Carpal Fractures and Dislocations

John T. Capo, MD

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Revised John T. Capo, MD, January 2006
Original Authors: Thomas F. Varecka, MD
and Andrew H. Schmidt, MD; March 2004

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

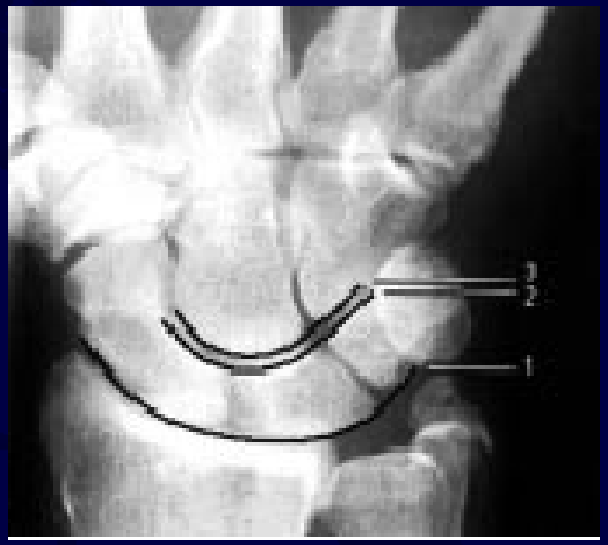
- Connected to both scaphoid and triquetrum by strong interosseous ligaments.

- 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.

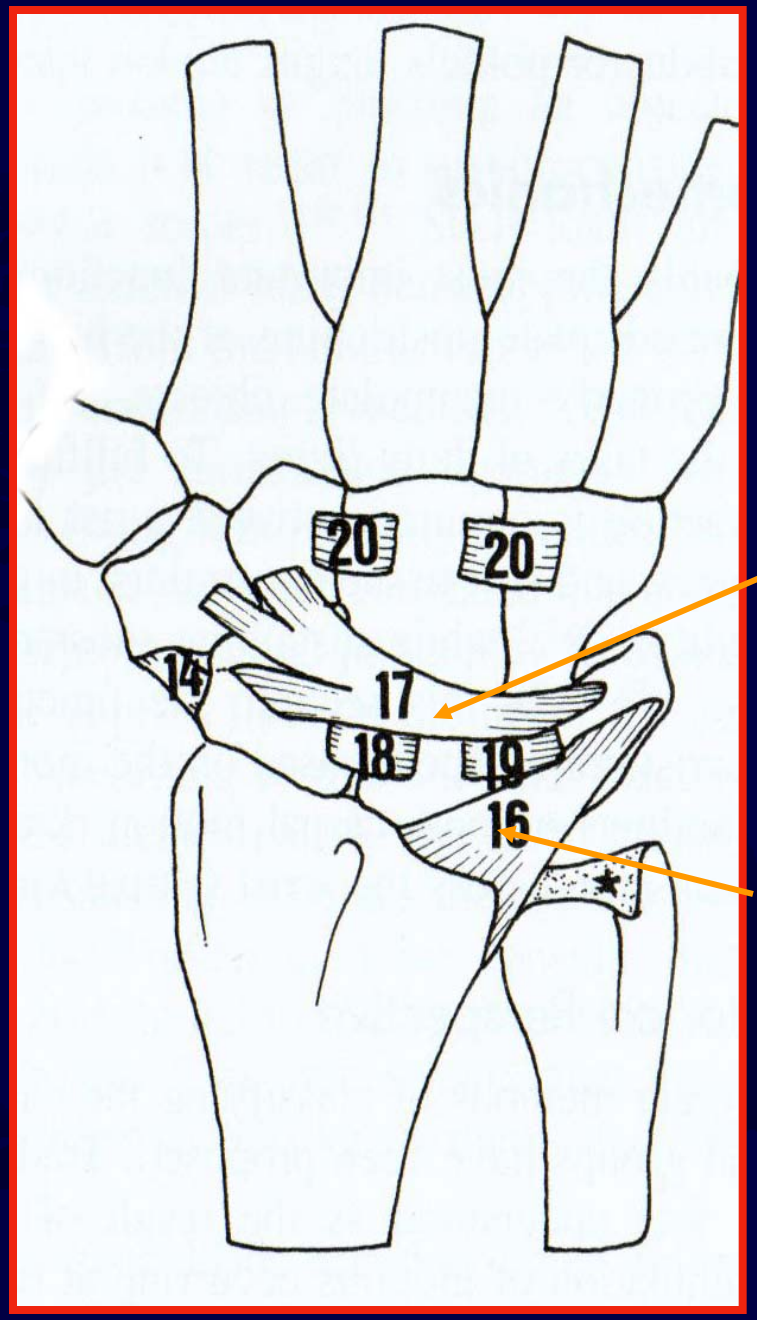
- Injury to these ligaments leads to abnormal motion between the two rows, and non-dissociative wrist instability patterns.

