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Carpal ligament injuries, pathomechanics, and classification

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SYNOPSIS

Carpal instability is a complex array of maladaptive and post-traumatic conditions that leads to the inability of the wrist to maintain anatomic relationships under normal loads. Many different classification schemes have evolved to explain the mechanistic evolution and pathophysiology of carpal instability, including two of the most common malalignment patterns of volar intercalated segment instability (VISI) and the more common dorsal intercalated segment instability (DISI). Recent classifications emphasize the relationships within and between the rows of carpal bones. Future research will likely unify the disparate paradigms used to describe wrist instability.

Keywords

Carpal ligament injuries; carpal instability; perilunate instability; pathomechanics; classification

INTRODUCTION

Carpal instability exists when the wrist is unable to maintain its normal alignment as it moves through its motion arc under physiologic loads. While the majority of carpal instabilities are traumatic in nature, any condition that alters the relationship between the radius, ulna, and carpal bones may result in instability, including inflammatory arthritis, infections, or congenital pathology. Trauma-related carpal derangements may result from simple or accumulated sprains of carpal soft tissue restraints or more severe injury resulting in complete ruptures of the ligamentous stabilizers and dislocation. They comprise a spectrum of injury patterns most commonly incurred as a result of a fall from a standing height, motor vehicle collision, or injury during sporting activities [1].

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Several paradigms have been used to better understand the mechanistic evolution and pathophysiology of carpal instability. *Progressive perilunate instability* describes the characteristic sequence of injury propagation centered on the lunate. Mayfield and coworkers described four stages that progress in an ulnar direction about the lunate (Figure 1) [2]. In the first stage, there is disruption through the scapholunate interval. As the distal carpal row is brought into hyperextension, the palmar midcarpal ligaments, in particular the scaphotrapezotrapezoid (STT) ligament and scaphocapitate ligament, are progressively stretched, pulling the scaphoid into extension and opening the space of Poirier. However, the lunate does not follow the scaphoid into extension as it is tightly constrained by the short and long radiolunate ligaments. The resulting extension force on the scaphoid may cause progressive rupture of the scapholunate interosseus ligament (SLIL) in a palmar to dorsal direction [2,3]. If the wrist were instead in radial deviation, then a scaphoid fracture may occur, as opposed to scapholunate dissociation. In the second stage, this force continues on to the space of Poirier, which is located at the palmar aspect of the proximal capitate, lying between the palmar radiocapitate and palmar radiotriquetral ligaments [3]. With progressive wrist extension, the lunocapitate articulation is disrupted as the capitate rotates dorsally relative to the lunate. Further progression of the injury in the third stage violates the lunotriquetral connection, completing the “perilunate” nature of the injury. The entire carpus separates from the lunate as the lunotriquetral ligaments are torn; the palmar radiotriquetral ligament and ulnotriquetral ligament may also be injured to a variable extent [3]. Finally, in the fourth stage, the dorsal radiocarpal ligament fails, allowing the capitate to reduce from its dorsally displaced position to become realigned with the radius. This causes the lunate to dislocate from its fossa into the carpal tunnel, where it exhibits a variable degree of rotation [2,4]. Herzberg et al. classified perilunate dislocations as stage I injuries and lunate dislocations as stage II injuries [5]. Lunate dislocations are further classified as stage IIA when the lunate exhibits minor rotation less than 90 degrees and stage IIB when the lunate exhibits rotation greater than 90 degrees (Figure 2).

The high-energy traumatic injuries that cause perilunate instability may involve bones, ligaments, or a combination of the two. Injuries that disrupt the scaphoid, capitate, lunate, hamate, or triquetrum bones are termed greater arc injuries. In contrast, injuries that are confined to ligaments about the lunate (i.e. scapholunate, lunotriquetral) are termed lesser arc injuries (Figure 3) [6].

