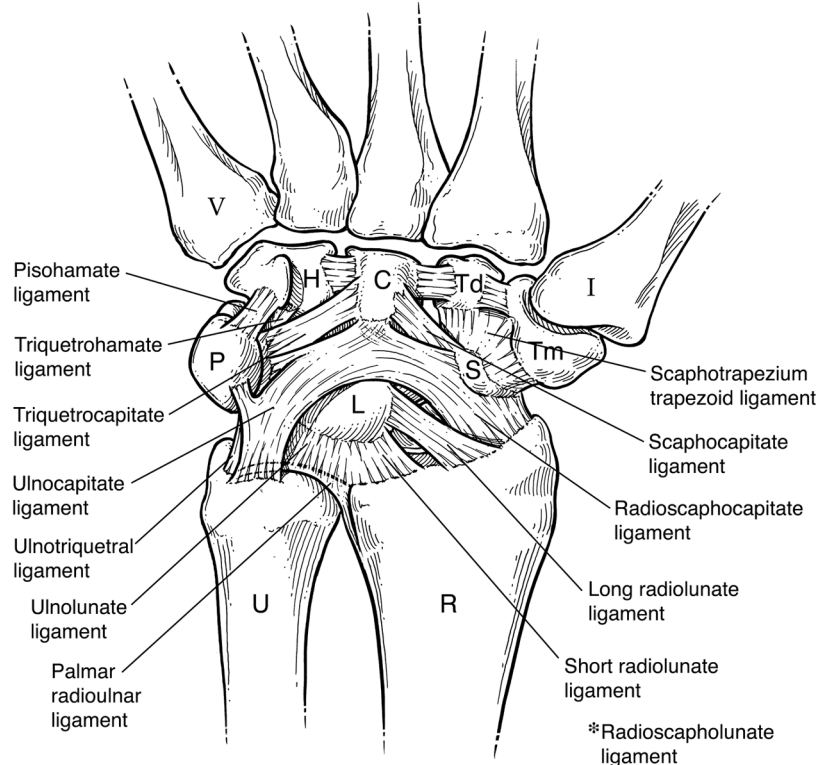

Fig. 2

The extrinsic ligaments of the wrist as seen from the volar perspective of the carpus. C = capitate, H = hamate, L = lunate, P = pisiform, R = radius, S = distal pole of scaphoid, Td = trapezoid, Tm = trapezium, U = ulna, I = first metacarpal, and V = fifth metacarpal. (Reprinted with permission of the Mayo Foundation.)
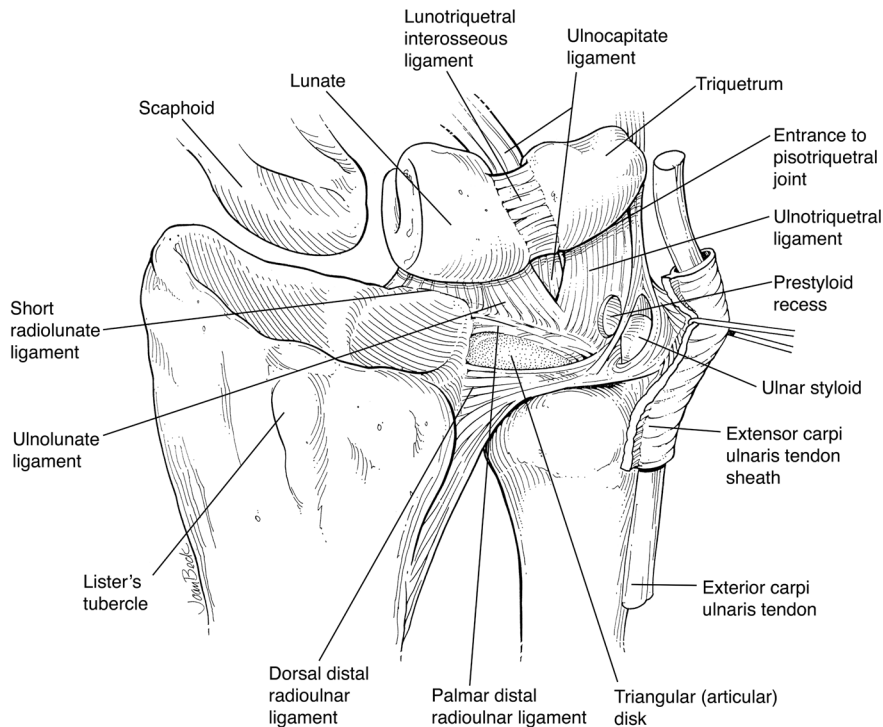
Fig. 3

The distal part of the radius and the radiocarpal capsule and ligaments from a dorsal view. The dorsal and palmar radioulnar ligament as well as the ulnar border of the radius form the margins for the triangular disk, and all together they form the triangular fibrocartilage complex. Note how the ulnotriquetral and ulnolunate ligaments arise from the portions of the palmar radioulnar ligament and how the dorsal and palmar radiolunate ligaments attach to the styloid recess. The extensor carpi ulnaris tendon sheath is intimately associated with the dorsal aspect of the ulna. (Reprinted with permission of the Mayo Foundation.)

Triangular Fibrocartilage Complex

The triangular fibrocartilage complex is the complex of soft tissues interposed between the distal part of the ulna and the ulnar side of the carpus, arising from the distal part of the radius and extending across the ulnar pole to insert into the fovea and the base of the ulnar styloid (Fig. 3). Considered the primary stabilizer of the distal radioulnar joint, the term *triangular fibrocartilage complex* emphasizes both the functional and the anatomic interdependence of its elements. Palmer and Werner described the different components of the triangular fibrocartilage complex[41] as the triangular fibrocartilage proper (the articular disk), the palmar and dorsal radioulnar ligaments, the meniscus homologue, the ulnar collateral ligament, and the subsheath of the extensor carpi ulnaris tendon.

The vascular supply of the trian-gular fibrocartilage complex has been well described[42]. Supplied by terminal portions of both the anterior and the posterior interosseous arteries, the palmar, ulnar, and dorsal components of the disk and radioulnar ligaments are well vascularized, whereas the central and radial portions are avascular. This pattern of supply has direct implications with regard to the healing potential of the disk and the radioulnar ligaments following injury, with peripheral ulnar-sided detachments demonstrating a superior capacity to heal following repair when compared with radial-sided detachments.

Examination and Diagnostic Tools for Ulnar-Sided Wrist Pain

The etiology of ulnar-sided wrist pain can often be determined on the basis of a complete history, a detailed clinical examination, and appropriate diagnos-tic tests. Once a firm diagnosis has been established, treatment can ensue.