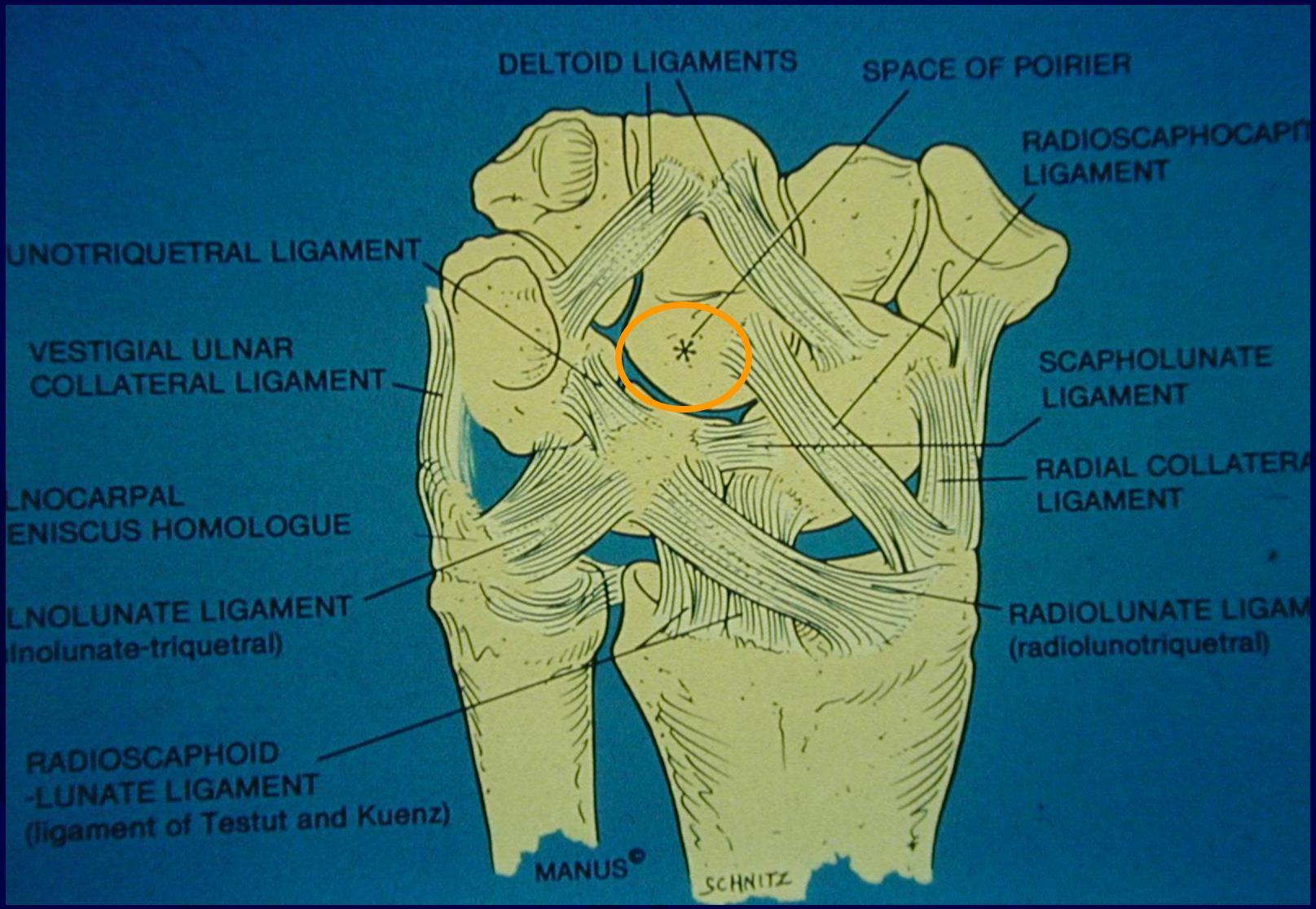


Dorsal Extrinsic Ligaments

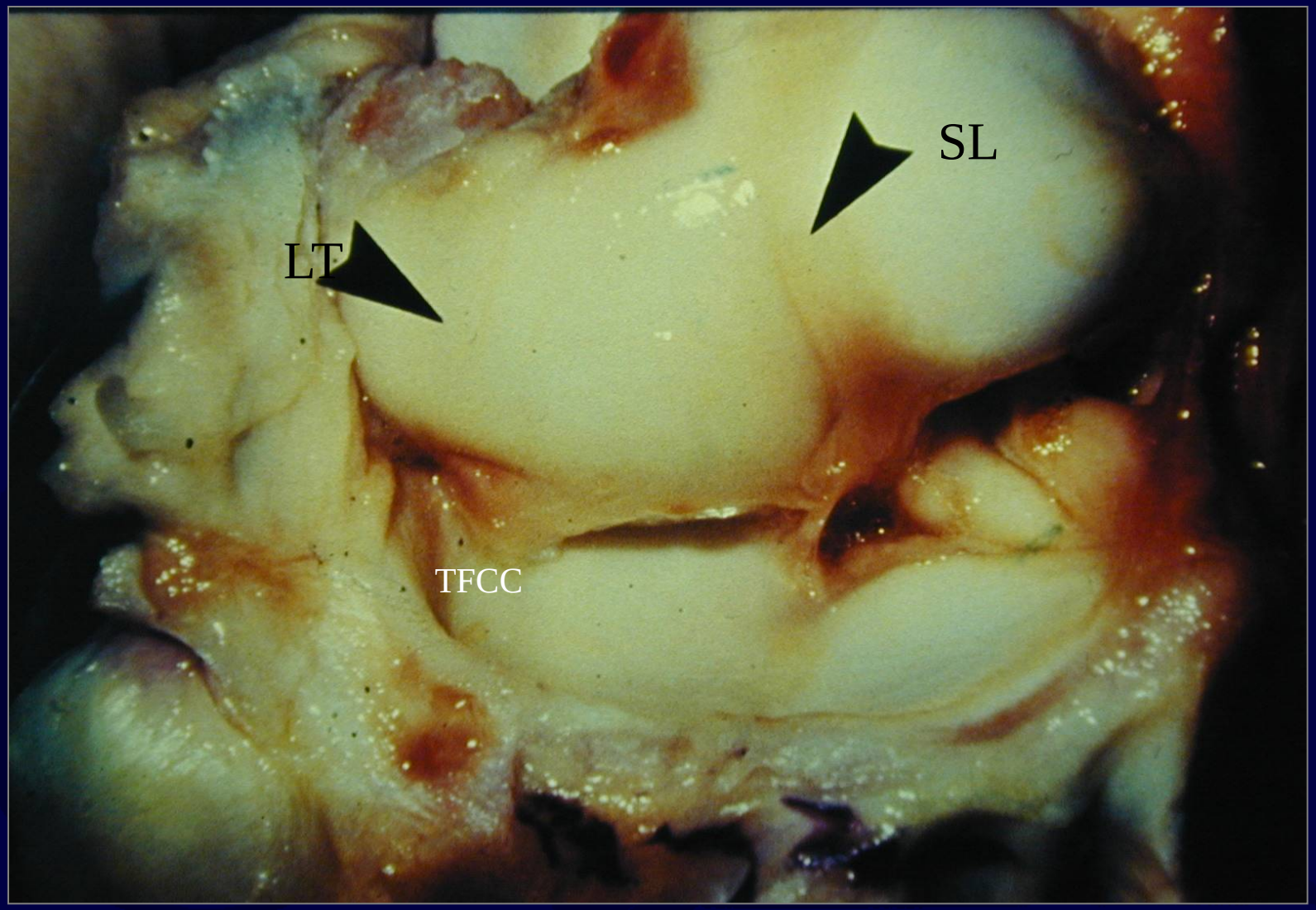
DRC: dorsal radio-carpal

DIC: dorsal inter-carpal



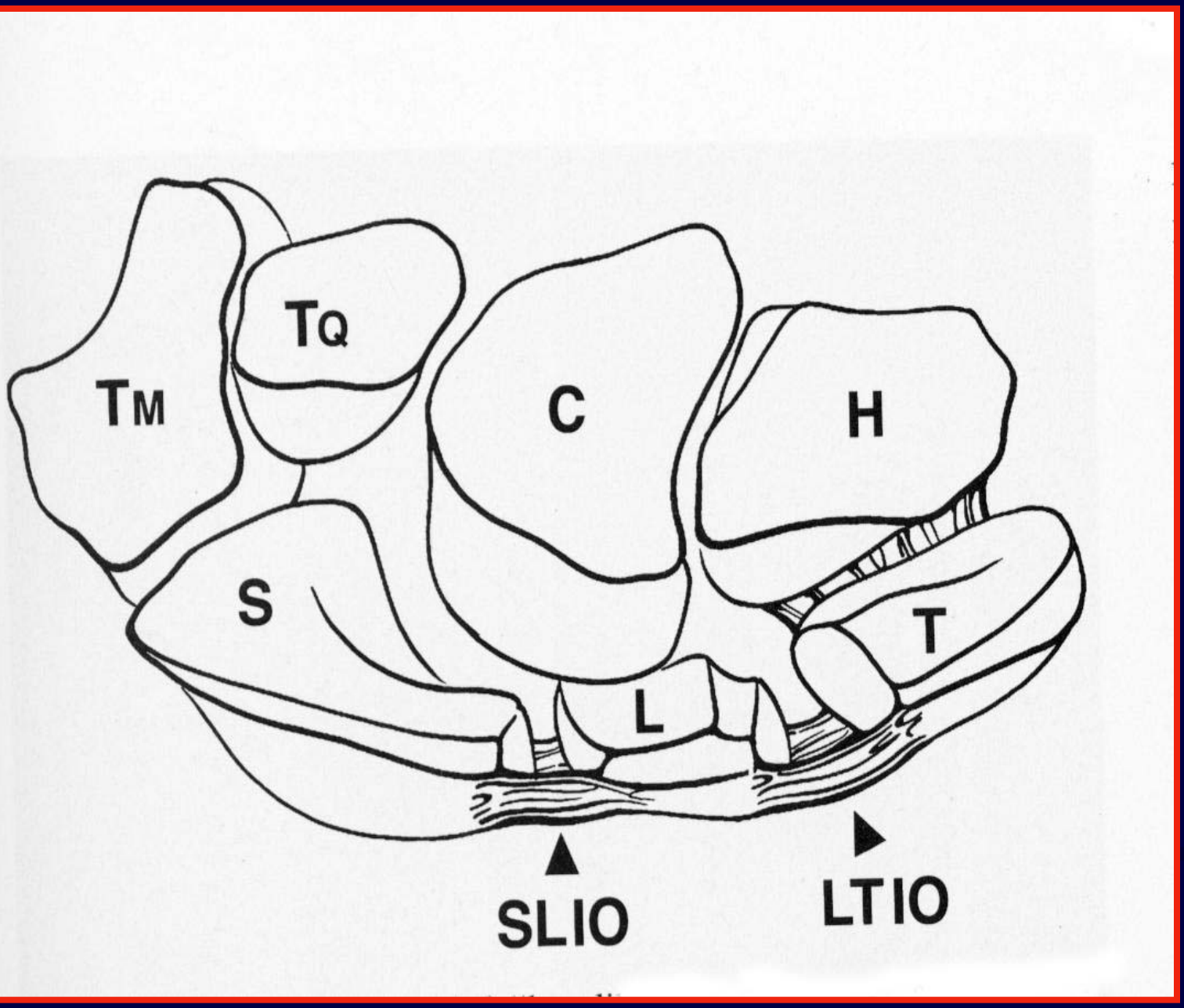


Volar
Ligaments



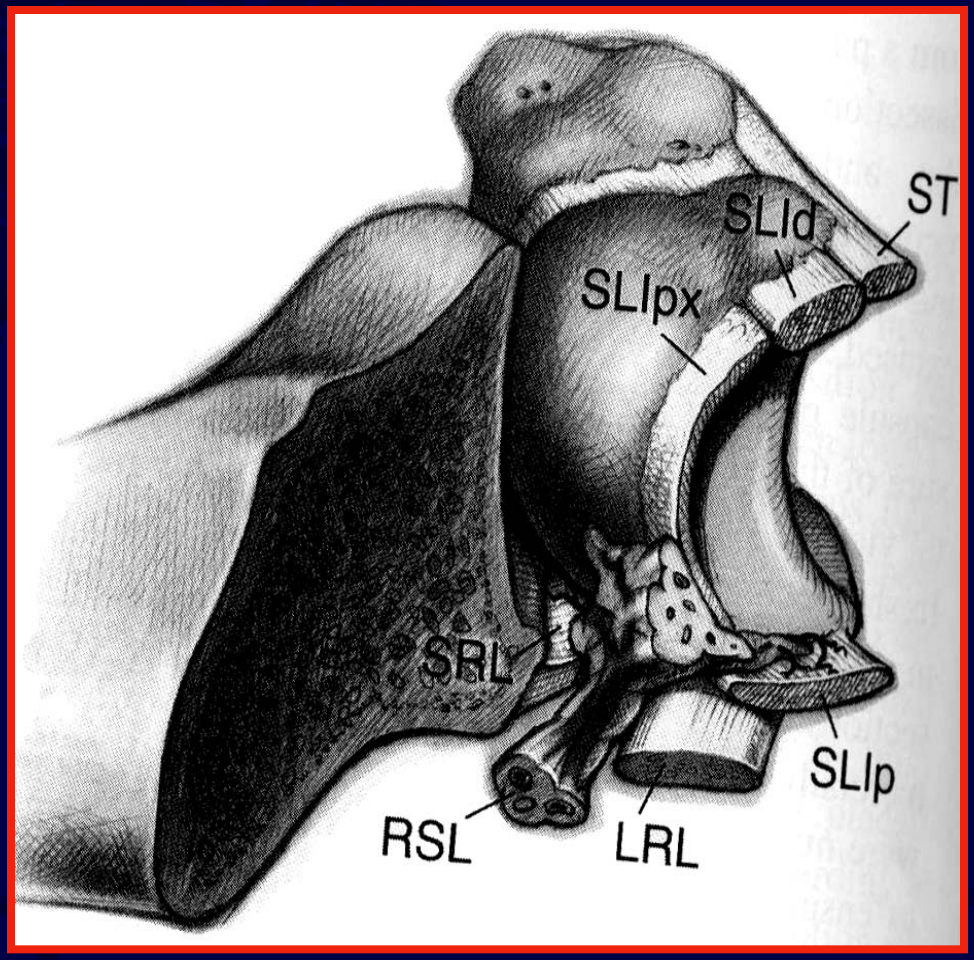
Interosseous Ligaments:

looking dorsal to volar


TM
TQ
C
H
S
T
L
SLIO
LTIO

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.
  - Munk, Acta Orthop Scand, 1995
    - 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

