Wrist Ligaments and Instability

The Wrist
The wrist or carpus provides a stable support for the hand, allowing for the transmission of grip forces as well as positioning of the hand and digits for fine movements. The main function of the wrist is to fine tune grasp by controlling the length-tension relationship in the extrinsic muscles to the hand.

Wrist Stability
Traditionally, the carpal bones are described as being arranged in two anatomic rows. The proximal carpal row consists of the scaphoid, lunate, and triquetrum, and the distal row is formed by the trapezium, trapezoid, capitate, and hamate. The pisiform lies within the flexor carpi ulnaris tendon and, through its articulation with the trapezium, functions as a sesamoid; therefore, it is not included as a functional member of the proximal carpal row. The scaphoid links the proximal and distal rows. Both rows move with respect to each other in the midcarpal joint, and the proximal row moves on the radius in the radiocarpal joint.

The carpus may also be considered in terms of three functional columns. The central or flexion-extension column is formed by the distal carpal row and the lunate. This column functions as a longitudinal link between the radius and metacarpals and its integrity depends on the carpal ligaments because the muscles that produce wrist motion attach distal to the central column. The lateral or mobile column is the scaphoid. The medial or rotational column is the triquetrum.

The arrangement of the carpal bones and their ligaments is crucial to wrist stability. The two carpal rows articulate to form the midcarpal joint, which consists of three different types of articular surfaces. On the radial side, the trapezium and trapezoid are concave with their articulations to the distal scaphoid and lateral capitate. The head of the capitate in the center of the midcarpal joint is convex. The ulnar-sided hamate-triquetral articulation is helicoid in nature.

The proximal carpal row has a single biconvex joint surface that articulates with a shallower, concave distal radius with two facets and a triangular fibrocartilage complex.
The radiocarpal joint, therefore, appears relatively incongruent. The distal radius has an average of 14 degree of palmar tilt, and 22 of radial inclination. This structure probably contributes to the limitation of motion such that flexion is greater than extension and ulnar deviation greater than radial deviation. The radial articular surface of the wrist affords no real bony stability; stability is provided primarily by the soft-tissue envelope of the wrist.

**Wrist Ligaments**

Ligaments are the primary stabilizers of the wrist. They usually are classified into palmar (volar) and dorsal ligaments as well as extrinsic and intrinsic ligaments.

**Volar Ligaments**

Ligaments of wrist are most highly developed on palmar side of wrist; palmar wrist ligaments originate laterally from radial styloid, & are directed in a distal ulnar direction. The palmar ligaments, which are more numerous and substantial than the dorsal ligaments and are considered the principle stabilizers of the wrist, function principally to resist hyperextension forces.

They can be divided into two major groups:
1. Extrinsic ligaments, which connect the carpus and radius or metacarpals, and
2. Intrinsic ligaments, which originate and insert entirely on the carpal bones.

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<th>Volar wrist ligaments</th>
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<td>• Extrinsic</td>
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<td>1. Carpus to radius</td>
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<tr>
<td>2. Carpus to metacarpus</td>
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<tr>
<td>• Intrinsic</td>
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<td>1. Intercarpal</td>
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The majority of the extrinsic ligaments, which arise from the radius and ulna and attach to the carpus, insert on the proximal carpal row.

The important **extrinsic ligaments** are:
1. the radioscapohapatate,
   - *radioscaphoid* inserts onto the tuberosity of scaphoid & is radial expansion of radiocapitate ligament;
   - The *radiocapitate* runs from volar aspect of radial styloid process, runs across the scaphoid, and inserts into the capitate. It courses over palmar concavity of scaphoid proximal to tuberosity before inserting on palmar aspect of the keel and neck of the capitate. It forms a fulcrum over which the scaphoid rotates. The radiocapitate ligament is the primary stabilizer of capitolunate joint, and is the primary stabilizer of the distal carpal row on proximal carpal row;
2. radiolunotriquetreal,
   - radiolunate ligament (RLL) goes on to pass from lunate to triquetrum as lunotriquetral ligament;
3. Radioscapholunate: (ligament of Testut and Kuenz)
   • The radioscapholunate ligament is relatively thin and offers little stability, but contains blood vessels.
   • Originates from palmar aspect of ridge between scaphoid & lunate fossae & inserts into scapholunate interosseous ligament.
   • It acts as neurovascular supply to scapholunate interosseous membrane and is not a true extrinsic ligament of wrist.\(^1\)

4. Ulnolunate.
   • Ulnolunate is a key ligament along with the TFC. On occasion, it may avulse from its insertion on the lunate, and this injury will allow dye extension both into the distal radioulnar joint and into the mid-carpal joint.

