Carpal Instability: Clarification of the Most Common Etiologies and Imaging Findings

Corey Matthews DO, Nicholas Strle DO, Donald von Borstel DO
Oklahoma State University Medical Center, Department of Radiology
Disclosure Statement

● None of the authors have conflicts of interest or relevant financial relationships to disclose.

● Target audience
  ● Seasoned and training radiologists
Objectives

1. Discuss an approach to the radiological evaluation of the wrist.
2. Review basic wrist anatomy as visualized on radiography and magnetic resonance imaging (MRI).
3. Review of the overall classification of carpal instability.
4. Discuss the imaging manifestations of the most common etiologies of carpal instability.
Radiologic Evaluation of the Wrist

• Plain film radiographs offer an adequate cursory evaluation of carpal instability.
  • Ensure proper positioning (PA and lateral projections)
  • Assessment of joint spaces and carpal arcs
  • Screening for acute injury/fracture

AP (A) and Lateral (B) radiographs of the wrist demonstrate proper positioning. Normal, parallel carpal arcs (orange lines) are identified on the AP view. Proper alignment of the radius (orange arrow), lunate (blue arrow), and capitate (white arrow) are appreciated on the lateral view.
Radiologic Evaluation of the Wrist

- MRI provides a more thorough evaluation for underlying pathology and associated sequelae.
  - Incorporate an appropriate protocol for MRI of the wrist
    - Ax PD and PD FS; Cor T1, Cor PD FS, and 3D DESS; Sag PD FS (as utilized by our institution)
  - Offers exquisite detail of bones/cartilage, ligaments, tendons, and nerves

Normal MRI of the wrist demonstrating protocol utilized by our institution. Axial PD FS (A), Axial PD (B), Coronal PD FS (C), Coronal T1 (D), and Sagittal PD FS (E) provide exceptional anatomic detail and clarification of suspected carpal instability.
Overall Classification of Carpal Instability

- **Carpal Instability Dissociative (CID)**
  - Derangement within or between carpal bones in the same row

- **Carpal Instability Non-Dissociative (CIND)**
  - Derangement between the radius and proximal carpal row

- **Carpal Instability Complex**
  - Features of both CID and CIND

- **Carpal Instability Adaptive**
  - Injury proximal or distal to carpal bones causes instability
Carpal Instability Dissociative (CID)

- CID involves injury within or between bones of the same carpal row.
- Most common instability patterns include:
  - Scapholunate dissociation
  - Scapholunate advanced collapse (SLAC wrist)
  - Scaphoid nonunion advanced collapse (SNAC wrist)
- A less common presentation of CID is a lunotriquetral dislocation.
Carpal Instability Dissociative (CID)

- **Scapholunate dissociation (SLD)**
  - Disruption of the ligamentous link between the scaphoid and lunate
  - Most frequent carpal instability pattern
  - Can be isolated or in association with scaphoid fractures

Axial T1 (A) and Coronal PD FS (B) MRI, and frontal radiograph (C) of the wrist demonstrating scapholunate dissociation. Tear of the dorsal component of the scapholunate ligament (orange arrow) and the proximal zone (white arrow) in the setting of Scapholunate Advanced Collapse of the wrist (SLAC wrist). Widening of the scapholunate interval (asterisk) is noted on plain film.
Carpal Instability Dissociative (CID)

- **Dorsal Intercalated Segment Instability (DISI)**
  - Scapholunate ligament injury
  - Concomitant failure of scaphoid stabilizers and often permanent carpal malalignment
  - Lunate dorsiflexed and scaphoid tilted volarly with scapholunate angle >60° and capitolunate angle >30°

![Lateral radiograph of the wrist demonstrating Dorsal Intercalated Segmental Instability (DISI). Intersecting axes of the lunate and capitate (orange lines) form a 43° capitolunate angle.](image)
Carpal Instability Dissociative (CID)

- **Scapholunate Advanced Collapse (SLAC wrist)**
  - Degenerative joint disease centered at the radioscaphoid joint from chronic SLD

- Three progressive stages of disease
  - Stage I: radial styloid and scaphoid degeneration
  - Stage II: degeneration between the scaphoid and entire scaphoid facet of the radius
  - Stage III: degeneration between the capitate and lunate

- Scapholunate ligament tear and progressive scapholunate interval widening
Carpal Instability Dissociative (CID)

- Scapholunate Advanced Collapse (SLAC wrist)

Coronal T1-weighted image depicting a stage II SLAC wrist. There is radioscaphoid degenerative joint disease (orange arrow) with subchondral sclerosis, chondromalacia, and joint space narrowing. Also, there is a proximal zone scapholunate ligament tear with resulting scapholunate interval widening (asterisk). No significant degeneration of the capitolunate joint.