CLASSIFICATION

Various classification schemes have been proposed to aid in the diagnosis and treatment of carpal instability. Two of the most common malalignment patterns are *volar intercalated segment instability (VISI)* and the more common *dorsal intercalated segment instability (DISI)* [7]. A VISI deformity describes an abnormal volar tilt of the lunate, typically the result of disruption to the midcarpal stabilizers that results in flexion of the proximal row. A DISI deformity refers to extension of the lunate relative to the capitate and radius and is most commonly observed following rupture of the scapholunate interosseous ligament (Figure 4). While this nomenclature focuses on the direction of the carpal malalignment, recent classifications have emphasized the relationships within and between the rows of carpal bones. Dobyns and Linscheid described four patterns of carpal instability that include

the spectrum of intrinsic and extrinsic ligament injuries [8] (Box 1). A *carpal instability dissociative (CID)* pattern occurs when intrinsic ligament injuries cause disruption of bones from the same carpal row [9]. In contrast, a *carpal instability nondissociative (CIND)* pattern describes injuries to extrinsic ligaments wherein carpal bones of the same row remain linked, but there exists dysfunction between the proximal and distal row or the radius and proximal row [8,9]. In a *carpal instability adaptive (CIA)* pattern, a derangement outside of the wrist causes the carpal malalignment, most commonly in the setting of a malunion of a distal radius fracture [10,11]. *Carpal instability complex (CIC)* are instabilities to the carpus that possess qualities of both CID and CIND patterns [10].

Box 1

Classification of carpal instability

Classification of carpal instability

Carpal instability dissociative

- a. Scapholunate dissociation
- b. Lunotriquetral dissociation
- c. Scaphoid fracture

Carpal instability nondissociative

- a. CIND-VISI
- b. CIND-DISI
- c. Combined CIND

Carpal instability adaptive

Carpal instability complex

- a. Dorsal perilunate dislocations (lesser arc injuries)
- b. Dorsal perilunate fracture-dislocations (greater arc injuries)
- c. Palmar perilunate dislocations
- d. Axial dislocations

Carpal Instability Dissociative

Carpal instability that disrupts the bonds between bones of the same carpal row is termed carpal instability dissociative (CID) [9]. CID may arise from a number of etiologies including scapholunate dissociation (SLD), lunotriquetral dissociation, scaphoid fracture, nonunion, and inflammatory disease. The most common dissociative injuries will be discussed.

Scapholunate Dissociation—The term scapholunate dissociation (SLD) was introduced by Linscheid et al. to describe dysfunction in the mechanical linkage between the scaphoid and the lunate with or without malalignment of the carpus [11]. SLD results from a disruption of the scapholunate ligamentous complex consisting of extrinsic capsular ligaments as well as the scapholunate interosseus ligament (SLIL). The SLIL attaches along the dorsal, proximal, and volar margins of the articulating surfaces. The dorsal component

has been identified as the strongest and most important stabilizer of the scapholunate interval, as it functions as a primary restraint to distraction, torsion, and translation [12]. The thinner volar component contributes to rotational stability. SLD may progress to rotatory subluxation of the scaphoid when the ligaments secured to both ends of the scaphoid have failed, causing the scaphoid to collapse into flexion and pronation [13]. While injuries to the scapholunate ligaments may occur in isolation, they may alternatively be the first stage in the process of carpal destabilization around the lunate.