5. Ulnotriquetral

The palmar and dorsal radiocarpal ligaments are obliquely oriented to resist the tendency of the proximal carpal row to slide down the palmar and ulnar inclined surface of the distal radius.

The intrinsic ligaments

The intrinsic ligaments of the wrist originate and insert on the carpal bones. Intrinsic ligaments arise on palmar facet of radial styloid passing on to capitate. Volar part of capsule of wrist has area of weakness, called space of Poirier. It lies between main ligamentous structures that are attached proximally on lunate & distally on capitate.\(^2\)

These volar ligaments, which are thicker and stronger than the dorsal ligaments, are further divided into short, intermediate, and long ligaments.

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<th>Intrinsic wrist ligaments</th>
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<td>• Short</td>
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\(^1\) The radioscapholunate ligament, between the long and short radiolunate ligaments, emerges through the palmar capsule of the radiocarpal joint. It was found to be a neurovascular structure surrounded by synovial tissue with vascular origins from the anterior interosseous and radial arteries and a neural origin from the anterior interosseous nerve. On entering the radiocarpal joint it attaches proximally to the interfacet prominence on the articular surface of the radius and distally to form the proximal membrane of the scapholunate interosseous ligament system. There is no anatomic evidence that this structure should be considered a ligament in a traditional mechanical sense. However, this structure may be clinically important as the vascular supply of the scapholunate interosseous ligament, as well as a sensory pathway from the scapholunate articulation.

\(^2\) Anatomical defect or weak spot in the floor of the carpal tunnel. It lies at the volar aspect of the proximal capitate, lying between the volar radiocapitate and volar radiotriquetral ligaments. The area expands when wrist is dorsiflexed & disappears in palmar flexion. A rent develops during dorsal dislocations, & it is thru this defect that lunate displaces into the carpal canal. The space of Poirier allows concomitant extension at the midcarpal joint with radiocarpal but also allows escape of distal carpal row from lunate in perilunar dislocations.
1. Trapeziotrapezoidal
2. Trapeziocapitate
3. Capitohamate

- Intermediate
  1. Scaphoid-trapezium
  2. Scaphoid-lunate
  3. Lunate-triquetral

- Long
  1. Deltoid

The short intrinsic ligaments, which include the trapeziotrapezoidal, the trapeziocapitate, and the capitohamate, bind together the four bones of the distal row into a single, functional whole.

The intermediate intrinsic ligaments connect the trapezium to the scaphoid and then to the bones of the proximal carpal row. These include the scaphoidtrapezium, the scaphoid-lunate, and the lunate-triquetral ligaments. The triquetrum is more firmly secured than the scaphoid to the lunate, permitting transmission of a dorsiflexion force from triquetrum to lunate and causing secondary lunate dorsiflexion with ulnar deviation. The scapholunate ligament and the lunotriquetral ligament are important links in the proximal carpal row and provide additional stability to the wrist.

Of the two long intrinsic ligaments the volar (which is more important) has been referred to as the "deltoid," "radiate," "arcuate," and "V" ligament. The volar ligament stabilizes the capitate and may fan out proximally (from the capitate) to the scaphoid, lunate, and triquetrum. Often the central point of this "deltoid" fan ligament is absent, and there are attachments only to the scaphoid and triquetrum, forming an inverted "V" with the distal lunate in the middle of the opening. (See later)

In lower primates the ulna styloid articulates with the triquetrum. In humans a cartilaginous structure, the ulnocarpal meniscus homolog, is interposed between the ulna and triquetrum; there is no direct ligamentous connection between the ulna and the carpus. This cartilage meniscus is separate from the triangular fibrocartilaginous complex (TFCC), although both attach to the dorsoulnar corner of the radius. The TFCC is connected to the carpus by the ulnolunate ligament, which secures the dorsoulnar radius to the volar carpus. The volar and radial corner of the radius is connected to the carpus by the deep (volar) radiocarpal ligaments. Therefore the carpus can be seen as "suspended" from the radius; the head of the ulna is not really part of the wrist joint itself. The ulnar collateral ligament represents a thickening of joint capsule on the ulnar side rather than a true ligament.

The stability provided by the volar intrinsic and extrinsic ligaments may be best described by the double V configuration that they form.
The arcuate ligaments, consisting of:
1. the (radio-)scaphocapitate and
2. (ulno-)triquetrum capitate ligaments,
These converge on the capitate to form the distal V.