Humpback deformity

-In plane of scaphoid

-demonstrates subtle mal-alignment

Classification

- Typically by location:
  - Proximal third
  - Middle third (Waist)
  - Distal Third
  - Tuberosity

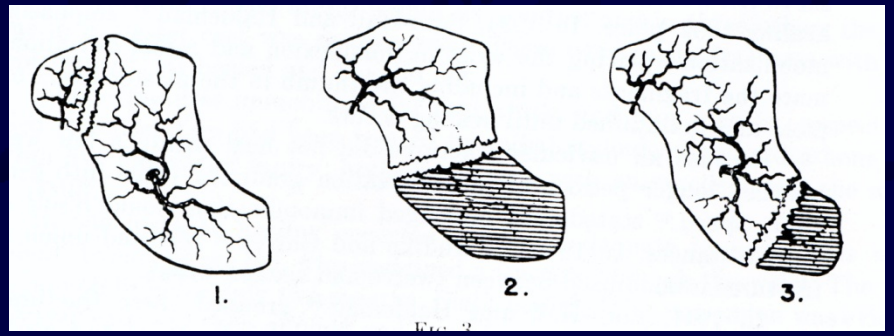
Scaphoid Fxs: Location Of Fracture

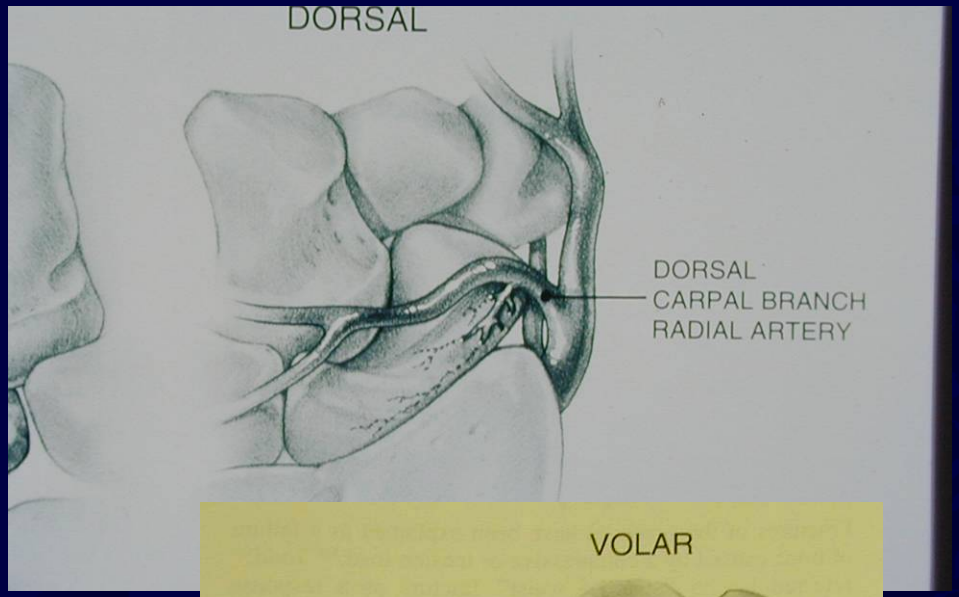
- Tuberosity: 17% to 20%
- Distal Pole: 10% to 12%
- Waist: 66% to 70%
  - Horizontal oblique: 13% to 14%
  - Vertical Oblique: 8% to 9%
  - Transverse: 45% to 48%
- Proximal Pole: 5% to 7%

