Carpal Fractures and Dislocations

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Anatomy of the Wrist

- Carpal bones tightly linked by capsular and interosseous ligaments.
- Capsular (extrinsic) ligaments originate from the radius and insert onto the carpus.
- Interosseous (intrinsic) ligaments traverse the carpal bones.
- The lunate is the key to carpal stability.
Lunate

- Connected to both scaphoid and triquetrum by strong interosseous ligaments.

- Injury to the scapholunate or lunotriquetral ligaments leads to asynchronous motion of the lunate and leads to dissociative carpal instability patterns.
Intercarpal Ligaments

- The proximal and distal carpal rows are attached by capsular ligaments on each side of the lunocapitate joint.

- Injury to these ligaments leads to abnormal motion between the two rows, and non-dissociative wrist instability patterns.
Dorsal Extrinsic Ligaments

DRC: dorsal radio-carpal
DIC: dorsal inter-carpal
Volar Ligaments
Interosseous Ligaments:

looking dorsal to volar
Scapholunate Ligament

- Three Portions
  1. Dorsal
     - Strongest
  2. Proximal/membranous
     - Capsule
  3. Palmar
Imaging

• Plain radiographs: multiple views necessary:
  – Anteroposterior
  – Lateral
  – Oblique
  – Clenched-fist AP
  – Radial and ulnar deviation
General Principles of Treatment

• Carefully evaluate x-rays for subtle fractures and/or evidence of carpal instability.

• Reduce and immobilize scaphoid fractures or perilunate injuries pending definitive treatment.

• Diagnose and appropriately treat ligament and bony injuries.
Scaphoid Fractures

“Therapy of this fracture has been characterized by: confusion, impatience, invention, intervention, reaction, re-evaluation and frustration.”

Mazet & Hohl, JBJS, 45A, 1963
Introduction

• Scaphoid most commonly fractured carpal bone
  – Incidence of scaphoid fractures estimated to be ~15% of all wrist injuries.
    • 160 scaphoid fx’s among 1,052 pts. seen in E.D. for wrist injuries.
Mechanism of Injury

• Fall on outstretched hand
  – 75% to 80%

• Kick-back injury, e.g., jammed drill, etc
  – 12% to 15%

• Direct Blow
  – 2% to 3%
Evaluation

- History - suspect scaphoid injury in anyone with radial wrist pain after an injury
- Physical Exam
- Imaging
Physical Findings

• “Snuff box” tenderness
  – scaphoid waist exposed with ulnar deviation

• Pain with palpation of scaphoid tuberosity

• Limited painful wrist ROM, especially forced dorsiflexion
Differential Diagnosis: radial sided wrist pain

• Scapholunate instability
  – Pain and clicking in wrist
  – Tender just distal to Lister’s tubercle
  – Positive “Watson” test
• FCR tendon rupture or tendinitis
• Radial styloid fracture
• deQuervain’s disease
• CMC (basal) joint arthrosis
• Radio-scaphoid arthrosis
Imaging

- **X-rays**  
  - Initial films non-diagnostic in up to 25% of cases
- **CT Scan**
- **MRI** - most accurate
- **Bone Scan** – rarely used
Radiographic Imaging of Scaphoid Fractures

- PA of wrist
- Lateral of wrist
- Scaphoid view
  - PA x-ray with wrist neutral and in ulnar deviation
  - elongates scaphoid to better visualize
- Pronated oblique view
Standard PA wrist view
CT scan

- In plane of scaphoid
- Demonstrates subtle mal-alignment

Humpback deformity
Classification

• Typically by location:
  – Proximal third
  – Middle third (Waist)
  – Distal Third
  – Tuberosity
Scaphoid Fxs: Location Of Fracture

- Tuberosity:  17% to 20%
- Distal Pole: 10% to 12%
- Waist: 66% to 70%
  - Horizontal oblique: 13% to 14%
  - Vertical Oblique: 8% to 9%
  - Transverse: 45% to 48%
- Proximal Pole:  5% to 7%

Leslie, JBJS 63-B, 1981
Why is Fracture Location so Important in the Scaphoid?