Injuries to the SLIL are among the more common wrist ligament injuries, and approximately 30% of intra-articular distal radius fractures are associated with SLIL injuries [14,15]. These injuries typically occur in the setting of a hyperextended wrist that is in ulnar deviation. As the extended carpus undergoes further loading, the proximal pole of the scaphoid displaces posteriorly while the distal pole displaces anteriorly. While a complete transection of the SLIL changes the motion between the scaphoid and lunate, it does not result in permanent changes due to the presence of the secondary scaphoid stabilizers, including the palmar radioscaphoid-capitate (RSC), scaphoid capitate (SC), and anterolateral scapho-trapezio-trapezoid (STT) ligaments [12]. If left untreated, attritional wear to these secondary stabilizers alters carpal mechanics and leads to a DISI deformity as the lunate rotates into abnormal extension and the scaphoid rotates into abnormal flexion. With chronic SLD, the carpus eventually loses congruency, leading to scapholunate advanced collapse (SLAC) (Figure 5). [13,16]. Patients with SLD will report a “popping” or “clicking” sensation or pain with loading activities. Physical examination will reveal tenderness at the dorsal scapholunate interval and pain with wrist extension and radial deviation. In addition, some patients may display a positive scaphoid shift test, which is considered diagnostic for SLD [17]. In this maneuver, the examiner applies pressure to the scaphoid tuberosity as the wrist is moved from ulnar to radial deviation. If there is disruption to the SLIL, the proximal pole of the scaphoid will subluxate dorsally relative to the radius, causing pain on the dorsoradial aspect of the wrist. As pressure is released, a dramatic clunk is noted as the scaphoid falls back into normal position (Figure 6).

Imaging on standard posteroanterior radiographs may reveal an increased scapholunate (SL) interosseus gap of greater than 5 mm [14,15]. The clenched fist radiographic view may accentuate the distance seen on unstressed films. In the lateral view, the scaphoid will be flexed and the lunate extended in the classical posture of a DISI deformity [13]. A so-called cortical ring sign may be produced by the foreshortened distal pole of the flexed scaphoid (Figure 7) [14]. The SL angle will typically be greater than 70 degrees (normal 45 to 60 degrees), and the radiolunate (RL) angle greater than 15 degrees (Figure 7).

Lunotriquetral Dissociation—As with SLD, lunotriquetral dissociation occurs along the spectrum of progressive perilunate dislocation. Relative to the scapholunate ligamentous complex, the triquetrum possesses more extensive ligamentous insertions on its dorsal, ulnar, and palmar surfaces, making lunotriquetral dissociation a more stable injury pattern than SLD. Isolated injuries to the lunotriquetral ligaments may result from a fall onto an outstretched hand with the wrist in extension and radial deviation [11]. The magnitude of the force is directed onto the hypothenar eminence, causing the pisiform to be driven into the triquetrum, producing its dorsal translation. However, the lunate remains in place as it is

restrained volarly by the long radiolunate ligament and dorsally by the distal radius. Displacement of the triquetrum relative to the lunate leads to the accumulation of shear stresses that cause eventual stretching and rupture of the lunotriquetral ligaments [11,18].

Several investigations have studied the effect of lunotriquetral ligament disruptions on carpal kinematics. In their cadaveric study, Ritt and coworkers observed that sectioning of the palmar lunotriquetral ligament produced divergence of the triquetrum and lunate without carpal malalignment [19]. With additional division of the dorsal radiotriquetral and scaphotriquetral ligaments, the authors noted a consistent pattern of static carpal collapse into a VISI orientation. These findings are in agreement with previous studies that have demonstrated the palmar lunotriquetral ligament to be the major stabilizer of the lunotriquetral joint as well as the role of the dorsal radiotriquetral and scaphotriquetral ligaments as important secondary restraints [20,21].

Evaluation of these patients will reveal tenderness with ulnar deviation and axial compression. Most patients with lunotriquetral dissociation display a positive lunotriquetral ballottement test as described by Reagan and colleagues [18]. The examiner grasps the lunate between the thumb and index finger of one hand while the triquetrum is translated in a dorsal and volar direction with the fingers of the other hand. Painful shear motion suggests injury to the lunotriquetral ligament.

Standard radiographs may be unremarkable with the exception of possible subtle breaks in Gilula's lines. On stress radiographs, there may be increased palmar flexion of the scaphoid and lunate on radial deviation without a concomitant change in the triquetrum, which is suggestive of a loss of the proximal row integrity present in the normal wrist [20]. In the lateral view, the SL angle may be less than 30 degrees, consistent with a VISI deformity [18]. The lunotriquetral (LT) angle will deviate from its mean normal value of 15 degrees to a mean value of negative 16 degrees.