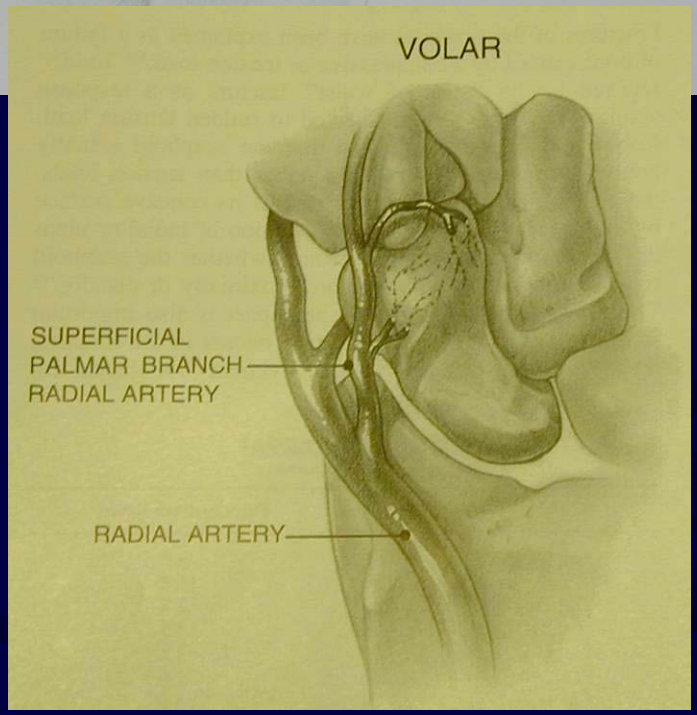
Leslie, JBJS 63-B, 1981

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

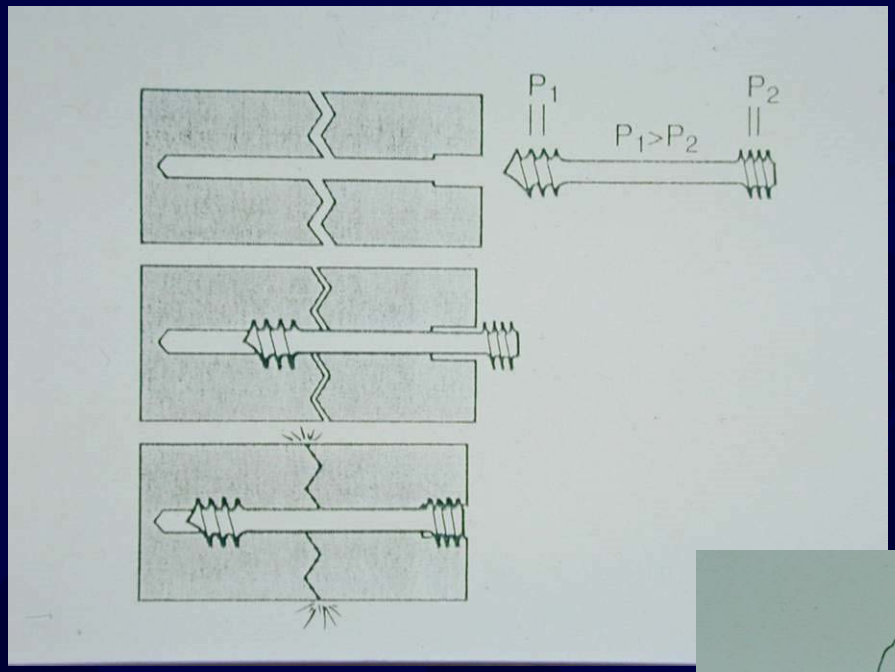
Bond, Shin, et al JBJS 2001

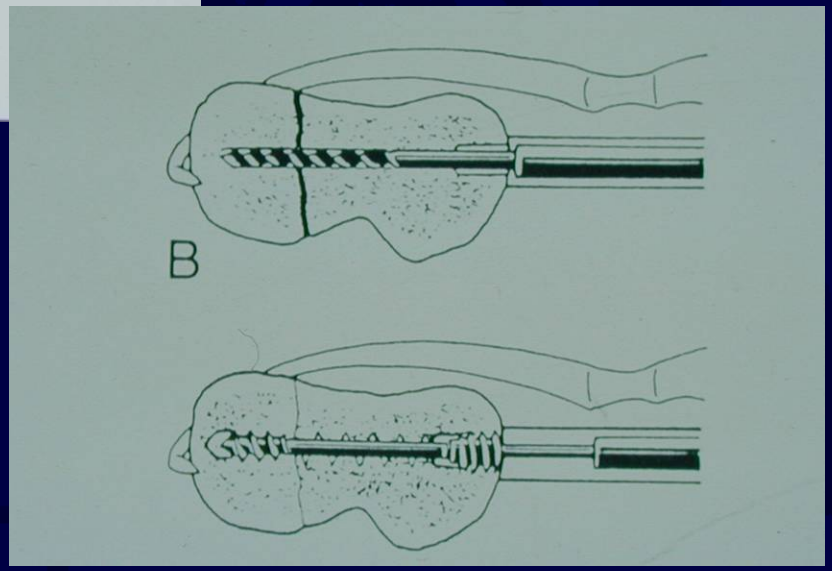
- 25 pts with acute nondisplaced fracture of the scaphoid waist
- Randomized to either:
  - cast immobilization (14)
  - fixation with a percutaneous cannulated screw (11)
- Fracture union
  - screw fixation group 7 weeks
  - cast immobilization group 12 weeks ($p = 0.0003$)
- Return to work
  - screw fixation 8weeks
  - 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