Ulnar-sided wrist pain can be divided into three categories: acute traumatic injuries, chronic overuse injuries, and chronic degenerative problems.

Acute injuries typically result from a notable traumatic event. This may be a fall from either a height or a standing position, or it may be a hyperextension injury from a heavy object falling against the wrist. Most injuries involve a hyperextension, ulnar deviation moment, although flexion injuries and direct blows may also result in ulnar-sided lesions. Patients may report hearing a pop and noticing immediate swelling or pain. Injuries such as a fracture or distal radioulnar joint dislocation may lead the patient to seek immediate attention, whereas it may take several months for a patient to present with an injury such as a tear of the lunotriquetral ligament or the triangular fibrocartilage complex. The patient, however, will typically remember the index event.

Chronic overuse injuries may have a more indolent presentation. Patients with chronic repetitive ulnar loading, such as mechanics and plumbers, may present with vague ulnar-sided pain without a history of specific injury. Patients with low-grade repetitive loading, such as assembly workers and computer operators, may present with extensor carpi ulnaris tendinitis following an increase or change in activity.

Chronic degenerative problems may result from previous acute traumatic events, previous injuries that have altered the anatomy, and abnormalities that arise from anatomic or congenital variations. Examples include ulnar-sided wrist pain resulting from a malunited distal radial fracture, a previous radial head fracture with subsequent radial shortening, congenital radial head dislocation, and pisotriquetral arthritis.

A detailed history is essential to determine which of these categories applies to a particular patient. It must include a detailed medical history as well as a history of previous injuries and previous surgical procedures involving not only the wrist but the elbow as well.

Asking the patient about his or her symptoms will often help to narrow the differential diagnosis of ulnar-sided wrist pain. The patient can be asked whether the pain is ulnar or radial to an imaginary line drawn through the center of the dorsal aspect of the wrist. Patients with ulnar-sided lesions are usually able to localize the pain to the ulnar side of the wrist. Patients often report pain with ulnar deviation and loading of the wrist such as occurs when they elevate themselves out of a chair or swing a hammer. Patients may also report pain with hyperextension of the wrist. Occasionally, they report catching or clicking in the wrist, and this must be further investigated with a physical examination since noise with wrist motion can be normal. Ulnar nerve symptoms may point to diagnoses such as a fracture of the hook of the hamate or more proximal ulnar nerve compression. Vascular symptoms point to diagnoses such as ulnar artery thrombosis.

The physical examination begins with inspection. The wrist and elbow should be examined for previous surgical scars. Prominence of the ulna either volarly or dorsally may indicate some degree of instability of the distal radioulnar joint. A volar sag and supination of the wrist may indicate the capsuloligamentous instability that occurs in rheumatoid arthritis. Intrinsic atrophy and clawing may indicate ulnar nerve neuropathy. Splinter hemorrhages beneath the nails and decreased turgor in the volar digital pads suggest vascular insufficiency.

Palpation should proceed in a systematic fashion by isolating anatomic structures. The examination should be performed with the patient's elbow resting on the table, the hand pointing toward the ceiling, and the forearm in neutral as if the patient is about to arm wrestle with the examiner. Tenderness over any anatomic structure suggests a specific clinical diagnosis. The lunotriquetral interval is palpated between the fourth and fifth compartments one fingerbreadth distal to the distal radioulnar joint with the wrist in 30° of flexion. The extensor carpi ulnaris tendon is palpated along the distal part of the ulna and is most palpable just distal to the ulnar head. The extensor carpi ulnaris insertion is at the base of the fifth metacarpal, well away from the wrist joint (Fig. 4). The fifth carpometacarpal joint is just proximal to the extensor carpi ulnaris insertion. The triangular fibrocartilage complex is best palpated midway between the extensor carpi ulnaris and the flexor carpi ulnaris in the soft recess just distal to the ulnar styloid (Fig. 5). The pisotriquetral joint is palpated volar to the triangular fibrocartilage complex, and the pisiform can be moved between the examiner's thumb and index finger. The distal radioulnar joint is palpated dorsally in various degrees of forearm rotation.

The differential diagnosis of ulnar-sided wrist pain can be narrowed further by performing provocative maneuvesrs.

Abnormalities of the lunotriquetral joint can be assessed with three separate stress maneuvers. Lunotriquetral ballottement can be achieved by compressing the lunate against the triquetrum. This is performed with the examiner's thumb placed against the lateral border of the triquetrum and compressing the triquetrum against the lunate.

The Regan "shuck" test is performed by the examiner placing his or her thumb and index finger on the triquetrum and pisiform, respectively, and placing the other hand on the radial carpus and lunate. The examiner moves his or her right and left hand in opposing (volar and dorsal) directions, placing shear stress across the lunotriquetral joint. Since the lunate and triquetrum are the only bones not stabilized, the force is transmitted across the lunotriquetral joint, with pain indicating a pathologic condition.

The Kleinman "shear" test allows a more subtle application of force and is considered the most specific provocative test for lunotriquetral disorders. The examiner places his or her thumb on the pisiform volarly and the remaining fingers of the same hand dorsally along the ulnar carpus. The other hand is used to stabilize the lunate and the radial side of the carpus. Force is generated across the pisiform in a dorsal-to-volar direction while the other hand is held still. This allows for controlled stress across the lunotriquetral joint (Fig. 6). Prior to this maneuver, the pisotriquetral joint should be palpated in the ulnar-to-radial plane to rule out pathologic changes in this joint.

Pathologic changes in the triangular fibrocartilage complex can be isolated with the ulnocarpal impaction maneuver. This is again performed with the patient's elbow flexed and hand pointing toward the ceiling. The examiner moves the ulnarly deviated wrist in a volar-to-dorsal direction while applying an axial load across the ulnar side of the wrist (Fig. 7). This maneuver translates load across the triangular fibrocartilage complex, which may cause grinding and reproduce pain.

The piano key test is performed to isolate disorders of the distal radioulnar joint. Ballottement of the ulna is performed by the examiner applying a dorsal-to-volar load with his or her hand 4 cm proximal to the distal radioulnar joint. This isolates abnormalities of the distal radioulnar joint by avoiding pressure on the overlying structures such as the extensor digiti minimi tendon.

Selective anesthetic injections are an important adjunct to confirm pathologic changes suspected on clinical examination. If a corticosteroid is added to the anesthetic injection, therapeutic benefits may also be achieved. Injections should be performed in joints or along tendons that are suspected of being injured. If a lesion of the triangular fibrocartilage complex is suspected, the injection should be performed in the ulnocarpal joint. If extensor carpi ulnaris tendinitis is the working diagnosis, then the injection should be performed in the extensor carpi ulnaris tendon sheath, with avoidance of the ulnocarpal joint. Such selective injections can be used to distinguish intra-articular from extra-articular lesions.