Scaphoid Fracture—Coordinated motion between the proximal and distal carpal rows depends on the ability of the scaphoid to transfer loads normally. When the integrity of the scaphoid bone is compromised, such as in a fracture, global carpal instability may ensue. The unstable scaphoid fragments displace differently depending on the actions of nearby structures. Specifically, the distal fragment is loaded into flexion by the trapezoid and trapezium while the proximal fragment moves into extension as it follows the lunate and triquetrum [22]. If left untreated, the resultant nonunion leads to the so-called humpback deformity of the scaphoid that often leads to a DISI deformity of the wrist [22,23].

Carpal Instability Nondissociative

Carpal instability nondissociative (CIND) is characterized by symptomatic disruption between the radius and the proximal carpal row or the proximal and distal carpal rows, without dysfunction between bones of the same carpal row [10,11]. CIND may be further subdivided into the following four groups: palmar CIND or CIND-VISI (volar intercalated segment instability), dorsal CIND or CIND-DISI (dorsal intercalated segment instability), and combined CIND.

CIND-VISI—With ulnar deviation of the wrist, the proximal carpal row rotates from flexion into extension. This movement is aided by the action of the volar midcarpal ligaments, which ensures that the transition occurs smoothly without risk for collapsing into a VISI deformity. Several cadaveric investigations have shown that injury or attenuation to the triquetral-hamate-capitate ligament and scaphotrapezium ligament leads to symptomatic CIND-VISI [24–26]. When these ligaments fail, the proximal row is no longer pulled into extension and instead remains palmar flexed during ulnar deviation. At the same time, there is concurrent volar translation, or “volar sag,” of the distal row [24]. As the wrist reaches the extreme of ulnar deviation, the proximal row abruptly rotates into an extended position, producing a palpable “catch-up clunk” in the process (Figure 8) [24,26].

Patients with CIND-VISI will demonstrate ulnar-sided tenderness and general ligamentous laxity. Many patients report painful clicking with pronation and ulnar deviation. The midcarpal shift test demonstrates the clunk observed during this movement [25,26]. The examiner passively translates the pronated wrist in a palmar direction. As the wrist is then placed into ulnar deviation, the classic catch-up clunk is noted as the proximal row shifts into extension. Because of the dynamic nature of this instability, stress radiographs in varying degrees of radial and ulnar deviation may aid in the diagnosis of CIND-VISI.

CIND-DISI—As with palmar CIND, dorsal CIND is due to carpal ligament dysfunction that prevents smooth rotation of the carpal rows during ulnar deviation. Unlike its counterpart, in CIND-DISI the proximal row remains normally aligned throughout the motion arc [10,27]. In this variant, the clunk occurs from dorsal subluxation of the capitate as the proximal row extends during ulnar deviation. The tendency of the capitate to subluxate dorsally during this movement is likely secondary to insufficiency of the dorsal intercarpal ligament as well as failure of the radioscaphocapitate ligament, which creates excessive laxity in the space of Poirier [27].

CIND-DISI usually presents in young patients with bilateral hypermobile wrists [10]. They will typically report pain during grasping maneuvers, particularly when the arm is in supination. The dorsal capitate-displacement apprehension test is useful for diagnosis [28] (Figure 9). The examiner applies dorsal pressure to the scaphoid tubercle while longitudinal traction with flexion and ulnar deviation is applied to the wrist. A painful clunk is noted as the capitate subluxates in a dorsal direction.

Combined CIND—Combined CIND possesses features of both palmar and dorsal CIND. As in palmar CIND, the proximal row suddenly rotates into extension with ulnar deviation due to attenuation of the volar carpal ligaments. As ulnar deviation continues, dorsal subluxation of the capitate is noted due to additional laxity of the dorsal carpal ligaments [11]. In addition to midcarpal instability, these patients may have radiocarpal instability with abnormal flexion of the proximal row with radial deviation [10]. Combined CIND tends to be predominant in young teenagers with global laxity. Examination will often be positive for both volar carpal sag as well as a positive dorsal displacement test.