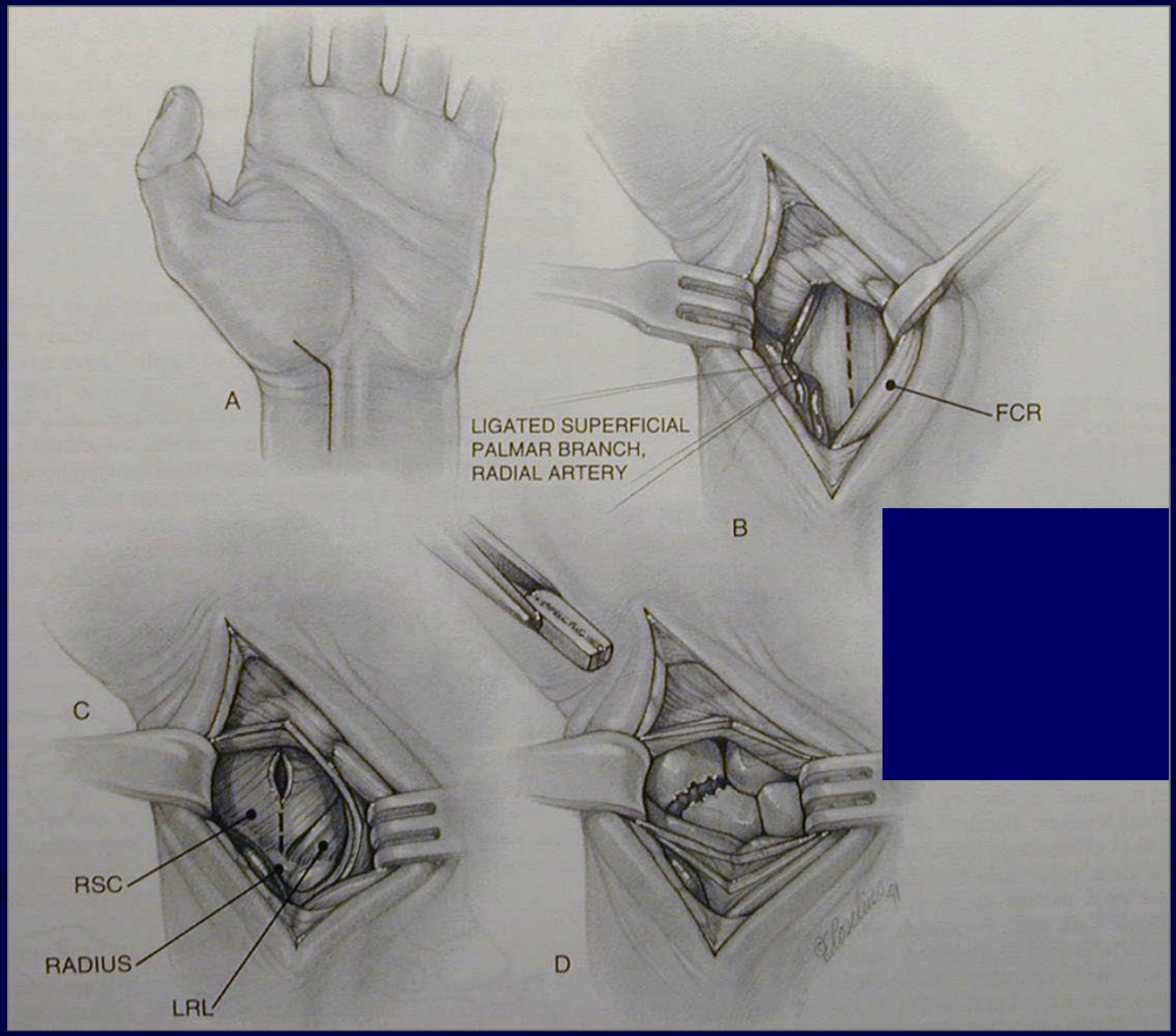
Herbert Screw

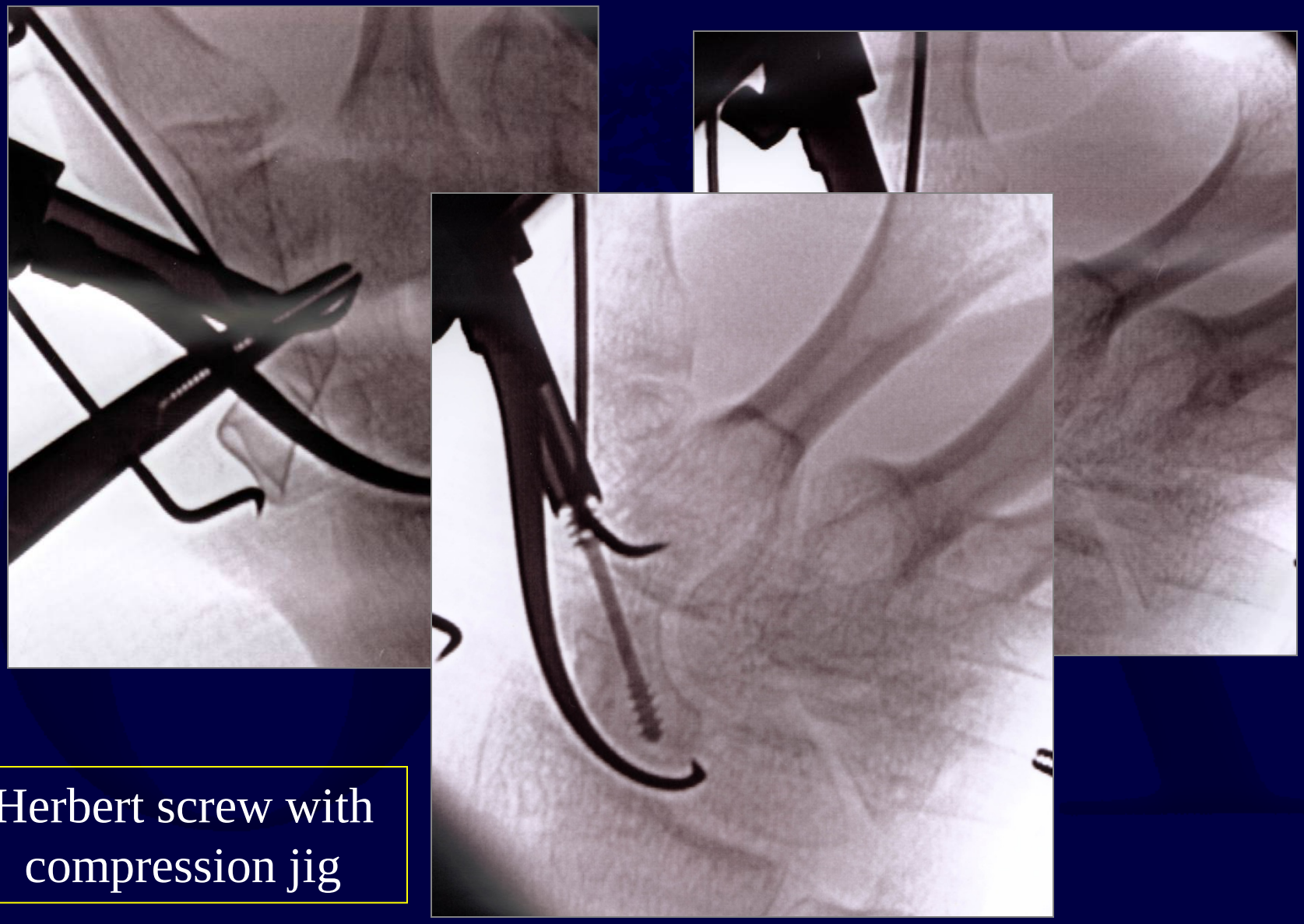




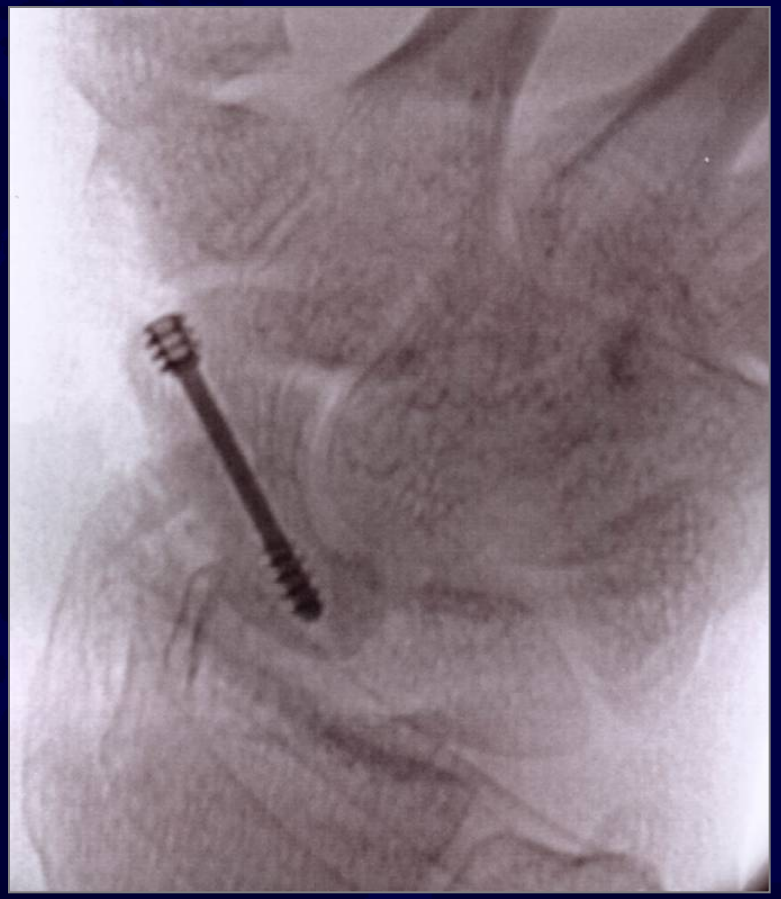
Differential pitch and jig provides compression