The proximal V is formed by
1. the radiolunotriquetral,
2. radioscapoid,
3. ulnolunate, and
4. ulnotriquetral ligaments.

With ulnar deviation, the proximal V changes to an L configuration. The ulnolunate ligament assumes a more transverse orientation to essentially limit lunate displacement, and the radiolunate ligament assumes a more longitudinal configuration to limit lunate extension. The distal V ligamentous configuration similarly assumes an L configuration, but in the opposite direction. The scaphocapitate ligament becomes transverse to limit ulnar translation of the capitate, and the triquetral capitate ligament assumes a longitudinal configuration to prevent capitate flexion. The opposite is felt to occur in radial deviation.

**Dorsal Wrist Ligaments**
- superficial layer;
  - dorsal oblique radiotriquetral ligaments:
  - dorsal transverse intercarpal (trapezoidal-triquetral ligament):
    - this ligament has some fibers which insert on the dorsal ridge of the scaphoid but none that insert on the distal pole of the scaphoid;
    - the major portion of the ligament inserts onto the trapezium;

The dorsal radiocarpal ligament, or radiolunate triquetrum ligament, originates on the dorsal rim of the radius and inserts on the scaphoid, lunate, and triquetrum. Further support is provided by the extensor tendon compartments.
The dorsal intercarpal ligament originates from the triquetrum and inserts dorsally into the scaphoid and trapezium.

- deep layer:
  - scapholunate interosseous ligament;
  - lunotriquetral interosseous ligament;

**Wrist Ligament Injuries**
The apex of carpal rotation in the anteroposterior plane is in the center of the capitate. With progressive extension of the wrist, the volar ligaments become progressively tauter. Extremes of extension and volar flexion of the scaphoid are checked by the radioscaphoid ligament. Movement of the various carpal bones in radial and ulnar deviation is controlled by the complex ligamentous insertions of the volar ligaments.

When the wrist is progressively extended, an interligamentous space develops by the separation of the radiocapitate and volar radiotriquetral ligaments (space of Poirier). This inherently weak volar area is important in the pathogenesis of carpal injuries.

Most of tension injuries to wrist occur with wrist hyperextension. Radiocarpal ligaments will exceed their normal elastic limits with extreme hyperextension. Injuries that result may be characterized as part of spectrum of injuries including scapholunate dissociation and perilunar dislocation. Interosseous ligaments of distal row seldom fail clinically.

Carpal injuries represent a spectrum of bony and ligamentous damage. Each injury is not a separate entity, but part of a continuum. The final injury is determined by

- (1) the type of three-dimensional loading;
- (2) the magnitude and duration of the forces involved;
- (3) the position of the hand at the time of impact; and
- (4) the biomechanical properties of the bones and ligaments.

**Progressive Perilunar Instability**
At impact on the thenar side of the wrist, the wrist is levered progressively into hyperextension, ulnar deviation, and intercarpal supination. The intercarpal injuries begin at the scapholunate joint and proceed around the lunate, progressively creating ligamentous injury and scapholunate, capitolunate, and triquetrolunate instability.

- In stage I perilunar instability (PLI) the primary instability is limited to the scapholunate joint.
- In stage II PLI, ligamentous damage at the capitolunate articulation is added, and in stage III PLI, ligamentous damage at the triquetrolunate joint is added to the preceding damage.
- In stage IV PLI, dorsal disruption of the dorsal radiocarpal ligament (as a result of intercarpal supination) allows the lunate to volarly rotate on its volar radiotriquetral and ulnolunate ligamentous hinge.

In stages I and II PLI, spontaneous reduction of the capitolunate and triquetrolunate joints frequently occurs as the wrist recoils from injury. In this situation, persistent
scapholunate diastasis may be the only manifestation of these more severe injuries. In stage IV PLI (lunate dislocation) the roentgenographic manifestations are more obvious.

**Scapholunate Instability**
Patients frequently complain of persistent pain over the radial aspect of the wrist joint after various hyperextension injuries of this joint. If scapholunate diastasis is present with or without stress roentgenograms then the diagnosis is clear. However, in many cases no appreciable scapholunate diastasis can be clinically documented. This can be explained by two distinct types of incomplete ligamentous injury that occur at this joint. In the first type, limited volar interosseous and radioscaphoid ligament failure occurs. Forced hyperextension can be associated with an intact dorsal interosseous ligament but with volar interosseous ligament disruptions as the scaphoid rotates on the lunate through the dorsal axis of this joint. In the second type of limited scapholunate ligamentous injury, scapholunate interosseous and radioscaphoid ligament elongation occurs without complete ligament failure.