Carpal Instability Adaptive

Carpal instability is not always secondary to intracarpal pathology. A carpal instability adaptive (CIA) pattern occurs when the dysfunction lies outside the carpus. A classic example of CIA is seen after malunion of a distal radius fracture [11]. The resultant dorsal tilt of the typical malunited distal radius loosens the normally taut palmar midcarpal ligaments, thereby preventing the smooth transition of the proximal row from flexion into extension with ulnar deviation [10]. In most cases, the entire proximal row assumes a flexed posture with dorsal translation of the capitate and distal row.

Clinically, CIA manifests with clunking or snapping as the wrist is ulnarly deviated along with a lack of range of motion in flexion. Patients may report tenderness to palpation at the midcarpal joint. A history of a distal radius fracture is often given. Standard radiographs will show a dorsally malunited distal radius fracture. In the lateral view, the lunate is typically extended and the capitate is variably flexed.

Carpal Instability Complex

Carpal dysfunction that alters the linkage both between bones of the same carpal row (CID) as well as between carpal rows (CIND) is classified as carpal instability complex (CIC) [11,29]. This pattern of instability may be further subdivided into four categories: 1) dorsal perilunate dislocations (lesser arc injuries); 2) dorsal perilunate fracture-dislocations (greater arc injuries); 3) palmar perilunate dislocations (lesser or greater arc injuries); and 4) axial dislocations [29].

Dorsal Perilunate Dislocations and Dorsal Perilunate Fracture-Dislocations—

Dorsal perilunate dislocations and perilunate fracture dislocations comprise a spectrum of high-energy injuries that result in carpal derangement around the lunate. Dorsal perilunate dislocation represents one stage in the spectrum of progressive perilunar instability in which the capitate is translated dorsally relative to the lunate while the lunate remains in the lunate fossa [4]. Eventually, the dorsally displaced capitate may be pulled volarly back into the radiocarpal space, thereby exerting a volarly directed force onto the lunate. The lunate consequently dislocates into the carpal tunnel in what is the final stage of perilunate injury [4,30]. Dorsal perilunate dislocations that involve purely ligamentous structures are termed lesser arc injuries; when there is an associated fracture to the scaphoid, capitate, or triquetrum, the dorsal perilunate fracture-dislocations are referred to as greater arc injuries (Figure 10) [6].

Palmar Perilunate Dislocations—Palmar perilunate dislocations are infrequent injuries that may follow a lesser or greater arc injury pattern [31,32]. They typically occur in association with dorsally displaced lunate fractures that result in palmar capitate extrusion.

Axial Dislocations—Axial dislocations of the carpus generally result from traumatic crush injuries that compress the wrist in a dorsopalmar direction [33,34]. The high-energy nature of these injuries often causes associated soft tissue compromise and neurovascular injury. In particular, the flexor retinaculum is typically avulsed from its insertions, leading to flattening of the transverse carpal arch. The longitudinally directed force divides the carpus

into two columns, with one column remaining in its reduced position and the other displacing in either a radial or ulnar direction [34]. The direction of the unstable column forms the basis for the two major patterns of axial dislocations. In axial ulnar dislocations, the radial column remains reduced relative to the radius while the ulnar column is displaced. In axial radial dislocations, the ulnar column remains reduced relative to the radius while the radial column is displaced [34] (Figure 11).

SUMMARY

Carpal instability is a complex array of maladaptive and post-traumatic conditions that leads to the inability of the wrist to maintain anatomic relationships under normal loads. Many classification schemes have evolved to explain or categorize one or another aspect of this multifactorial condition. An understanding of the anatomy and the general methods of classification is essential to the care of these injuries. Future research will likely unify the disparate paradigms used to describe wrist instability.