ORIF: volar approach



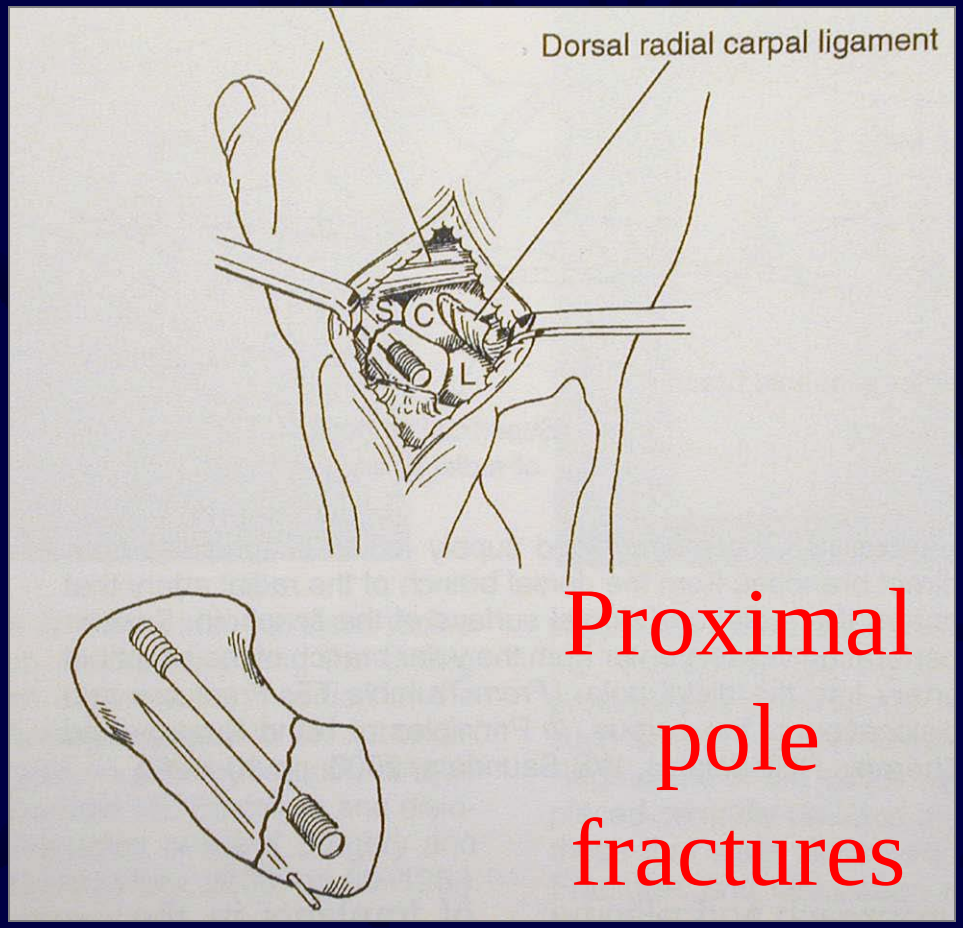


Herbert screw with compression jig

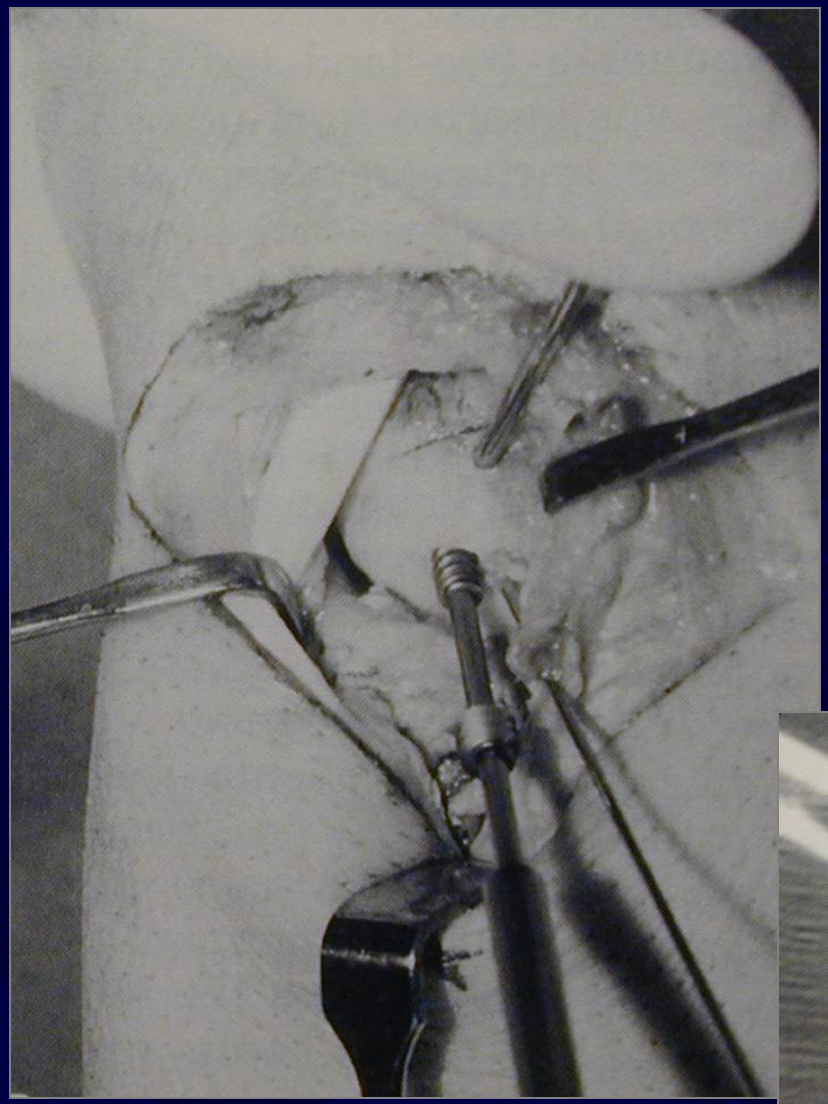


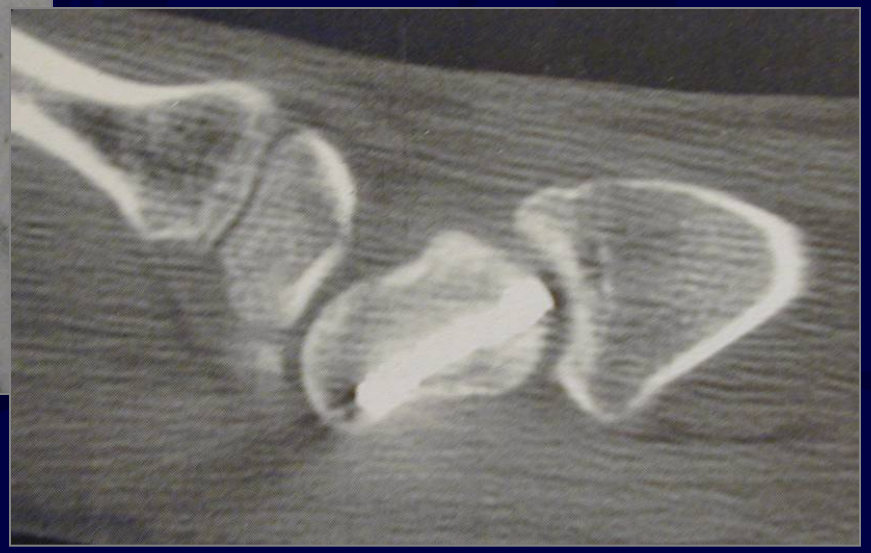
Final screw placement

Dorsal Approach



Proximal pole fractures

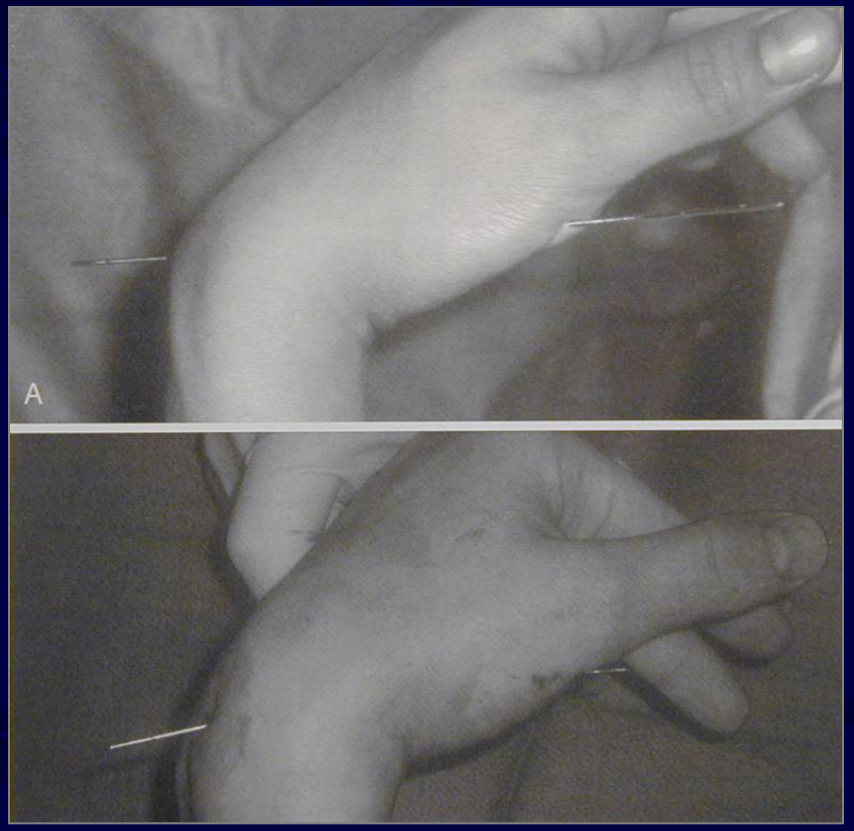


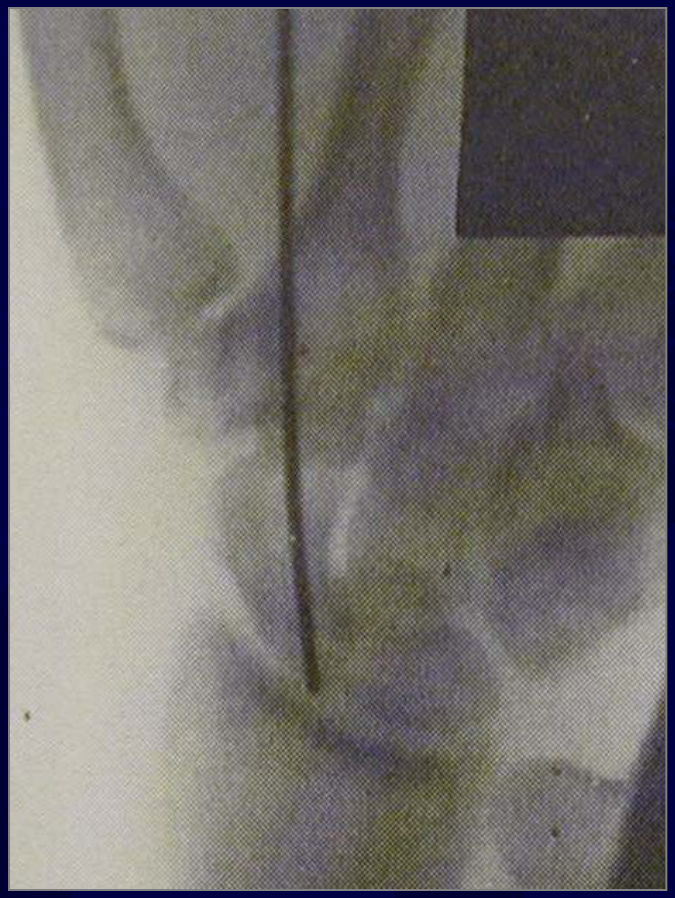


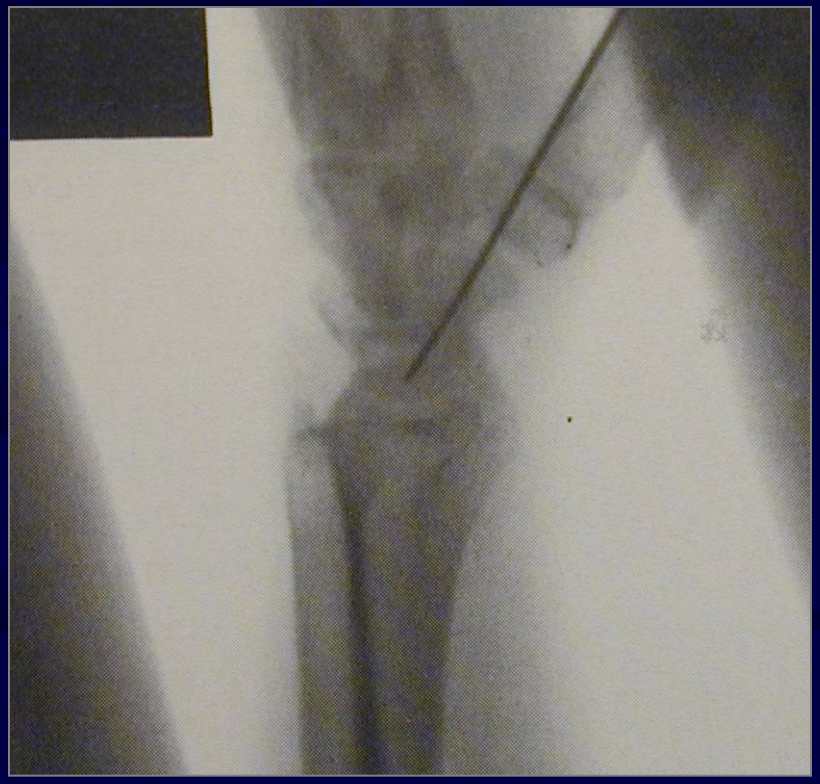
