Imaging and Evaluation of Scapholunate Advanced Collapse (SLAC) Wrist

Alvin S. Chen, Harvard Medical School Year III
Gillian Lieberman, MD
Radiology Core Clerkship
Overview

- **Wrist: Normal Anatomy & Biomechanics**
- Approach to Wrist Imaging: Menu of Tests & Efficacious Use
- Index Patient
- SLAC Wrist: Clinical Implications & Radiographic Diagnosis
- SLAC Wrist: Treatment
Normal Anatomy of the Wrist: PA

Source: http://radiologymasterclass.co.uk
Normal Anatomy of the Wrist: PA

Note:
- Pisiform and Triquetrum overlap
- The other carpal bones partly overlap

Source: http://radiologymasterclass.co.uk
Normal Anatomy of the Wrist: Lateral

Source: http://radiologymasterclass.co.uk
Normal Anatomy of the Wrist: Lateral

Note:
- The scaphoid is difficult to see clearly on this view
- This view is essential to check for alignment of the radius, lunate and capitate

Source: http://radiologymasterclass.co.uk
Normal Anatomy of the Wrist: Ligaments

Flexor retinaculum removed: palmar view

- Short radiolunate ligament
- Palmar radiolunate ligament
- Ulnolunate ligament
- Ulnocapitate ligament
- Ulnotriquetral ligament
- Lunotriquetral ligament
- Triquetrohamate ligament
- Triquetrococpitate ligament
- Capitohamate ligament

Trapeziopevic ligament
Scapholunate ligament
Scaphocapitate ligament
Radioscaphocapitate ligament
Long radiolunate ligament
Metacarpal bones

Source: Netter’s Atlas of Anatomy, 4e
Normal Anatomy of the Wrist: Ligaments

Posterior (dorsal) view

- Dorsal radial metaphyseal arcuate ligament
- Dorsal radioulnar ligament
- Ulnotriquetral ligament (dorsal view)
- Triquetrohamate ligament
- Dorsal intercarpal ligament
- Capitohamate ligament
- Dorsal radiocarpal ligament
- Trapeziotrapezoid ligament
- Trapeziocapitate ligament

Scapholunate ligament

Source: Netter’s Atlas of Anatomy, 4e
Normal Anatomy of the Wrist: Ligaments

Coronal T-1 weighted MRI showing normal SL ligament (arrow) (S, scaphoid; L, lunate; T, triquetrum)

Source: www.orthobullets.com
Three distinct biomechanical concepts have been proposed, but the “intercalated row” concept is most widely accepted.

The wrist is comprised of radius/ulna, proximal and distal rows.

Scaphoid serves as a bridge between rows.

The proximal carpal row has no tendinous attachments so its position is determined by the position of the radius and distal carpal row.

Disruption (fracture or ligamentous injury) leads to instability in wrist motion.
Wrist Biomechanics

Hamate
Capitate
Trapezoid
Trapezium
Pisiform
Triquetrum
Scaphoid
Lunate
Proximal Intercalated Row

Source: www.wikiradiography.com
Wrist Biomechanics – Scaphoid Axis

- True axis of scaphoid is the line through the mid-points of its proximal and distal pole
- A parallel line bordering the ventral points of the proximal and distal poles of the bone can be used as a good proxy

Source: www.radiologyassistant.nl
Wrist Biomechanics – Lunate Axis

- Lunate axis runs through midpoints of the convex proximal and concave distal joint surfaces
- Best approximated by tracing the perpendicular line to a line joining the distal palmar and dorsal borders
- Normal SL angle: 30-60⁰
- Borderline: 60-80⁰
- Abnormal: >80⁰ (indicates wrist instability)

Source: www.radiologyassistant.nl
Wrist Biomechanics – Capitate Axis

- Capitate axis joins the midportion of the proximal convexity of the third metacarpal and that of the proximal surface of the capitate
- Normal CL angle: $<30^\circ$
- Abnormal: $>30^\circ$ (indicates wrist instability)

Source: www.radiologyassistant.nl
Overview

- Wrist: Normal Anatomy & Biomechanics
- Approach to Wrist Imaging: Menu of Tests & Efficacious Use
- Index Patient
- SLAC Wrist: Clinical Implications & Radiographic Diagnosis
- SLAC Wrist: Treatment
Menu of Tests & Efficacious Use