References

1. Weil WM, Slade JF III, Trumble TE. Open and arthroscopic treatment of perilunate injuries. *Clin Orthop Relat Res.* 2006; 445:120–32. [PubMed: 16601413]
2. Mayfield JK, Johnson RP, Kilcoyne RK. Carpal dislocations: pathomechanics and progressive perilunate instability. *J Hand Surg Am.* 1980; 5:226–41. [PubMed: 7400560]
3. Kennedy SA, Allan CH. In brief: Mayfield et al. classification: carpal dislocations and progressive perilunate instability. *Clin Orthop Relat Res.* 2012; 470:1243–5. [PubMed: 22322787]
4. Mayfield JK. Mechanism of carpal injuries. *Clin Orthop Relat Res.* 1980; 149:45–54. [PubMed: 7408319]
5. Herzberg G, Comtet JJ, Linscheid RL, et al. Perilunate dislocations and fracture-dislocations: a multicenter study. *J Hand Surg Am.* 1993; 16:768–79. [PubMed: 8228045]
6. Johnson RP. The acutely injured wrist and its residuals. *Clin Orthop Relat Res.* 1980; 149:33–44. [PubMed: 7408318]
7. Linscheid RL, Dobyns JH. Treatment of scapholunate dissociation. *Hand Clin.* 1992; 8:645–52. [PubMed: 1460063]
8. Wright TW, Dobyns JH, Linscheid RL, et al. Carpal instability non-dissociative. *J Hand Surg Br.* 1994; 19:763–73. [PubMed: 7706884]
9. Dobyns JH, Linscheid RL, Macksoud WS. Proximal carpal row instability-non dissociative. *Orthop Trans.* 1985; 9:574.
10. Wolfe SW, Garcia-Elias M, Kitay A. Carpal instability nondissociative. *J Am Acad Orthop Surg.* 2012; 20:575–85. [PubMed: 22941800]
11. Linscheid RL, Dobyns JH, Beabout JW, et al. Traumatic instability of the wrist: diagnosis, classification, and pathomechanics. *J Bone Joint Surg Am.* 1972; 54:1612–32. [PubMed: 4653642]
12. Short WH, Werner FW, Green JK, et al. Biomechanical evaluation of ligamentous stabilizers of the scaphoid and lunate: part III. *J Hand Surg Am.* 2007; 32:297–309. [PubMed: 17336835]
13. Watson H, Ottoni L, Pitts EC, Handal AG. Rotary subluxation of the scaphoid: a spectrum of instability. *J Hand Surg Br.* 1993; 18:62–4. [PubMed: 8436866]
14. Walsh JJ, Berger RA, Cooney WP. Current status of scapholunate interosseous ligament injuries. *J Am Acad Orthop Surg.* 2002; 10:32–42. [PubMed: 11809049]
15. Geissler WB, Freeland AE. Arthroscopic management of intra-articular distal radius fractures. *Hand Clin.* 1999; 15:455–65. [PubMed: 10451821]
16. Watson HK, Ballet FL. The SLAC wrist: scapholunate advanced collapse pattern of degenerative arthritis. *J Hand Surg Am.* 1984; 9:358–65. [PubMed: 6725894]