Percutaneous Fixation

Volar

Dorsal



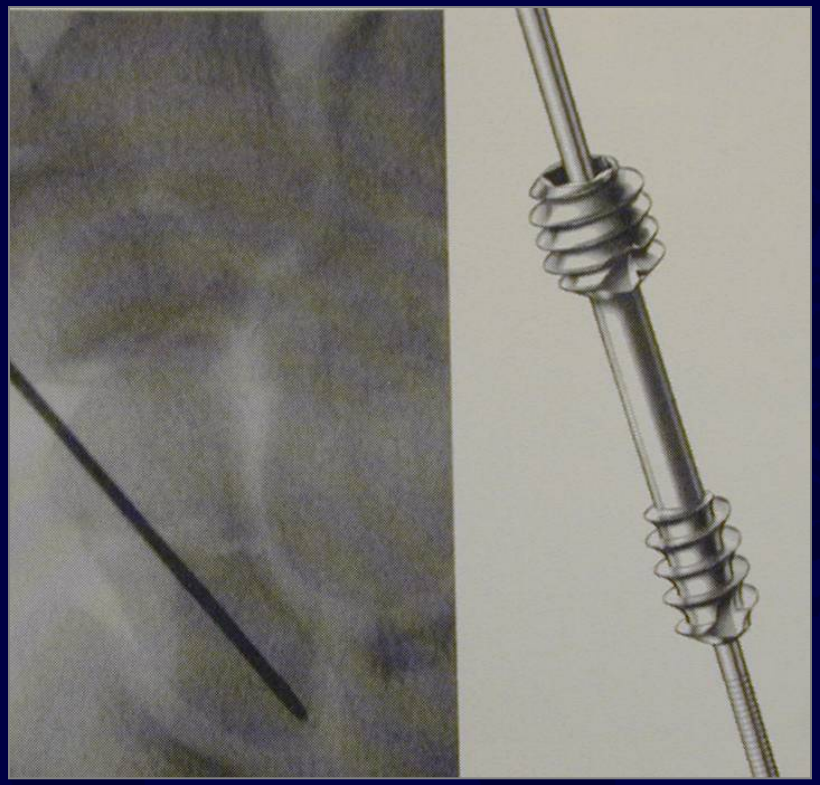




Guidewire centered in scaphoid in all views

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*

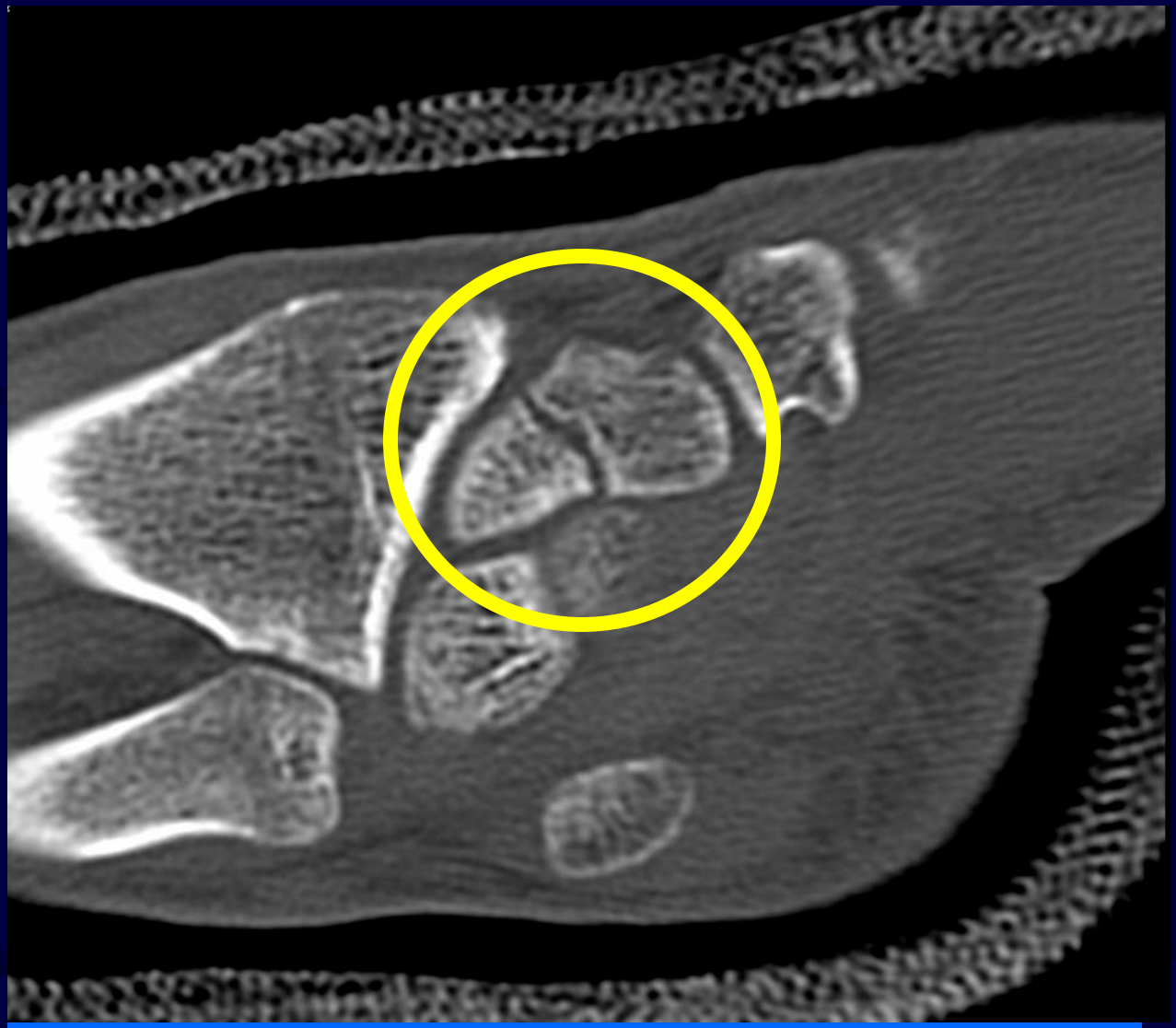
- ORIF with cancellous bone graft
- ORIF with structural tricortical graft
- ORIF with vascularized graft
- Percutaneous fixation alone