Frontal radiograph depicting SLAC type III wrist. There is radioscaphoid degenerative joint disease involving the entire scaphoid facet of the radius (orange arrows) with subchondral sclerosis, cartilage thinning, and joint space narrowing. Also, there is scapholunate interval widening (asterisk) and arthrosis at the capitolunate joint (blue arrow).
Carpal Instability Dissociative (CID)

- Scaphoid Nonunion Advanced Collapse (SNAC wrist)
  - Scaphoid fracture, especially non-union fractures, with distal scaphoid fracture segment flexion, and resulting abnormal radioscaphoid articulation and degeneration
  - Post-traumatic arthritis and carpal collapse following nonunion scaphoid fracture

Coronal T1-weighted image depicting SNAC wrist. Nonunion fracture of the scaphoid (orange arrow) with associated radioscaphoid degenerative change (white arrow) and radioscaphoid interval widening (blue arrow). There is diffuse hypointense signal of the scaphoid proximal pole (asterisk) consistent with osteonecrosis.
Carpal Instability Dissociative (CID)

• **Lunotriquetral dislocation:**
  - Can occur from trauma or ulnocarpal abutment associated with triangular fibrocartilage complex pathology
  - Injury to lunotriquetral ligament results in Volar Intercalated Segment Instability (VISI)
    - Lunotriquetral ligament injury
    - Lunate volarly flexed resulting from scaphoid flexion, which remains attached to the lunate by the intact scapholunate ligament.
  - Imaging findings of capitolunate angle $>30^\circ$ and scapholunate angle $<30^\circ$
Carpal Instability Non-Dissociative (CIND)

- Dysfunction between the radius and first carpal row (radiocarpal) or between the first carpal row and the second carpal row (midcarpal)

- Involves the extrinsic ligaments of the wrist

- The individual carpal bones maintain their normal anatomic relationship with each other within each respective row; therefore, the carpal rows maintain their intrinsic shape.
Carpal Instability Non-Dissociative (CIND)

Ulnar Translocation
• Tearing of the extrinsic ligaments of the wrist resulting in ulnar shift of the proximal carpal row
• Type I ulnar translocation involves tear of the radioscaphoid and radioscaphocapitate extrinsic ligaments with resultant widening of the radioscaphoid interval and ulnar shift of the entire proximal carpal row.
• In type II ulnar translocation, the radioscaphoid joint is maintained with ulnar shift of the remaining proximal carpal row.

Lateral (A) and AP (B) radiographs of the wrist depict ulnar translocation (type I). Posterior displacement of the proximal carpal row in relation to the radius (white arrow). Widening of the radioscaphoid joint (orange arrow) with ulnar shift of the proximal carpal row (blue outline).
Carpal Instability Complex (CIC)

Carpal derangement involving altered relationship between bones in the same carpal row and between the proximal and distal carpal rows

Five groups:

- **Group 1**: Dorsal perilunate dislocation (lesser arc injury)
  - Stages I - IV
- **Group 2**: Dorsal perilunate fracture-dislocation (greater arc injury)
- **Group 3**: Palmar perilunate dislocation (lesser or greater arc injury)
- **Group 4**: Axial dislocation
- **Group 5**: Isolated carpal bone dislocation
Carpal Instability Complex (CIC)

Dorsal Perilunate Dislocation

• Dorsal perilunate dislocations are ligamentous lesser arc injuries within the carpal instability complex class of injuries.