Techniques and Indications for Imaging of the Ulnar Side of the Wrist

Numerous imaging modalities are available for the evaluation of ulnar-sided wrist pain. In almost all cases, plain radiographs are made first. The decision to use more advanced imaging modalities is based on the suspected diagnosis.

Standard Radiographs

Initial radiographic evaluation should include neutral rotation posteroanterior, neutral rotation lateral, and oblique plain radiographs of the wrist. These views are useful as a general screening tool to look for evidence of fractures, arthritic changes, and bone lesions. Numerous indices can be measured on these radiographs[43].

On the posteroanterior radiograph, particular attention should be paid to Gilula's lines, ulnar variance, the carpal height ratio, and evidence of carpal instability. The lateral radiograph is most useful for measurements of carpal instability, including the scapholunate, capitolunate, and lunotriquetral angles.

It is important that the posteroanterior and lateral radiographs are made with the forearm in neutral rotation, as changes in forearm rotation can influence the measurement of various radiographic indices. For example, pronation increases ulnar variance and supination decreases it[44]. On the posteroanterior radiograph, neutral rotation can be confirmed by visualizing the groove of the extensor carpi ulnaris tendon adjacent to the ulnar styloid. On the lateral radiograph, the anterior surface of the pisiform should project midway between the anterior aspect of the capitate head and the distal pole of the scaphoid.

Special Views

In addition to the standard views described above, there are special plain radiographic views that can provide additional diagnostic information. The decision to obtain additional views is based on the suspected diagnosis.

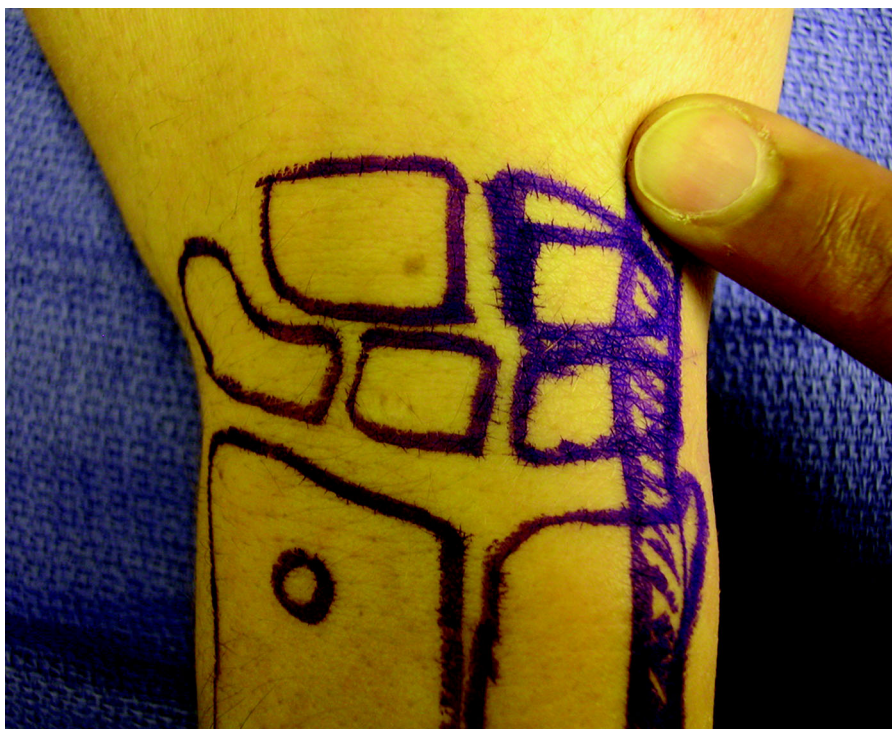Comparison of standard posteroanterior, ulnar deviation posteroanterior,

Fig. 4

Surface anatomy of the ulnar side of the wrist. The extensor carpi ulnaris tendon insertion, the lunate, and the triquetrum are shown. Note that the extensor carpi ulnaris insertion is well away from the radiocarpal and midcarpal joints. The lunotriquetral interval is one fingerbreadth distal to the distal radioulnar joint.

Fig. 5

The triangular fibrocartilage complex is best palpated midway between the extensor carpi ulnaris and the flexor carpi ulnaris in the soft recess just distal to the ulnar styloid.

Fig. 6
The Kleinman "shear" test. One of the examiner's hands holds the radial side stable while a volar-to-dorsal force is applied across the pisiform with the thumb of the examiner's other hand.

Fig. 7
The ulnocarpal impaction maneuver. The examiner moves the ulnarly deviated wrist in a volar-to-dorsal direction while applying an axial load across the ulnar side of the wrist.

and radial deviation posteroanterior radiographs may provide indications of abnormal radiocarpal or midcarpal motion. An ulnar deviation posteroanterior radiograph, commonly used to show an elongated view of the scaphoid, may also reveal lunotriquetral instability or evidence of ulnocarpal abutment, especially when it is compared with a standard posteroanterior radiograph. If ulnocarpal abutment is suspected, it is often useful to make a posteroanterior radiograph with the forearm in pronation and the fist clenched, which increases ulnar variance. Other stress radiographs, such as those made with dorsal or volar stress on the distal part of the ulna of patients with suspected instability of the distal radioulnar joint, may also assist in confirming the diagnosis.

The scaphoid tubercle, the pisiform, and the hook of the hamate are often difficult to visualize on standard radiographs. A 30° supinated oblique radiograph is useful to visualize these structures, especially the pisotriquetral joint and the hamate. A carpal tunnel radiograph is also useful. However, it is often difficult to make a proper carpal tunnel radiograph of a patient with an acute wrist injury, as it requires positioning the wrist in full extension.

Computed Tomography
Computed tomography scans provide better osseous detail than do plain radiographs. They are very useful in the evaluation of suspected fractures of bones that are difficult to visualize on plain radiographs, such as the hamate hook (Fig. 8). Computed tomography scanning is a very effective modality for the evaluation of a healing fracture (Fig. 8). In addition to providing thin-slice axial views of the bones, computer reconstruction can provide images in any desired plane or can generate three-dimensional images if needed (Fig. 8).

Computed tomography is the imaging modality of choice for the evaluation of subluxation of the distal radioulnar joint. The congruity of the distal radioulnar articular surfaces can also be evaluated accurately. In a study of computed tomography criteria for the determination of subluxation of the

distal radioulnar joint, Wechsler et al. emphasized the need to obtain simultaneous views of both extremities with the forearms in neutral rotation, full supination, and full pronation[45].