17. Wolfe SW, Gupta A, Crisco JJ 3rd. Kinematics of the scaphoid shift test. *J Hand Surg Am.* 1997; 22:801–6. [PubMed: 9330136]
18. Reagan DS, Linscheid RL, Dobyns JH. Lunotriquetral sprains. *J Hand Surg Am.* 1984; 9:502–14. [PubMed: 6747234]
19. Ritt MJPF, Linscheid RL, Cooney WP, et al. The lunotriquetral joint: kinematic effects of sequential ligament sectioning, ligament repair, and arthrodesis. *J Hand Surg Am.* 1998; 23:432–45. [PubMed: 9620184]
20. Viegas SF, Patterson RM, Peterson PD, et al. Ulnar-sided perilunate instability: an anatomic and biomechanic study. *J Hand Surg Am.* 1990; 15:268–78. [PubMed: 2324456]
21. Murray PM, Palmer CG, Shin AY. The mechanism of ulnar-sided perilunate instability of the wrist: a cadaveri study and 6 clinical cases. *J Hand Surg Am.* 2012; 37:721–8. [PubMed: 22397843]
22. Vance RM, Gelberman RH, Evans EF. Scaphocapitate fractures: patterns of dislocation, mechanisms of injury, and preliminary results of treatment. *J Bone Joint Surg Am.* 1980; 62:271–76. [PubMed: 6987237]
23. Amadio PC, Berquist TH, Smith DK, et al. Scaphoid malunion. *J Hand Surg Am.* 1989; 14:679–87. [PubMed: 2787817]
24. Trumble TE, Bour CJ, Smith RJ, et al. Intercarpal arthrodesis for static and dynamic volar intercalated segment instability. *J Hand Surg Am.* 1988; 13:384–90. [PubMed: 3379275]
25. Lichtman DM, Bruckner JD, Culp RW, et al. Palmar midcarpal instability: result of surgical reconstruction. *J Hand Surg Am.* 1993; 18:307–15. [PubMed: 8463599]
26. Lichtman DM, Schneider JR, Swafford AR, et al. Ulnar midcarpal instability-clinical and laboratory analysis. *J Hand Surg Am.* 1981; 6:515–23. [PubMed: 7276484]
27. Johnson RP, Carrera GF. Chronic capitulate instability. *J Bone Joint Surg Am.* 1986; 68:1164–76. [PubMed: 3771598]
28. Louis DS, Hankin FM, Greene TL, et al. Central carpal instability-capitate lunate instability pattern: diagnosis by dynamic displacement. *Orthopaedics.* 1984; 7:1693–96.28.
29. Green DP, O'Brien ET. Classification and management of carpal dislocations. *Clin Orthop Rel Res.* 1980; 149:55–72.
30. Stanbury SJ, Elfar JC. Perilunate dislocation and perilunate fracture-dislocation. *J Am Acad Orthop Surg.* 2011; 19:554–62. [PubMed: 21885701]
31. Conway WF, Gilula LA, Manske PR, et al. Translunate, palmar perilunate fracture-subluxation of the wrist. *J Hand Surg Am.* 1989; 14:635–39. [PubMed: 2754195]
32. Masmejean EH, Romano SJ, Saffar PH. Palmar perilunate fracture-dislocation of the carpus. *J Hand Surg Br.* 1998; 23:264–5. [PubMed: 9607678]
33. Garcia-Elias M, Dobyns JH, Cooney WP III, et al. Traumatic axial dislocations of the carpus. *J Hand Surg Am.* 1989; 14:446–57. [PubMed: 2661650]
34. Reinsmith LE, Garcia-Elias M, Gilula LA. Traumatic axial dislocation injuries of the wrist. *Radiology.* 2013; 267:680–9. [PubMed: 23704291]

Key points

- Carpal instability is a complex array of maladaptive and post-traumatic conditions that leads to the inability of the wrist to maintain anatomic relationships under normal loads.
- Many different classification schemes have been used to better understand the mechanistic evolution and pathophysiology of carpal instability.
- Progressive perilunate instability describes the global pattern of injury propagation centered around the lunate.
- Two of the most common malalignment patterns are volar intercalated segment instability (VISI) and the more common dorsal intercalated segment instability (DISI).
- Recent classifications have emphasized the relationships within and between the rows of carpal bones, including carpal instability dissociative; carpal instability nondissociative; carpal instability adaptive; and carpal instability complex.

Figure 1.

Stages of progressive perilunar instability. Stage I involves disruption of the scapholunate ligamentous complex (arrow). In stage II, the force propagates through the space of Poirier and interrupts the lunocapitate connection (arrow). In stage III, the lunotriquetral connection is violated, and the entire carpus separates from the lunate. In stage IV, the lunate dislocates from its fossa into the carpal tunnel, the lunate rotates into the carpal tunnel, and the capitate becomes aligned with the radius (arrow). (From Kozin SH: Perilunate injuries: diagnosis and treatment. *J Am Acad Orthop Surg* 1998;6:114–20; with permission.)

Figure 2.