- **Plain film (X-ray) – Wrist Series**
  - Standard: AP, Lateral, and Oblique
  - Obtain scaphoid view (semipronated oblique) if there is suspicion for scaphoid fracture
  - Obtain ‘clenched fist’ view if there is suspicion for ligamentous injury, especially SL ligament

- **MRI:** if suspicion for fracture or ligamentous injury but radiographs negative
  - More sensitive than plain film for detecting fracture, ligament tears, edema and arthritis
  - Allows for early detection of AVN
  - MR Arthrography can be used in suspected intercarpal ligament or TFCC tears
Menu of Tests & Efficacious Use

- **Less commonly used tests:**
  - Conventional CT Scan
    - Allows for 3-D visualization of carpal bones, soft tissue detail
    - Can assess nonunion of fractures, usually scaphoid waist fx
    - Utilized to better define a previously detected fracture or assess the distal radial ulnar joint
  - Fluoroscopy
    - Useful for dynamic detection of abnormal bony motion and ligamentous/capsular injury
  - Bone Scintigraphy
    - Can be used to work-up occult fractures; high sensitivity, low specificity
  - Ultrasound
    - Limited use in trauma setting, may allow for evaluation of extensor or flexor tendons to exclude rupture
    - Can visualize foreign bodies, cysts or effusions
  - Arthroscopy
    - Allows for direct visualization of wrist structures, gold-standard, invasive
Overview

- Wrist: Normal Anatomy & Biomechanics
- Approach to Wrist Imaging: Menu of Tests & Efficacious Use
- Index Patient
- SLAC Wrist: Clinical Implications & Radiographic Diagnosis
- SLAC Wrist: Treatment
Index Patient: History of Present Illness

- 49 yo AA man w/PMHx ulcerative colitis and ankylosing spondylitis presenting with 9 months of insidious onset right wrist pain
- Reports swelling and erythema of the right wrist over the dorsal surface
- Worse with palpation and flexion/extension
- Has tried Tylenol with minimal relief
- Does not remember specific trauma that may have caused this, but has had a few falls over the past year
- SocHx: works as a secretary at a local hospital
- ROS, FMHx non-contributory
Index Patient: Physical Examination

- Vital signs within normal limits
- General: obese man in NAD
- HEENT/Neck: no malar rash, no lymphadenopathy
- Cardiopulmonary exam: normal
- Joint exam: right-sided 2+ edema in medial dorsal aspect of wrist, tender to palpation, significantly decreased ROM, positive Watson scaphoid shift test
Watson Scaphoid Shift Test

- With firm pressure over the palmar tuberosity of the scaphoid, the wrist is moved from ulnar to radial deviation
- Dorsal wrist pain or a clunk during this maneuver may indicate instability of SL ligament
- Sens: 86%, Spec: 57%

Index Patient: Differential Diagnosis

- Scapholunate Advanced Collapse (SLAC)
- Scaphoid Non-Union Advanced Collapse (SNAC)
- Carpal fracture (scaphoid, lunate, triquetral, etc.)
- Carpal arthritis (OA vs. RA)
- Wrist tendonitis
- Carpal tunnel syndrome
- Chronic osteomyelitis
- De Quervain tenosynovitis
- Kienbock’s disease
- Scaphotrapezoid-trapezial (STT) joint arthritis
- Ulnar nerve entrapment
Index Patient: Plain Films

Please pause to evaluate, continue to view findings

Source: PACS, BIDMC
Index Patient: Plain Films

Please pause to evaluate, continue to view findings.
Index Patient: Plain Film Interpretation

- Abnormal sclerosis of scaphoid
- Degenerative changes in the radiocarpal joint involving the scaphoid fossa with subchondral sclerosis and marginal osteophytes
- Widening of the scapholunate interval with proximal displacement of the capitate
- No acute fracture or dislocation seen
- Appearance of scaphoid reflects degenerative change vs. AVN
- Appearance consistent with possible SLAC wrist
- To better characterize underlying cause of degenerative arthritis and possible ligamentous injury, an MRI was ordered
Index Patient: Coronal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Slice 1

Source: PACS, BIDMC
Index Patient: Coronal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Source: PACS, BIDMC
Index Patient: Coronal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Slice 3
Index Patient: Coronal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Index Patient: Coronal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Slice 5

Source: PACS, BIDMC
Index Patient: Coronal T2-weighted FS MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Index Patient: Coronal T2-weighted FS MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Slice 2
Index Patient: Coronal T2-weighted FS MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Index Patient: Coronal T2-weighted FS MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Index Patient: Coronal T2-weighted FS MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.
Index Patient: Sagittal T1-weighted MRI

Please scroll through sequences to evaluate, findings will be provided on summary slide following these images.