**Carpal Instability Patterns:**

1. **Ulnar translocation:**
   - carpus shifts ulnarward (frequently seen in rheumatoid wrist)
   - most frequent radiocarpal instability;
   - the lunate is translocated ulnarly, and therefore is not supported by the radius;
   - Ulnar translation is also commonly seen in disease such as RA or in Madelung's deformity. In RA, may occur along with caput ulnae syndrome.

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3 Ulnar caput syndrome results from synovitis stretching ulnar carpal ligaments. There is dorsal dislocation of distal ulna, supination of carpus on hand, volar subluxation of the Extensor Carpi Ulnaris (ECU). If left untreated, ulnar translocation may occur.

**Role of ECU tendon:**
- in normal wrist tendon crosses extensor surface of distal ulna;
- in RA wrist tendon lies on volar surface of ulna as distal ulna begins to subluxate on the radius;
- thus tendon behaves as flexor of wrist rather than as extensor;
- resulting muscle imbalance also contributes to radial deviation;
- as tendon slips from its anatomical position, it no longer serves as a stabilizer of distal ulna, which results in even more dislocation.

**Effects on the extensor tendons:**
- volar subluxation of the ECU causes in loss of ulnar deviation and extension and the wrist begins to deviate radially;
- this brings the ulnar-sided extensor tendons directly over the prominent ulna;
- radial deformity of wrist results from volar subluxation of ECU and increases potential for attrition ruptures of extensor tendons (Vaughn-Jackson syndrome);
- further, erosion of the distal ulna causes its edge to sharpen leading to rupture of extensor tendons.

**Effects on MCP joint:**
- as wrist is pulled into radial deviation, fingers become pulled into ulnar deviation;
- dislocation of ulna, together w/ severe erosions on lower end of bone, puts extensor tendons of fingers at considerable risk;
- abnormal translation of lunate in ulnar direction is pathognomonic of ulnar translocation
- Clinical Presentation:
  - Clinically the carpus and hand are offset ulnarward;
- Radiographs:
  - On x-ray, lunate is positioned just distal to the ulna and a large space between the radial styloid and the scaphoid.
  - Two types according to position of scaphoid:
    1. Type I:
      - entire carpus, including scaphoid, is displaced, & distance between radial styloid process & scaphoid is widened;
    2. Type II:
      - distance between scaphoid & radial styloid process, remains normal, but the scapholunate space is widened;

It is important to distinguish between the two types of ulnar translocation since appearance of a wide scapholunate gap may lead to the erroneous diagnosis of scapholunate dissociation

2. Dorsal intercalated segment instability (DISI);
   - present when lunate has rotated into dorsiflexion, as seen on lateral x-rays;
   - capitate displaces dorsal to long axis of radius, producing zigzag radiolunatocapitate alignment that is called DISI;
   - lunate will tend to flex with loss of ulnar ligamentous support from the triquetrum; lunate extends when there is loss of radial ligamentous stability.
   - DISI may arise as a result of:
     a. scaphoid fracture;
     b. scapholunate dissociation;
     c. perilunate dislocation (especially trans-scaphoid perilunate dislocation);
   - end result may be SLAC (Scapholunate Advance Collapse) wrist;
   - Radiographic Analysis:
     - on lateral x-rays, when lunate slips into statically dorsiflexed position > 10 deg, condition is defined as DISI;

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4 Scapholunate advanced collapse (SLAC) refers to a specific pattern of osteoarthritis and subluxation which results from untreated chronic scapholunate dissociation or from chronic scaphoid non-union. Degenerative changes occur most often in areas of abnormal loading. Radial-scaphoid joint is involved initially, followed by degeneration in the unstable lunatocapitate joint, as capitate subluxates dorsally on lunate.
- similarly, when lunate lies palmar to capitate but faces dorsally, collapse pattern is also consistent with dorsiflexion instability;
- DISI deformity is also present when the scapholunate angle is greater than 70 degrees;
- When diagnosing this condition, be sure that the lateral radiograph was taken with proper technique and that the wrist is not dorsiflexed.