Arthrography

In the past, arthrography had been the favored imaging modality for the evaluation of ruptures of the interosseous ligaments and tears of the triangular fibrocartilage complex. Triple-injection arthrography had been considered the "gold" standard for detecting perforations of the triangular fibrocartilage complex. However, several authors have maintained that arthrography of the wrist is much less accurate than arthroscopy and that it has a relatively high rate of false-negative findings[20,46]. Others have pointed out the poor correlation between arthrographic findings and symptoms reported by patients[47-49]. Zanetti et al. suggested that this poor correlation is due to a dependence on the detection of communicating defects of the triangular fibrocartilage complex[50]. Those authors suggested that careful attention to detail allows detection of noncommunicating defects of the triangular fibrocartilage complex, which have a more reliable association with symptomatic ulnar-sided lesions of the triangular fibrocartilage complex[50].

Over the past several years, arthrography has been largely supplanted by magnetic resonance imaging for the evaluation of lesions of the triangular fibrocartilage complex. However, arthrography continues to be used to evaluate the integrity of the scapholunate and lunotriquetral interosseous ligaments (Fig. 9). The value of arthrography may be increased by the simultaneous use of real-time fluoroscopic imaging.

Fluoroscopy

Abnormal motion of the carpal bones can be most accurately demonstrated with real-time fluoroscopic imaging. In particular, in patients who demonstrate a sudden shift or clunk with wrist deviation, the site of the pathologic entity can often be identified fluoroscopically. When a patient has an injury of the lunotriquetral interosseous ligament, fluoroscopy may demonstrate the so-called catch-up of the triquetrum moving into extension as the wrist moves from radial to ulnar deviation[19]. Fluoroscopy is similarly useful for demonstrating dynamic instabilities in patients with instability of the scapholunate, midcarpal, or distal radioulnar joint.

Radionuclide Imaging

Radionuclide imaging, or bone-scanning, provides excellent sensitivity for the detection of occult or nondisplaced fractures. A single-phase scan is sufficient for the detection of fractures if additional information, such as the status of osseous blood flow, is not required. Bone scans are very sensitive to the locations of pathologic lesions of bone, but they often do not provide a definite diagnosis. The modality is a useful, relatively low-cost screening tool for the evaluation of occult fractures, osteonecrosis, and osteomyelitis. The relative value of bone-scanning compared with computed tomography for the evaluation of occult fractures on the ulnar side of the wrist has not been determined, and some have suggested that magnetic resonance imaging is as useful as bone-scanning for detecting an occult lesion[51]. If such a lesion is found, a subsequent computed tomography scan is the most accurate modality for evaluating the osseous details of the fracture,

Fig. 8

A, Posteroanterior radiograph of a wrist with a fracture of the hamate hook (arrow). The fracture is difficult to visualize because the hamate hook overlaps the fourth and fifth carpometacarpal joints on this view. B, Computed tomography image of the same wrist. The axial view clearly demonstrates the fracture of the hamate hook (arrow). C, Computed tomography image demonstrating a healed fracture of the base of the hamate hook (arrow). D, Three-dimensional reconstruction performed from computed tomography data demonstrating a nonunion of the hamate hook (thick black arrow) and also demonstrating the pisotriquetral joint (thin white arrow).

if that information is needed. Radio-nuclide imaging may also be useful for the evaluation of complex regional pain syndromes.

Magnetic Resonance Imaging

Magnetic resonance imaging is the procedure of choice for the assessment of a wide range of soft-tissue lesions, including ligament and cartilage lesions, soft-tissue tumors, tendinitis, and joint effusions. While computed tomography provides superior osseous detail, magnetic resonance imaging may have greater sensitivity for the detection of subtle changes such as bone edema and is therefore particularly useful for the evaluation of occult fractures and stress fractures. Magnetic resonance imaging clearly provides a great deal more anatomic detail than does arthrography alone. Magnetic resonance imaging with use of a dedicated wrist coil and combined with arthrography may supplant magnetic resonance imaging alone for the diagnosis of intercarpal and triangular fibrocartilage complex abnormalities. Recently, techniques combining magnetic resonance imaging with single-injection gadolinium arthrography have been developed (Figs. 10-A and 10-B), but their use has not been thoroughly studied. After injection of gadolinium into the radiocarpal or the midcarpal joint, contrast medium leaking into the distal radioulnar joint or into the radiocarpal joint can be indicative of a tear of the triangular fibrocartilage complex or an injury of the intercarpal ligament. Magnetic resonance imaging can also provide information concerning the vascular status of the lunate and the ulnar head, which is valuable in the diagnosis of ulnocarpal abutment[21].

Magnetic resonance imaging has become widely used for the evaluation of tears of the triangular fibrocartilage complex. Early studies demonstrated that magnetic resonance imaging had poor accuracy for predicting the location of such tears seen at arthroscopy[52,53]. In one recent study, magnetic resonance imaging had an accuracy of 92% for predicting tears of the triangular fibrocartilage complex[54]; however,

Fig. 9

An arthrogram of the midcarpal and distal radioulnar joints, demonstrating a perforation through the lunotriquetral ligament (small arrow) as well as the triangular fibrocartilage complex (large arrow). (Reprinted with permission of A.Y. Shin, owner of copyright.)

other authors have suggested that this level of accuracy may be somewhat lower in most clinical settings and is highly dependent on the experience of the individual interpreting the magnetic resonance imaging scans[55]. Magnetic resonance imaging has not yet proven reliable for the detection of tears of the lunotriquetral ligament[19,56].

Wrist Arthroscopy

Arthroscopy can serve as an important tool in the diagnosis and treatment of ulnar-sided wrist pain. Although diagnostic modalities such as magnetic resonance imaging and arthrography are helpful, arthroscopy is considered the gold standard for diagnosing and staging of intra-articular lesions. Tears of the scapholunate and lunotriquetral ligaments can be graded by visualizing them through both the radiocarpal and

the midcarpal portal. Partial tears can be appropriately débrided, and complete tears can be prepared for reconstruction. Central tears of the triangular fibrocartilage complex can be débrided arthroscopically, and peripheral tears can be repaired with arthroscopic assistance. Isolated areas of arthritis are often difficult to diagnose with other modalities. Arthroscopy allows the staging of degenerative or posttraumatic arthritis and can help the surgeon to determine which reconstructive procedures or limited fusions are appropriate. Arthroscopy of the distal radioulnar joint allows staging of arthritis of that joint. Furthermore, loose bodies and cartilage flaps that are difficult to visualize with other modalities can be seen and removed. Finally, normal arthroscopic findings allow the examiner to exclude intercarpal ligament, triangular

Fig. 10-A

Magnetic resonance arthrogram (T1-weighted fat-suppression image made after injection of gadolinium into the distal radioulnar joint) demonstrating a tear of the triangular fibrocartilage complex near its radial insertion (arrow).

fibrocartilage complex, and articular lesions as sources of pain and should lead him or her to look for pathologic changes elsewhere.