Perilunar instability. Stage I (top) refers to perilunate dislocations with dorsal dislocation on the left and the rarer volar perilunate dislocation on the right. Stage II (bottom) refers to lunate dislocations with volar lunate dislocation on the left and the rarer dorsal lunate dislocation on the right. Stage II can be broken down into stage IIA with $<90^\circ$ of lunate rotation and stage IIB with $>90^\circ$ of lunate rotation, or enucleation. (From Herzberg G: Acute dorsal trans-scaphoid perilunate dislocations: open reduction and internal fixation. *Tech Hand Up Extrem Surg* 2000;4:2–13; with permission.)

Figure 3.

The lesser and greater carpal arcs of perilunate instability. (From Kozin SH: Perilunate injuries: Diagnosis and treatment. *J Am Acad Orthop Surg* 1998;6:114–20; with permission)

Figure 4.

DISI and VISI deformities of the wrist. (From Garcia-Elias M: Carpal instability. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, eds. *Green's Operative Hand Surgery*. 6th ed. Philadelphia, PA: Churchill Livingstone Elsevier; 2011:470; with permission.)

Figure 5.

Example of a SLAC wrist. Osteophyte formation is noted at the radial styloid-scaphoid articulation (arrow). (From Garcia-Elias M: Carpal instability. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, eds. *Green's Operative Hand Surgery*. 6th ed. Philadelphia, PA: Churchill Livingstone Elsevier; 2011:493; with permission)

Figure 6.

Scaphoid shift test. Pressure is applied to the scaphoid tuberosity as the wrist is moved from ulnar to radial deviation (curved arrow). Disruption to the SLIL will cause the proximal pole of the scaphoid to subluxate dorsally relative to the radius (straight arrow). As pressure is released, a dramatic clunk is noted as the scaphoid falls back into normal position. (From Garcia-Elias M: Carpal instability. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, eds. *Green's Operative Hand Surgery*. 6th ed. Philadelphia, PA: Churchill Livingstone Elsevier; 2011:483; with permission.)

Figure 7. Posteroanterior (top) and lateral (bottom) radiographs showing the cortical ring sign (arrow) produced by the foreshortened distal pole of the flexed scaphoid and increased scapholunate angle (arrowhead). (From Walsh JJ: Current status of scapholunate interosseus ligament injuries. *J Am Acad Orthop Surg* 2002;10:32–42; with permission)

Figure 8.

Pathomechanics of CIND-VISI. (A) As the wrist reaches the extreme of ulnar deviation (large arrow), the proximal row abruptly rotates into an extended position, producing a palpable “catch-up clunk”ain the process (small arrow). (B) The lunate assumes an extended posture (dashed outline). (From Wolfe SW: Carpal instability nondissociative. J Am Acad Orthop Surg 2012;20:575–85; with permission.)

Figure 9.

Dorsal capitate-displacement test. Longitudinal traction with flexion and ulnar deviation is applied to the wrist as dorsal pressure is applied (arrow) to the scaphoid tuberosity. The clunk occurs from dorsal subluxation of the capitate as the proximal row extends during ulnar deviation. C = capitate, L = lunate, R = radius, S = scaphoid. (From Wolfe SW: Carpal instability nondissociative. *J Am Acad Orthop Surg* 2012;20:575–85; with permission)

Figure 10.

(A) Preoperative posteroanterior and (B) lateral radiographs demonstrating transscaphoid perilunate fracture-dislocation. (From Hildebrand KA, Ross DC, Patterson SD, et al: Dorsal perilunate dislocations and fracture dislocations: questionnaire, clinical, and radiographic evaluation. *J Hand Surg Am* 2000;25:1069–79; with permission.)

Figure 11.

Axial dislocations. (A–C) In axial radial dislocations, the ulnar column remains reduced relative to the radius while the radial column is displaced. (D–F) In axial ulnar dislocations, the radial column remains reduced relative to the radius while the ulnar column is displaced. (From Garcia-Elias M, Dobyns JH, Cooney WP III, et al: Traumatic axial dislocations of the carpus. *J Hand Surg Am* 1989;14:446–57; with permission.)