3. Volar intercalated segment instability (VISI)
   - characterized by palmar flexion of lunate.
   - by definition, consists of volar flexion of the lunate relative to the longitudinal axis of the radius and capitate, when the wrist rests in a neutral position;
   - lunate will tend to flex when there is loss of ulnar support from the triquetrum;
   - may result from disruption of radial carpal ligaments on ulnar side of wrist & is characterized by scapholunate angle < 30 deg.
   - volar flexion instability pattern is usually associated with triquetrolunate dissociation or triquetral-hamate instability.
   - the dorsal-radial-triquetral and triquetro-scaphoid ligaments have an increase space (increased "V") between them.
   - Two types:
     1. Static VISI:
       - when lunate slips into a statically fixed position > 15 deg of flexion;
     2. Dynamic VISI:
       - the normal wrist may assume a VISI pattern when relaxed, however, this is not considered abnormal unless it is symptomatic;
       - the etiology may be a laxity in the volar capitotriquetral ligament;
       - these patients may note pain on volar stress testing;
       - radiographs may show a widening between the capitate and the triquetrum, when the wrist is placed in radial deviation

4. Non dissociative carpal instability:
   a. capitolunate instability
   b. mid-carpal instability;

   - refers to a proximal row instability which occurs in the absence of instability between the individual proximal carpi; i.e., the scapholunate and lunotriquetral intervals are normal;
   - potential sites of pathology:
     i. capitolunate instability
• palmar subluxation of the capitate on the lunate, which occurs as a consequence of palmar translation of proximal row on the radius;
  ii. STT instability:
    iii. Ulnar mid-carpal instability;
  iv. Distal radial malunion;

- In a majority of patients, there is a painful clunk as the wrist moves from radial to ulnar deviation (causing the lunate to move from a flexed to an extended position).
- Radiographs:
  - palmar translation of the carpi on the radius may often show VISI deformity;
  - less often dorsal translation of the carpi may produce a DISI deformity;
  - arthograms are usually negative;

5. Dissociative instability: refers to instability between individual carpi of the proximal row;
   a. scapholunate instability:
   b. lunotriquetral dissociation:

Scapholunate instability
- most common and most significant ligament injury of wrist;
- risk factors: ulna minus configuration, slope of radial articular surface, and lunotriquetral coalition;
- **Spectrum of injury:** (increasing severity)
  i. dynamic scapholunate instability
    • no radiographic evidence of malalignment is present (i.e. dynamic deformity);
    • diagnosis is established by dorsal S-L tenderness and positive shift test;
  ii. rotatory subluxation of scaphoid:
  iii. scapholunate dissociation (SLD):
    • scapholunate ligament tear may lead to rotational dislocation of scaphoid allowing proximal pole to displace posteriorly & distal pole to displace anteriorly;
    • scaphoid inherently tends to palmar flex because of its oblique position and the loading applied thru (STT) joint;
    • because scaphoid lacks a proximal ligament, it will rotate around radiocapitate ligament leading to dorsal rotary subluxation of the proximal pole;
  iv. dorsal intercalated segment instability: (DISI)
  v. scapholunate advanced collapse:

- **Mechanism of injury:**
  • mechanism is similar to that of scaphoid fracture with stress loading of extended carpus, except it is usually in ulnar rather than radial deviation;
• with a severe hyperextension injury of the wrist, there is tear of scapholunate interosseous ligament;
• further loading causes tear of (in succession):
  1. radiocapitate ligaments;
  2. radiotriquetral ligaments;
  3. dorsal radiocarpal ligaments;
  4. lunate follows triquetrum into extension, & DISI deformity results;

- **ligamentous constraints:**
  • three main ligamentous structures which bind the scaphoid to lunate:
    a. volar radioscapopholunate ligament (largest);
    b. scapholunate interosseous ligament (consists of dorsal, proximal, and palmar portions);
    c. radiocapitolunate ligament;

- **associated injuries:**
  • simultaneous radial styloid fracture is relatively common with carpal dislocation;
  • always consider non-displaced scaphoid fracture

**Lunotriquetral Dissociation**
- ulnar side carpal instability;
- involves disruption of lunotriquetral & volar radioulnotriquetral ligaments & attenuation or rupture of dorsal radiotriquetral attachments;
- with a isolated tear of the LT interosseous ligament, there will be only a small amount of increased motion, however, even this is enough to cause symptoms;
- **mechanism:**
  • injury occurs with forced extension or extension-radial deviation, as scaphoid induces the lunate into a further flexion stance while triquetrum extends;
  • with advanced injury, lunotriquetral, volar radioulnotriquetral, & dorsal radiotriquetral ligaments are torn; VISI collapse deformity develops.