Treatment

Triangular Fibrocartilage Complex and Distal Radioulnar Joint

Palmer classified lesions of the triangular fibrocartilage complex as either traumatic (Type 1) or atraumatic (Type 2) (Fig. 11)[57]. Division of each group into subtypes, with Type-1 lesions classified on the basis of the structure that is disrupted and Type-2 lesions classified on the basis of the extent of the degenerative process, can direct treatment. Definitive treatment of traumatic or degenerative lesions of the triangular fibrocartilage complex remains controversial. Although there are exceptions, in general Type-1 lesions are treated either with immobilization or surgical repair, whereas Type-2 lesions can be treated either with a splint, anti-inflammatory drugs, or cortisone injection or with arthroscopic débridement

or ulnar shortening osteotomy.

Chronic radial or ulnar-sided detachment of the triangular fibrocartilage complex can lead to symptomatic instability (clunking on forearm rotation) or pain in the distal radioulnar joint secondary to degeneration of the articular cartilage of the sigmoid notch

Fig. 10-B

Photograph made during wrist arthroscopy, demonstrating a tear of the triangular fibrocartilage complex near its radial attachment (arrow). The lesion corresponds to the tear identified on the magnetic resonance image.
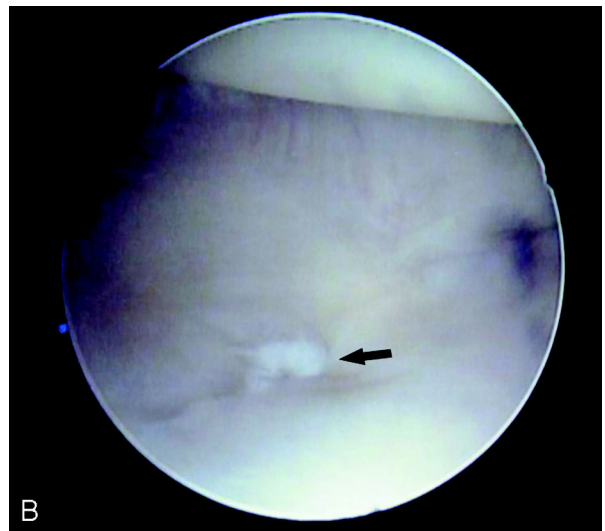

and the ulnar seat. Previous injury to the distal part of the radius (intra-articular fracture of the sigmoid notch) or to the ulnar seat can likewise lead to cartilage degeneration and symptomatic arthritis. Patients experience pain with forearm rotation and tenderness on palpation of the distal radioulnar joint. Surgical treatment should attempt to address both the arthritis of the distal radioulnar joint and the distal ulnar instability.

Lunotriquetral Instability

Several factors should be considered when choosing the optimal treatment for lunotriquetral injuries[19]. These include the amount of instability (static or dynamic), the elapsed time between the injury and treatment (acute or chronic), and the presence of associated injury or degenerative changes. Pain associated with lunotriquetral tears may be due to dynamic instability and/or local synovitis. The initial management of almost all acute and chronic tears without a dissociation or volar intercalated segmental instability should probably be conservative, with cast or splint immobilization. Careful cast-molding with a pad underneath the pisiform maintains optimal alignment as healing progresses. Midcarpal corticosteroid injections can be helpful to decrease synovitis. Operative treatment is indicated for acute and chronic dissociations that demonstrate a volar inter-

calated segmental collapse and chronic tears that are unresponsive to conservative management. The goal of surgical intervention is realignment of the lunocapitate axis and reestablishment of the rotational integrity of the proximal carpal row. A variety of procedures have been described, including lunotriquetral arthrodesis, ligament repair, and ligament reconstruction. If concomitant ulnar negative or positive variance or midcarpal or radiocarpal arthrosis is present, additional procedures such as ulnar lengthening or shortening, midcarpal arthrodesis, or proximal row carpectomy may be indicated. Total

wrist arthrodesis may be indicated when degenerative changes make other salvage procedures impossible.

Repair of the lunotriquetral ligament has been described by several authors[58,59]. The lunotriquetral interosseous ligament is reattached to the site of its avulsion, which is generally the triquetrum. As the strong volar ligament is also disrupted, a combined dorsal and volar approach as well as augmentation of the repair by plication of the dorsal radiotriquetral and dorsal scaphotriquetral ligaments may be of some value. Protracted immobilization is then necessary.