Widened CL angle!
Index Patient: MRI Interpretation

- Widening of SL interval consistent with SL ligament tear
- Severe radio-scaphoid osteoarthritis, but no definite thinning of capitate cartilage and proximal migration of the capitate, consistent with stage II SLAC wrist
- Peripheral low signal intensity associated with T2 hyperintense signal within subchondral aspects of the scaphoid, lunate, trapezoid, capitate, and hamate consistent with subchondral cysts vs. erosions vs. synovitis
- Dorsal intercalated segment instability (DISI) deformity (CL angle > 30°) noted on sagittal view, dorsiflexion of lunate with posterior subluxation of distal carpal row
Overview

- Wrist: Normal Anatomy & Biomechanics
- Approach to Wrist Imaging: Menu of Tests & Efficacious Use
- Index Patient
- SLAC Wrist: Clinical Implications & Radiographic Diagnosis
- SLAC Wrist: Treatment
SLAC Wrist: Etiology

- A condition of progressive wrist instability causing advanced arthritis of radiocarpal and midcarpal joints
- Describes the specific pattern of degenerative arthritis seen in chronic dissociation between the scaphoid and lunate
- Chronic SL ligament injury creates a DISI deformity – scaphoid becomes flexed volarly and lunate is extended dorsally
- Leads to aberrant force distribution across midcarpal and radiocarpal joints and malalignment of concentric joint surfaces
- Initially presents as arthritis of radioscaphoid joint, then progressing to arthritis of capitolunate joint
SLAC Wrist: Etiology

- Causes can be traumatic or atraumatic
  - Scaphoid fracture (SNAC wrist)
  - Scapholunate ligament tear
  - Kienbock’s disease (avascular necrosis of lunate)
  - Calcium pyrophosphate dehydrate deposition disease
  - Rheumatoid arthritis
  - Neuropathic diseases
  - $\beta_2$-microglobulin associated amyloid deposition disease
  - Extra-intestinal manifestation of IBD
SLAC Wrist: Presentation

- Symptoms
  - Difficulty bearing weight across wrist
  - Pain over dorsal surface of wrist, specifically in region of SL interval
  - Progressive hand weakness
  - Wrist stiffness

- Physical Exam
  - Tenderness to palpation over dorsal aspect of wrist
  - Significantly decreased ROM
  - Weakened grip strength
  - Positive Watson scaphoid shift test
SLAC Wrist: Radiographic Diagnosis

- **Stage I SLAC Wrist**: arthritis between scaphoid and radial styloid
- >3 mm diastasis between scaphoid and lunate (‘Terry Thomas sign’)
- PA radiograph shows radial styloid beaking, sclerosis and joint space narrowing between scaphoid and radial styloid

Source: www.orthobullets.com
SLAC Wrist: Radiographic Diagnosis

- **Stage II SLAC Wrist**: arthritis between scaphoid and entire scaphoid facet of the radius
- **>3 mm diastasis** between scaphoid and lunate (‘Terry Thomas sign’)
- PA radiograph shows **sclerosis and joint space narrowing** between the scaphoid and the entire scaphoid fossa of distal radius

Source: www.orthobullets.com
SLAC Wrist: Radiographic Diagnosis

- **Stage III SLAC Wrist**: arthritis between capitate and lunate
- **>3 mm diastasis** between scaphoid and lunate (‘Terry Thomas sign’)
- PA radiograph shows **sclerosis and joint space narrowing** between the lunate and capitate with **subchondral cyst formation**
- Eventually, the **capitate will migrate into the void** created by the SL dissociation
SLAC Wrist: Radiographic Diagnosis

- **Stage III SLAC Wrist:** arthritis between capitate and lunate
- **>3 mm diastasis** between scaphoid and lunate (‘Terry Thomas sign’)
- PA radiograph shows **sclerosis and joint space narrowing** between the lunate and capitate with **subchondral cyst formation**
- Eventually, the capitate will **migrate into the void** created by the SL dissociation