- **Blood supply**
  - Primary vascular supply enters dorsal ridge and runs *retrograde* to the proximal scaphoid.
  - The more proximal the fracture, the more likely are healing complications.
Scaphoid blood supply
Management of Suspected Scaphoid Fracture

• Clear injury and positive exam with normal x-rays
  – immobilize for 7-10 days (thumb spica best)
  – Repeat x-rays if patient still symptomatic

• If pain still present but x-ray continues to be normal
  – consider MRI early
  – recast and f/u at 3 weeks

• If acute diagnosis necessary
  – consider MRI or CT early
Treatment Options - Acute Injuries

• **Nonoperative**
  – Short vs. long-arm cast
  – Thumb spica vs. standard cast

• **Operative**
  – Percutaneous pin or screw fixation
  – ORIF
Indications for Nonoperative Treatment

- **Ideal indication** - nondisplaced distal third fracture
- **Tuberosity fractures** also heal well with casting
- 80-90% of **middle third fractures** heal
- Only 60-70% of **proximal third fractures** heal
  - of those that do, many have deformity
Nonoperative Treatment

• Immobilize in slight flexion and slight radial deviation.

• **Initial cast:** long-arm thumb spica cast for 6 weeks
  – shown to lead to more rapid union and less nonunion
  – Gellman et al, JBJS, 1989

• Replace with short-arm thumb spica cast until united.

• **Expected time to union:**
  – Distal third = 6-8 weeks
  – Middle third = 8-12 weeks
  – Proximal third = 12-24 weeks
Cast Management

- Cooney, CORR (1980):
  - Overall, 37 / 45 (82%) acute fx’s healed
  - Nondisplaced fx : 27 / 27 healed
    - time to union: 9.4 weeks
  - Displaced fx : 10 / 13 healed (77%)
    - 4 with asymptomatic malunions
Type of Cast to Use

- Gellman, JBJS-Am, (1989):
  - 51 acute fx’s followed prospectively
  - Short- vs. long-arm cast
  - LAC: n=28, 100% union
    - Time to union: 9.5 weeks
  - SAC: n=23, 65% union; 2 nonunions, 6 delayed unions
    - Time to union: 12.7 weeks

Improved results with long arm cast
Cast Management: Summary

- Cast treatment of non-displaced scaphoid waist and distal pole fractures is safe, effective, reliable, reproducible.
- Displaced fractures clearly benefit from ORIF.
- For experienced surgeon, ORIF may return patients to work faster and lower rehab costs.
- With advent of percutaneous techniques, early fixation is becoming more appealing.
Cast Management: Alternatives

- Open reduction, internal fixation (ORIF)
  - Headed screws placed radially
  - Headless screws
  - K-wires
- Percutaneous fixation with cannulated screw
  - Volar approach
  - Dorsal approach
Casting vs. Fixation


- 25 pts with acute nondisplaced fracture of the scaphoid waist
- Randomized to either:
  - cast immobilization (14)
  - fixation with a percutaneous cannulated screw (11)
- Fracture union
  - screw fixation group 7 weeks
  - cast immobilization group 12 weeks (p = 0.0003)
- Return to work
  - screw fixation 8 weeks
  - cast immobilization 15 weeks (p = 0.0001)
- no significant difference in ROM or grip strength at the 2 yr f/u
Indications for Surgery

- **Unstable Scaphoid Fractures**
  - Displacement of $> 1$ mm
  - Radiolunate angle $> 15$ degrees
  - Scapholunate angle of $> 60$ degrees
  - “Humpback” deformity
  - intra-scaphoid angle $> 10$ degrees

- **Nonunion**
Herbert Screw

Differential pitch and jig provides compression
ORIF: volar approach
Herbert screw with compression jig
Final screw placement
Dorsal Approach

Proximal pole fractures
Percutaneous Fixation

Volar

Dorsal
Guidewire centered in scaphoid in all views
Derotation pin

cannulated drill
Cannulated Screw
Outcomes and Complications

- AVN of proximal pole
- Nonunion
- Malunion
- Arthritis (SNAC) wrist
Scaphoid Non-Union

- Introduction
- How does it occur?
- Should it be treated?
- Can it be treated?
- How and when should it be treated?
Treatment Options - Scaphoid Nonunion: *Scaphoid preserving*

- ORIF with cancellous bone graft
- ORIF with structural tricortical graft
- ORIF with vascularized graft
- Percutaneous fixation alone
Treatment Options - Scaphoid Nonunion: *Salvage*

- Proximal row carpectomy
- Scaphoid excision and limited intercarpal fusion: *four corner*
- Distal pole excision
- Proximal pole excision or replacement
CT SCAN AT 4 MON. POST TREATMENT
51 y/o man presents with acute onset ulnar sided wrist pain after playing golf
Scaphoid Nonunion: Diagnosis

- Non-union often an "incidental" finding after re-injury to wrist
  - Probable disruption of a previous stable, and therefore asymptomatic, scaphoid non-union
- Exam: tender, loss of motion, weakness
Non-union: How Does It Occur?