Patients who engage in strenuous

pursuits or have chronic instability or a poor-quality lunotriquetral ligament may be best managed with ligament reconstruction rather than repair. Ligament reconstruction with a distally based strip of extensor carpi ulnaris tendon graft is one option. Unlike reconstruction of the scapholunate ligament, this technique, although demanding, has yielded uniformly good results in two studies[58,59]. Unlike lunotriquetral arthrodesis, reconstruction preserves lunotriquetral motion and provides the optimal chance for restoration of normal carpal interactions.
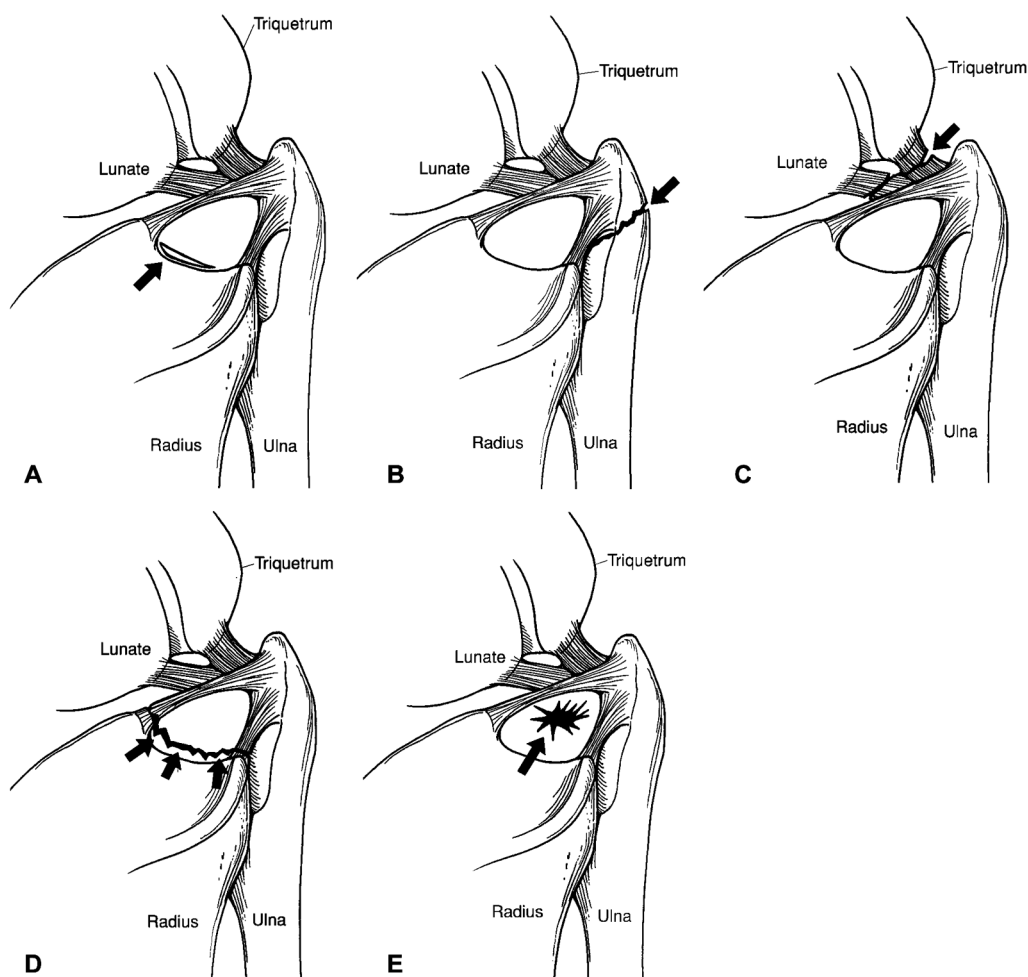
The observation of asymptomatic

Fig. 11

Diagrammatic representation of the different types of injuries of the triangular fibrocartilage complex as described by Palmer[57]. *A,* Type 1A, a central traumatic tear, usually in the sagittal plane, 1 to 2 mm from the articular surface of the radius. *B,* Type 1B, a medial avulsion that may or may not be associated with an ulnar styloid fracture. *C,* Type 1C, distal avulsions involving disruption of the ulnocarpal ligaments. *D,* Type 1D, lateral avulsions involving disruption of the radioulnar ligament and the articular disk attachments to the radius. This injury may or may not be associated with a fracture of the sigmoid notch. *E,* Type 2, degenerative perforations occurring centrally. (Reprinted, with permission, from: Chidgey LK. The distal radioulnar joint: problems and solutions. J Am Acad Orthop Surg. 1995;3:95-109.)

congenital lunotriquetral coalitions and the relatively little relative motion that normally occurs between the lunate and triquetrum led to the concept of lunotriquetral arthrodesis. It may be technically less demanding than ligament reconstruction or repair, and it has become the technique of choice of many surgeons. However, the method is not without substantial problems. The reported nonunion rate has ranged from 0% to 57%[19]. Use of Kirschner wires has been shown to result in an unacceptably high nonunion rate of 47%[19,59]. Use of compression screws may improve results, but nonunion remains a major problem. A 9% nonunion rate has been reported with the Herbert screw, and the use of conventional cortical screws may be associated with nonunion rates as high as 57%[19,59]. Ulnocarpal impingement required additional surgery in 23% (five) of twenty-two patients treated with lunotriquetral arthrodesis in one series[59]. This complication was not seen with lunotriquetral repair or reconstruction. A comparison of the results following arthrodesis, ligament repair, and reconstruction at the Mayo Clinic demonstrated that repair and reconstruction were superior to arthrodesis[59]. The lower complication rates, higher patient satisfaction, greater range of motion, and fewer subsequent reoperations led the Mayo Clinic group to prefer repair or reconstruction of the lunotriquetral ligament as their primary method of treatment for lunotriquetral injuries that require surgical intervention (Fig. 12).

Tendinopathies

Tendinopathies of the wrist are relatively common causes of ulnar-sided wrist pain. On the dorsal side of the wrist, the extensor carpi ulnaris and, less commonly, the extensor digiti minimi may be involved; on the flexor surface, the flexor carpi ulnaris and/or the pisiform may be involved.

An understanding of the anatomy of the extensor carpi ulnaris and its surrounding structures is essential for the diagnosis and management of extensor carpi ulnaris tendinitis[60]. The extensor carpi ulnaris tendon sits in a groove, or sulcus, at the distal part of the ulna. It is maintained within this groove during forearm rotation by the extensor retinaculum and a subsheath, which forms a fibro-osseous tunnel. The linea jugata connects the subsheath to the epimysium and prevents subluxation of the extensor carpi ulnaris in a palmar direction during full supination. Normally, the extensor carpi ulnaris tendon sits in the ulnar sulcus and helps to stabilize the distal radioulnar joint as the forearm moves from pronation to supination. If the extensor carpi ulnaris displaces in a volar direction during supination, it may cause the tendon to move out of the sulcus, often resulting in a painful snapping sensation and inflammation. The depth of the ulnar sulcus varies, and subluxation is more likely to occur if it is shallow. In the case of a traumatic dorsal subluxation or dislocation of the ulnar head, the extensor carpi ulnaris may be forcibly displaced volarly and there is often disruption of the triangular fibrocartilage complex. In addition, the extensor carpi ulnaris subsheath may rupture, with or without disruption of the extensor retinaculum. This may happen with forceful radial deviation with flexion of the wrist, which is seen in patients participating in activities such as baseball and rodeo. In pa-
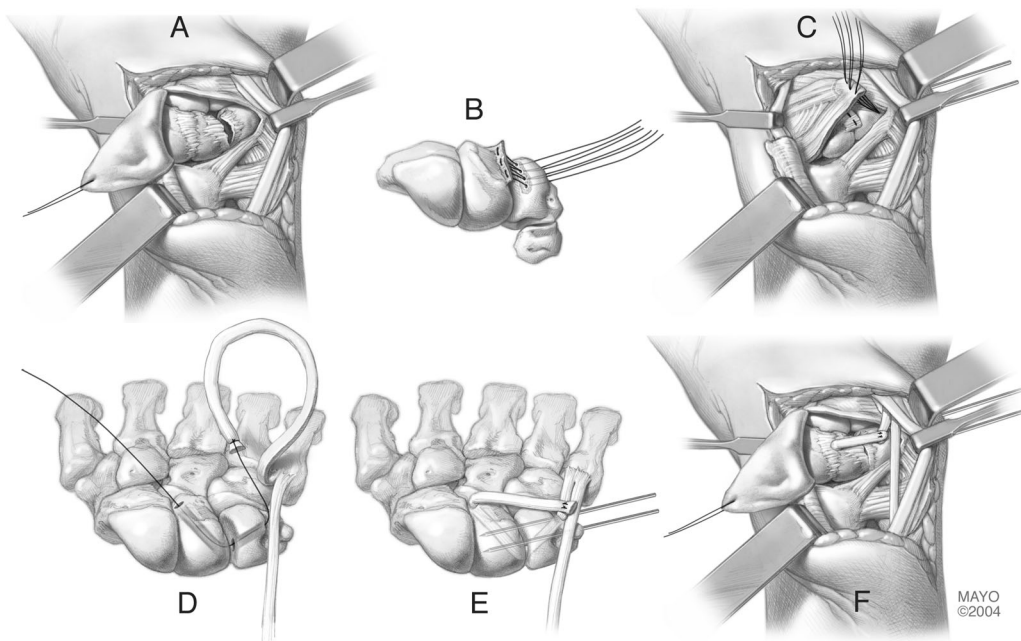