• There are four stages of progressive perilunate instability involving ligamentous injuries surrounding the lunate.
Carpal Instability Complex (CIC)

Group 1: Dorsal Perilunate Dislocation

Stage I: Scapholunate dissociation

- Defined by disruption of the dorsal scapholunate ligament when torque on the scapholunate ligament reaches threshold.

- Specific ligamentous injury well visualized by MRI.
Carpal Instability Complex (CIC)

Group 1: Dorsal Perilunate Dislocation

Stage II: Dorsal Perilunate Dislocation

- Scaphoid-capitate complex dislocates dorsal to lunate
- Extent of dorsal translation is determined by laxity of the radioscaphocapitate extrinsic ligament
- Radiographic findings:
  - Dorsal displacement of the capitate in relation to the lunate
  - Maintained alignment of the lunate with the distal radius is also visualized

Lateral radiograph of the wrist demonstrates Stage II perilunate dislocation. Dorsal displacement of the capitate (orange arrow) in relation to the lunate, which maintains normal articulation with the radius (blue arrow).
Carpal Instability Complex (CIC)

Group 1: Dorsal Perilunate Dislocation

Stage III: Midcarpal dislocation

- Progressive carpal hyperextension pulls the triquetrum into abnormal extension; which leads to tear of the lunotriquetral ligament or even avulsion injury of the triquetrum, which is best evaluated by MRI.

- Leaves only the short radiolunate and volar ulnolunate ligaments as stabilizers

- Radiographic findings:
  - Abnormal alignment of both the lunate and radius

Lateral radiograph of the wrist demonstrates Stage III perilunate dislocation. Mild dorsal displacement of the capitate (orange arrow) in relation to the lunate. The lunate has mild volar tilt in relation to the radius (blue arrow) without being completely dislocated.
Carpal Instability Complex (CIC)

Group 1: Dorsal Perilunate Dislocation

Stage IV: Lunate dislocation:

- Capitate pulled proximal and volar by the intact radioscaphocapitate extrinsic ligament.
- Capitate pushes the lunate volarly.
- Radiographic findings:
  - maintained alignment of the capitate centered over the radius.
  - Volar tilting and displacement of the lunate in relation to the radius, increased volar tilt compared to Stage III.

Lateral radiograph of the wrist demonstrates stage IV perilunate dislocation (lunate dislocation). The capitate is centered over the radius (orange arrows) while the lunate is volarly displaced in relation to the radius (blue arrow).
Carpal Instability Complex (CIC)

Group II: Dorsal perilunate fracture-dislocation

- Perilunate dislocation + carpal bone fracture (scaphoid, capitate, hamate, or triquetrum)
- Most common is the trans-scaphoid perilunate dislocation

AP (A) and Lateral (B) radiographs of the wrist demonstrating a perilunate fracture-dislocation. Displaced scaphoid fracture (white arrow) is best visualized on AP view. On lateral view, the capitate is displaced dorsal to the lunate (orange arrow), while the lunate maintains normal articulation with the radius.
Carpal Instability Adaptive (CIA)

The carpal rows will adapt and change their angle in response to pathology or abnormal anatomy near the wrist.

CIA results most commonly from abnormal tilt of the radius (ie. madelung’s deformity or fracture malunion).

Intrinsic ligament injury should be excluded with MRI of the wrist.
Conclusion

• The wrist has very complex anatomy which is important to understand in order to make the correct diagnosis regarding wrist pathology.

• Carpal instability often presents a challenging set of findings for radiologists to accurately diagnose. Discerning the most common etiologies of instability and their imaging findings is important to avoid increased morbidity and degenerative disease that can result from misdiagnosis.

• While recognizable on plain film radiography, MRI offers superior visualization of the extent of carpal instability, specific ligamentous injuries, and the resulting long-term sequelae.


Authors

Corey Matthews, DO
Oklahoma State University Medical Center
744 W 9th St
Tulsa, OK, 74127
coraymatt3316@gmail.com

Nicholas Strle, DO
Oklahoma State University Medical Center
744 W 9th St
Tulsa, OK, 74127

Donald von Borstel, DO
Oklahoma State University Medical Center
744 W 9th Street
Tulsa, Oklahoma 74127
donaldvonborstel@yahoo.com