• Fractures at risk
  – Waist fracture, especially if fracture line is transverse to scaphoid axis (Russe)
  – Displacement > 1mm associated with fracture instability (Weber, Gellman)
  – Fracture displacement occurring while in cast (Leslie, Herbert)
  – Inadequate treatment (Dias)
Non-union: How Does It Occur?

- Fractures at risk
  - Disrupted vascular patterns

Gelberman, J Hand Surg, 1980
Scaphoid Non-union: Should It Be Treated?

- Natural history of scaphoid nonunion suggests high incidence of wrist arthrosis
  - Mack, et al., JBJS, 1984:
  - 47 scaphoid nonunions, ranging from 5 to 53 yr. duration
  - *All developed degenerative changes*
  - Duration of non-union correlated with degree of arthrosis
    - 3 patterns of degeneration
Scaphoid Non-union: Should It Be Treated?

- Natural history of scaphoid nonunion suggests high incidence of wrist arthrosis
  - Belsky, et al., JBJS, 1985:
  - 55 scaphoid non-unions, followed for longer than 10 yrs.
  - Earliest degenerative changes noted by 5 yrs.
  - All had significant arthrosis by 10 yrs.
Scaphoid Non-union: predictable pattern of arthrosis

**TYPE I DJD:**
N/U < 10 YR.

**TYPE II DJD:**
N/U ~ 15 YR.

**TYPE III/IV DJD:**
N/U > 25 YR.

MACK, et al., JBJS, 1984
Chronic Non-union: SNAC wrist

Scaphoid Non-union
Advanced Collapse

- Radial styloid - scaphoid arthritis (1)
- Radius- proximal scaphoid joint (2)
- Mid-carpal joint (3)
- Pan-carpal (4)
Scaphoid Non-union: Should It Be Treated?

- Natural history studies strongly suggest scaphoid fractures left untreated lead to carpal collapse patterns and almost 100% certainty of developing degenerative changes.
Scaphoid Non-union: Can It Be Treated?

• Results of treatment of non-union vary widely
  – Green, J Hand Surg, 1984
    • Reports results of Russe type bone grafts
    • Addresses effect of avascular changes in proximal pole
    • 88% union rate; all patients with non-unions < 2yrs.
    • AVN not absolute contra-indication to treatment
Scaphoid Non-union: Can It Be Treated?

• Results of treatment of non-union vary widely

• Schuind, et al., J Hand Surg, 1999
  – Multivariate analysis of 138 surgically treated scaphoid nonunions
  – 75% healing rate
  – **Negative factors:** duration > 5 yr.; radial styloïdectomy; dorsal approach
Scaphoid Non-union: Can It Be Treated?

• Results of treatment of non-union vary widely

• More recent literature reports more favorable healing rates, up to 95% when:
  – 1) deformity corrected;
  – 2) iliac crest bone graft used;
  – 3) rigid internal fixation employed.
Scaphoid Non-union: How And When

- **Volar approach**: waist and distal third
- **Dorsal approach**: proximal pole fractures

- Fibrous interposition material removed
- Liberal use of bone graft
  - Iliac crest better in most reports
Scaphoid Non-union: How And When

- Before degenerative changes begin
  - Poorer prognosis for healing and functional recovery if non-union greater than 5 yr.

- Internal fixation positively correlates with improved chances of healing
Technique: Volar ORIF with bone graft
Exposure

- Gentle zigzag incision directly over the course of the flexor carpi radialis tendon
FCR TENDON: stay on radial side
Non-union
Fibrous non-union removed
Iliac crest graft placed into defect
Compression & Screw Insertion Jig
Edge of trapezium needs to be removed for proper screw placement.
26 y/o male, injured skiing; film at 10 days
4 months post injury, fracture has displaced in cast

-delayed union
18 months post ORIF, full motion, no pain, has returned to full activity
Non-union: Results

- Düppe, JBJS-A (1994):
  - 36 year follow-up of 56 fx’s
  - 52 acute fx’s, 91% union
  - 9 N/U’s: 4 primary, 5 ↓ treatment
    - 3 with DISI
    - 5 with DJD
  - ALL healed patients working
Non-union: Results