Fig. 12

On the basis of the lower complication rate, improved survivorship, and higher patient satisfaction, repair of an avulsed lunotriquetral ligament (if possible) (*A, B,* and *C*) or reconstruction with a distally based strip of extensor carpi ulnaris tendon (*D, E,* and *F*) is preferred over arthrodesis. The techniques used in repair and reconstruction of the lunotriquetral ligament are illustrated. (Reprinted with permission of the Mayo Foundation.)
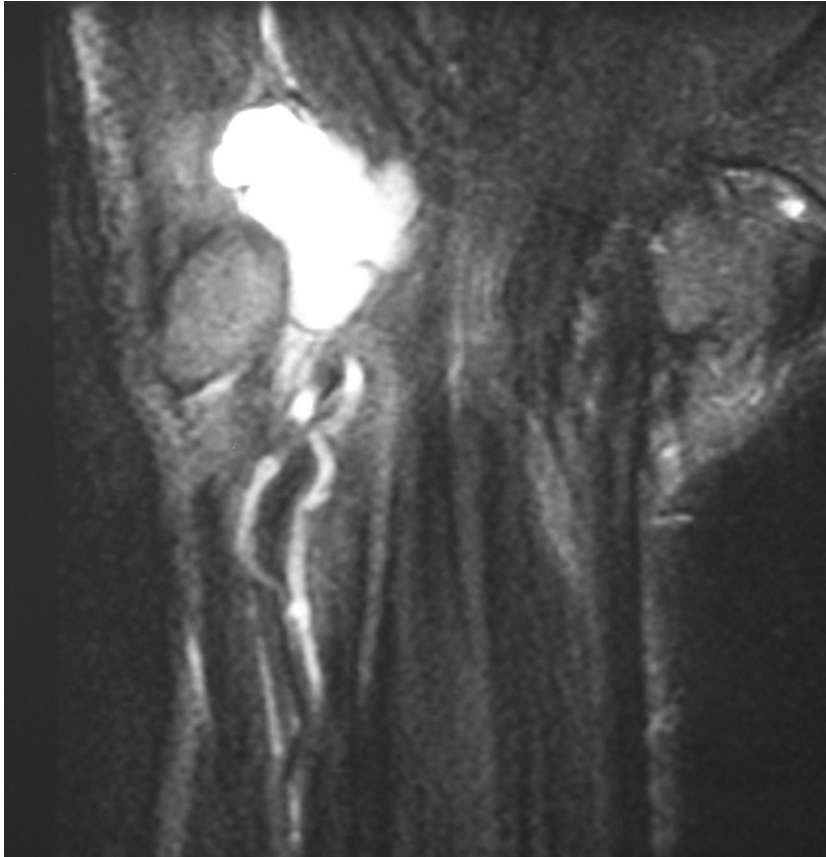
Fig. 13

A magnetic resonance image of the wrist demonstrates a ganglion in Guyon's space with compression of the ulnar nerve at the level of the wrist. (Reprinted with permission of A.Y. Shin, owner of copyright.)

tients with inflammatory disorders such as rheumatoid arthritis, attritional wear of the supporting structures may lead to subluxation of the extensor carpi ulnaris and extensor digiti minimi without a specific traumatic event.

Patients with extensor carpi ulnaris tendinitis due to subluxation may present with a painful snap or click during forearm rotation[18,28-30]. Often, there is tendinitis without detectable instability. In such cases, there may be tenderness at the distal part of the ulna, over the fifth (extensor digiti minimi) or sixth (extensor carpi ulnaris) dorsal compartment. Extensor digiti minimi tendinitis presents with pain or tenderness over the fifth dorsal compartment of the wrist. Less commonly, there is inflammation at the insertion of the extensor carpi ulnaris, which presents with pain and inflammation at the dorsal base of the fifth metacarpal.

Acute treatment of a traumatic injury involving the extensor carpi ulnaris tendon includes reduction of a distal radioulnar joint dislocation, if present, followed by immobilization of the wrist and forearm, rest, application of ice, and use of nonsteroidal anti-inflammatory medications. The forearm is usually immobilized in the neutral position, although it is sometimes necessary to immobilize it in supination to maintain reduction of the distal radioulnar joint after a dorsal dislocation. Subsequently, the distal radioulnar joint is stabilized by repair of the triangular fibrocartilage complex. The extensor carpi ulnaris tendon is stabilized by reconstruction of the extensor carpi ulnaris subsheath, with use of a flap of extensor retinaculum passed around the tendon as described by Spinner and Kaplan[60]. This procedure allows the extensor carpi ulnaris tendon to remain

within the ulnar sulcus during forearm and wrist rotation.

In patients with subluxation of the extensor carpi ulnaris due to inflammatory arthritis, dorsal subluxation of the ulnar head often must be addressed in addition to reconstruction of the extensor carpi ulnaris subsheath. Numerous procedures have been described for this purpose, and the choice of procedure is determined by the clinical presentation and the surgeon's preference.