Source: www.orthobullets.com
SLAC Wrist: Radiographic Diagnosis

- In scapholunate ligament injury, can also see ‘cortical ring sign’ caused by scaphoid malalignment
- May be present in any of the three stages of SLAC wrist

Source: www.orthobullets.com
SLAC Wrist: Radiographic Diagnosis

- Dorsal intercalated segmental instability (DISI) is easily diagnosed on lateral plain film
- DISI is caused by disruption of the SL articulation
- Lunate becomes angulated dorsally
- Radiographs are consistent with DISI pattern when scapholunate angle > 80⁰ or capitolunate angle > 30⁰
SLAC Wrist: Radiographic Diagnosis

- MRI is unnecessary for staging but would show:
  - Thinning of articular surfaces of the proximal scaphoid
  - Synovitis of the scaphoid facet of distal radius and capitolunate joint
  - Complete or partial rupture of the SL ligament

Source: PACS, BIDMC
Overview

- Wrist: Normal Anatomy & Biomechanics
- Approach to Wrist Imaging: Menu of Tests & Efficacious Use
- Index Patient
- SLAC Wrist: Clinical Implications & Radiographic Diagnosis
- SLAC Wrist: Treatment
SLAC Wrist: Treatment

- **Non-operative:**
  - Address underlying cause (e.g. treatment of rheumatologic disease)
  - NSAIDs
  - Wrist immobilization with splints
  - Corticosteroid injections

- **Operative**
  - Radial styloidectomy
  - Anterior and posterior interosseous nerve denervation
  - Distal scaphoid pole excision
  - Proximal row carpectomy
  - Four-corner arthrodesis
  - Capitohamate arthrodesis
SLAC Wrist: Radial styloidectomy

- Indicated for Stage I disease
- Excision of radial styloid
- Prevents impingement between proximal scaphoid and radial styloid
- May be performed open or arthroscopically via 1,2 portal
- Can be combined with other procedures for maximal relief in symptoms

Source: http://www.msdlatinamerica.com/ebooks/HandSurgery
SLAC Wrist: Proximal Row Carpectomy

- Indicated for Stage II disease
- Excision of entire proximal row of carpal bones while preserving radioscaphocapitate (RSC) ligament (to prevent ulnar subluxation)
- Contraindicated if RSC ligament is incompetent
- Results in capitate articulating with lunate fossa of radius
- Provides relative preservation of strength and motion

SLAC Wrist: Four-corner arthrodesis

- Indicated for Stage II & III disease
- After removal of cartilagenous structures, the capitate, lunate, hamate and triquetrum are fused using cancellous bone graft from either the radius or iliac crest
- Can also be fixed using circular plates
- Preserved articulation between lunate and distal radius
- Also provides relative preservation of strength and motion
- Similar long-term results between PRC and four-corner fusion

SLAC Wrist: Four-corner arthrodesis

AP film showing circular plate fixation for 4-corner fusion for SLAC wrist

SLAC Wrist: Capitolunate arthrodesis

AP film showing solid capitolunate fusion using cannulated screws for SLAC wrist

Back to our patient...

- Upon consultation with his rheumatologist, his symptoms were thought to be extra-intestinal manifestations of his ulcerative colitis.
- His colitis had been dormant for several years, and he had been off treatment during this same time period.
- He was restarted on Sulfasalazine 500 mg QID.
- On one month follow-up, his symptoms had decreased significantly and his right wrist ROM was back to normal.
Summary

- Scapholunate dissociation or ligament injury can lead to DISI deformity and eventually SLAC wrist
- Plain films (PA, lateral, oblique) are the study of choice for diagnosing and staging of SLAC wrist
- MRI can be used to elucidate the etiology of SLAC wrist, but is usually not necessary
- Several surgical techniques, including radial styloidectomy, denervation, proximal row carpectomy, and 4-corner fusion, have been shown to have positive outcomes in patients with SLAC wrist
References

References


Image & Web References

Acknowledgements

- Dr. Justin Kung
- Dr. Omer Awan
- Dr. Gunjan Senapati
- Dr. Jawad Hussain
- Dr. Gillian Lieberman
- Megan Garber