• In non-unions where stage I arthrosis is present, ORIF gives consistently satisfactory results.
• In nonunions > 5 yrs, achieving union is very difficult.
• Repeat procedure for persistent non-union has high percentage failure.
Early Non-union

Mild cystic changes, minimal collapse
Percutaneous internal fixation of selected scaphoid non-unions with an arthroscopically assisted dorsal approach

Slade, Geissler et al; JBJS-2003(85)

- 15 patients with early non-unions
- All cases with percutaneous screw fixation and arthroscopic assistance
- No bone grafts used
- All scaphoids healed at average of 14 weeks
Perc screw placement- *don’t over compress*
Non-union: healed at 10 weeks
Non-union with Arthrosis: Salvage

• **Arthrodesis**
  – Intercarpal: 4 corner

• **Proximal row carpectomy**
  – Complication rate lower

• **Arthroplasty**: *not recommended*
Non-union: Summary

- Scaphoid non-union is challenging problem with significant risk for the wrist.
- Left untreated, scaphoid non-unions have a near 100% rate of degenerative disease.
- If approached appropriately scaphoid healing may be achieved.
Perilunate Injuries
Mechanism of Injury

- Load applied to hand forcing the wrist into extension and ulnar deviation
- Severe ligament injury necessary to tear the distal row from the lunate to produce perilunate dislocation

- Injury progresses through several stages:
  - usually begins radially & destabilizes thru body of scaphoid (w/ fx) or thru scapholunate interval (w/ dissociation)
  - force is transmitted ulnarly thru the space of Poirier (between lunate and capitate volarly)
  - next force transmission disrupts the luno-triquetral articulation
Predictable patterns of Injury and Instability
Physical Exam

- Dorsal displacement of the carpus may be seen
- Significant swelling common
  - Evaluate for compartment syndrome
- If lunate is dislocated, median nerve symptoms may be present
Imaging

- Note lack of “colinearity” among the radius, lunate, and capitate on the lateral x-ray.
Imaging

- Note loss of normal carpal “arcs” and abnormal widening of the scapholunate interval.
- Look for associated fractures “trans-scaphoid” injuries
X-ray usually Obvious
X-ray may be subtle
Initial Treatment

- Closed reduction is performed with adequate sedation.

- Early surgical reconstruction if swelling allows.

- Immediate surgery needed if there are signs of median nerve compromise.

- Delayed reconstruction if early intervention is not necessary.
Technique of Closed Reduction

• Longitudinal traction for 5 - 10 minutes

• For dorsal perilunate injuries: apply dorsal directed pressure to the lunate volarly while a reduction maneuver is applied to the hand and distal carpal row

• Palmar flexion then reduces the capitate into the concavity of the lunate.
Closed Reduction and Pinning

• Poor results with closed reduction and pinning alone

• Very difficult to reduce adequately
  – wrist needs to be ulnarly deviated to correct scaphoid flexion
  – radial deviation needed to close S-L gap
  – paradox of reduction
ORIF with volar and dorsal approaches

Procedure of Choice
Provisional closed reduction
Dorsal Approach

Repair S-L ligament
Lunate may be dislocated volarly.

Volar mid-carpal ligament tear
Reduce lunate first- may need to temporary pin to radius
Pin Carpus: S-L, L-T and mid-carpal joints
Trans-scaphoid Perilunate Injuries

• Require reduction and fixation of the fractured scaphoid.

• Most of these injuries best treated
  – ORIF with volar and dorsal approaches
  – repair of injured structures.

• Open repair supplemented by pin and screw fixation.
Fix scaphoid first: dorsal approach
Pin L-T and Mid-carpal joints
Make sure Radius-Lunate-Capitate are colinear and S-L angle restored.
Scaphoid healing
Outcome of Perilunate Injuries

- 14 cases followed for mean of 8 years
- All treated operatively (ave 6 days post-injury)
  - 11 dorsal approach
  - 3 combined dorsal/volar approaches
- Mayo wrist scores:
  - 5 excellent
  - 3 good
  - 5 fair
  - 1 poor
- All cases had radiographic arthrosis that did not correlate with Mayo scores.

Perilunate Injuries Conclusion

- Perilunate fracture dislocations are high-energy injuries
- Must recognize different injury patterns
  - transcaphoid
  - pure ligamentous
  - trans radial-styloid
- Early open and anatomic fixation with volar and dorsal approaches provides the best chance at a reasonable functional result
Bibliography