In the case of nontraumatic tendinitis of the extensor carpi ulnaris or extensor digiti minimi tendon, the mainstay of treatment is rest, brief periods of immobilization, nonsteroidal anti-inflammatory drugs, and judicious use of corticosteroid injections. Surgery is rare and is reserved for chronic, recalcitrant cases. Insertional tendinitis of the extensor carpi ulnaris is treated with transfer of the extensor carpi ulnaris to the dorsum of the hamate. Tendovaginitis within the extensor sheath is treated with release of the extensor carpi ulnaris subsheath and reconstruction, as described above. If the extensor digiti minimi is involved, simple release of the fifth dorsal compartment has excellent results.

Treatment of tendinitis of the flexor carpi ulnaris similarly requires an understanding of the local anatomic structures[31,32]. The ulnar neurovascular bundle lies on the radial side of the flexor carpi ulnaris tendon just proximal to the wrist joint. It passes radial to the pisiform at Guyon's canal. The flexor carpi ulnaris is a large muscle and the most powerful wrist motor. It does not have a synovial sheath. It inserts into the proximal and anterior aspect of the pisiform, a sesamoid bone located within the flexor carpi ulnaris tendon that has a single articular surface, which articulates with the volar surface of the triquetrum. As there is no inherent stability of the pisotriquetral joint, stability depends on the pisohamate and pisometacarpal ligaments, which attach to the pisiform like spokes on a wheel[61]. Flexor carpi ulnaris tendinitis has an insidious onset. Patients present with aching pain on the ulnar flexor side of the wrist. The symptoms may be related to
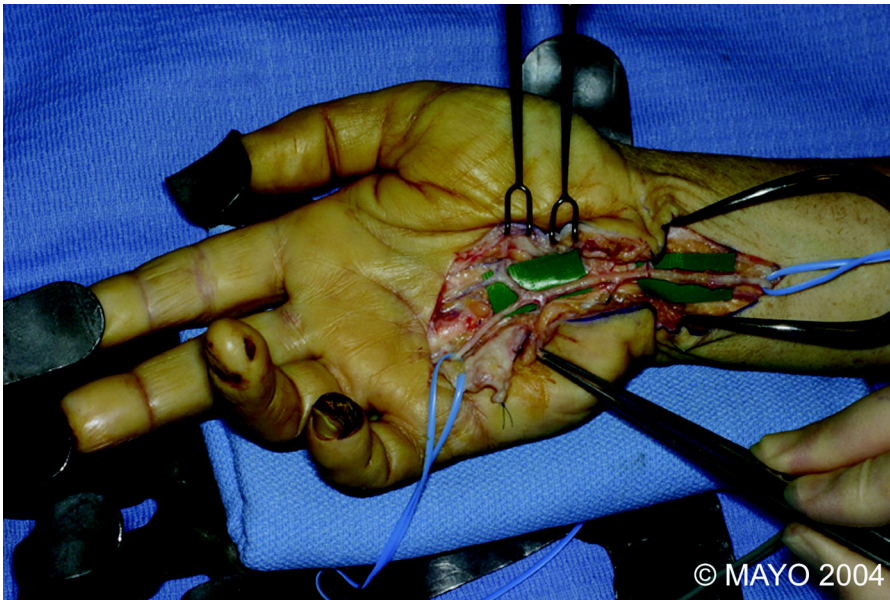
Fig. 14

An operative view of the thrombosed ulnar artery secondary to chronic trauma in the hypothenar area, also known as hypothenar hammer syndrome. The ulnar artery in this area is damaged by chronic trauma and can often present as a vague ulnar-sided wrist pain associated with ulnar digit ischemia. (Reprinted with permission of the Mayo Foundation.)

repetitive or overuse activities. There is tenderness near the insertion of the flexor carpi ulnaris on the pisiform and pain on resisted wrist flexion and ulnar deviation. Patients may present with associated ulnar nerve symptoms.

Pisotriquetral arthritis and, less commonly, pisotriquetral instability are causes of ulnar-sided wrist pain that may be misdiagnosed as flexor carpi ulnaris tendinitis. Pisotriquetral arthritis is associated with local pain and tenderness, which are exacerbated by grinding of the pisiform dorsally against the triquetrum. Instability may be subtle and more difficult to diagnose. A diagnostic injection of local anesthetic in combination with appropriate radiographic imaging will confirm both diagnoses.

Flexor carpi ulnaris tendinitis is most commonly treated nonoperatively[31,32]. As is the case for other soft-tissue conditions, it usually can be treated with rest, immobilization, nonsteroidal anti-inflammatory drugs, and, rarely, corticosteroid injection. Surgical treatment is rare and, if it is undertaken, the ulnar neurovascular bundle must be identified and protected. Flexor carpi ulnaris tendinitis that does not respond to nonoperative treatment may be relieved by z-plasty lengthening of the tendon proximal to its insertion on the pisiform. If the pathologic process primarily involves the pisiform, excision of the pisiform is the most commonly used surgical procedure.

Unusual Causes

Unusual causes of ulnar-sided wrist pain include those of neurogenic origin, vascular origin, and atypical fractures.

Ulnar nerve compression at Guyon's canal typically presents with fatigue, weakness, and the feeling of loss of coordination with fine motor activities[62]. Patients may have decreased sensation in the ring and small fingers but not on the dorsum of the hand since the dorsal sensory nerve branch originates more proximally. The diagnosis is made with nerve conduction studies and electromyography. Compression of the ulnar nerve in Guyon's canal may result from a mass effect, thrombosis of the ulnar artery, or a fracture of the hook of the hamate. Magnetic resonance imaging should be considered to determine if any of these factors, which can be treated with surgical decompression, are contributing to the ulnar nerve compression (Fig. 13).

Thrombosis of the ulnar artery (Fig. 14) otherwise known as hypothenar hammer syndrome, typically results from repetitive force against the ulnar artery as is seen in plumbers or other workers who use high-impact equipment[35]. More unusual causes include systemic conditions or a more proximal vascular event. Patients present with pain associated with cold exposure, splinter hemorrhages, and decreased turgor in the ulnar digits. The diagnosis is suspected on the basis of abnormal results of the Allen test and can be confirmed with Doppler studies. Surgical planning requires an arteriogram. Surgical treatment consists of either resection alone or resection combined with vascular reconstruction.

Conclusion

Although ulnar-sided wrist pain can be intimidating and confusing, it can be broken down into the fundamental elements and evaluated in a systematic fashion. A probable diagnosis can be made on the basis of a detailed history and a clinical examination of all of the entities that can cause ulnar-sided wrist pain. The diagnosis is then confirmed by appropriately selected radiographic studies. Anesthetic injections (with corticosteroids) can be utilized as a diagnostic tool as well as a therapeutic measure. Once the diagnosis is made, treatment (both conservative and operative) should be directed at restoring normal anatomy whenever possible.

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