Treatment Options - Scaphoid Nonunion: *Salvage*

- Proximal row carpectomy
- Scaphoid excision and limited inter-carpal fusion: *four corner*
- Distal pole excision
- Proximal pole excision or replacement

INITIAL FILM

AFTER 4 MONTHS
IN CAST



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

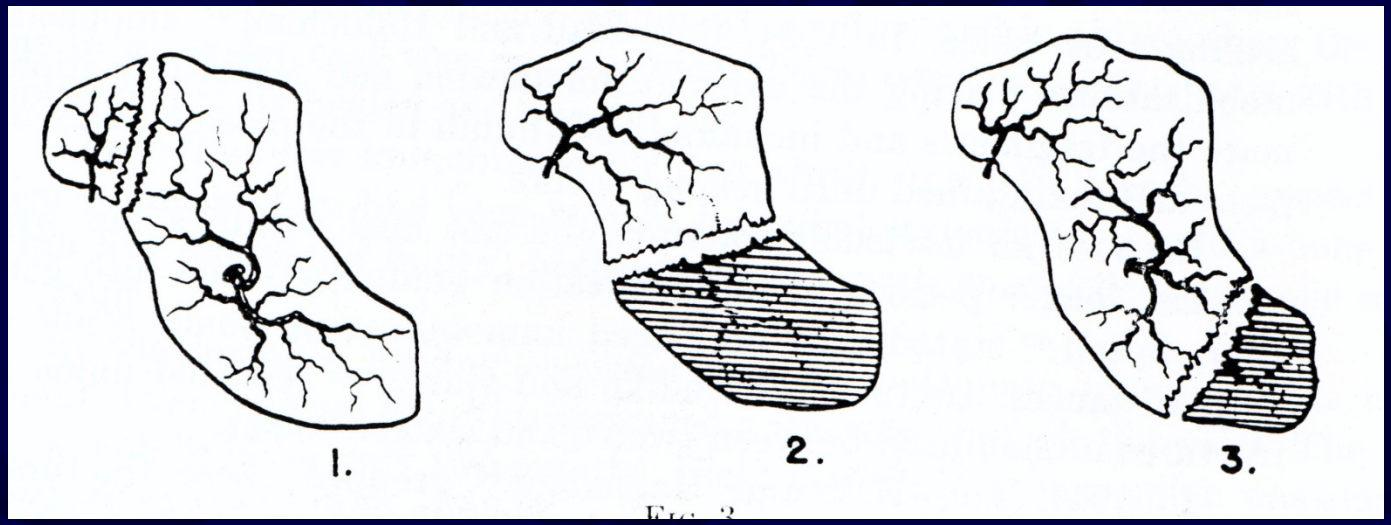
- Non-union often an “incidental” finding after re-injury to wrist
  - *Probable disruption of a previous stable, and therefore asymptomatic, scaphoid non-union*
- Exam: tender, loss of motion, weakness

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

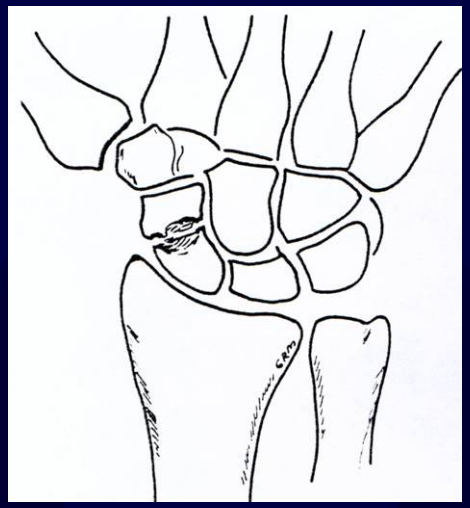
Scaphoid Non-union: Should It Be Treated ?

- 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

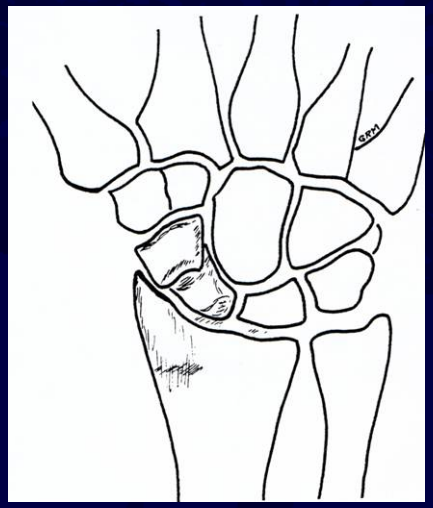
Scaphoid Non-union: Should It Be Treated ?

- 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.*

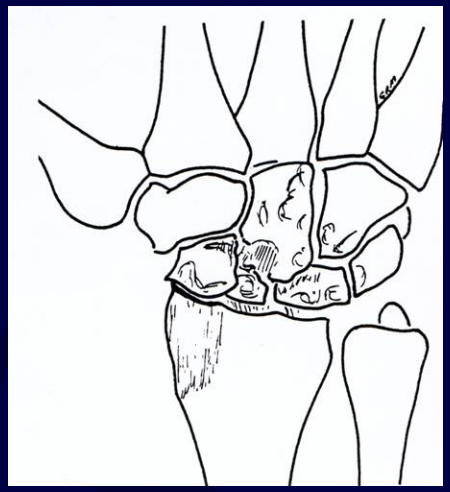
Scaphoid Non-union:
predictable pattern of arthrosis



TYPE I DJD:
N/U < 10 YR.



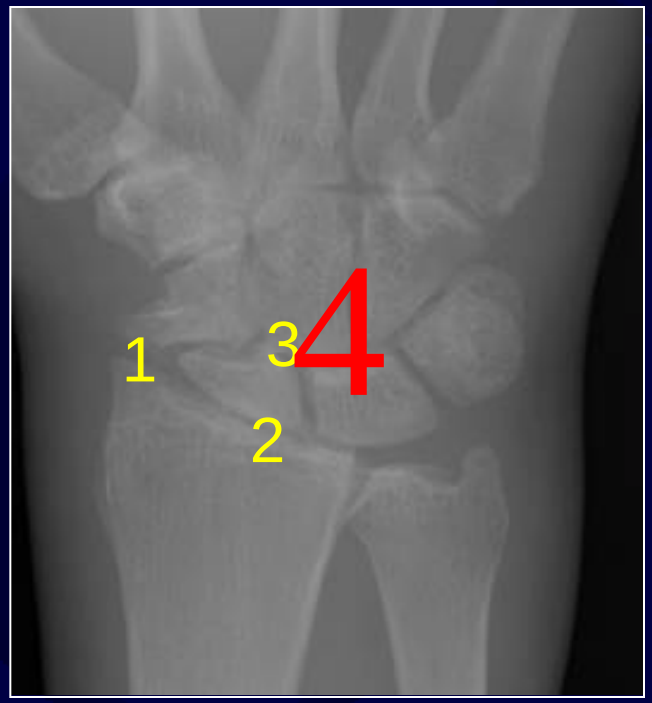
TYPE II DJD:
N/U ~ 15 YR.



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 styloidectomy; 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

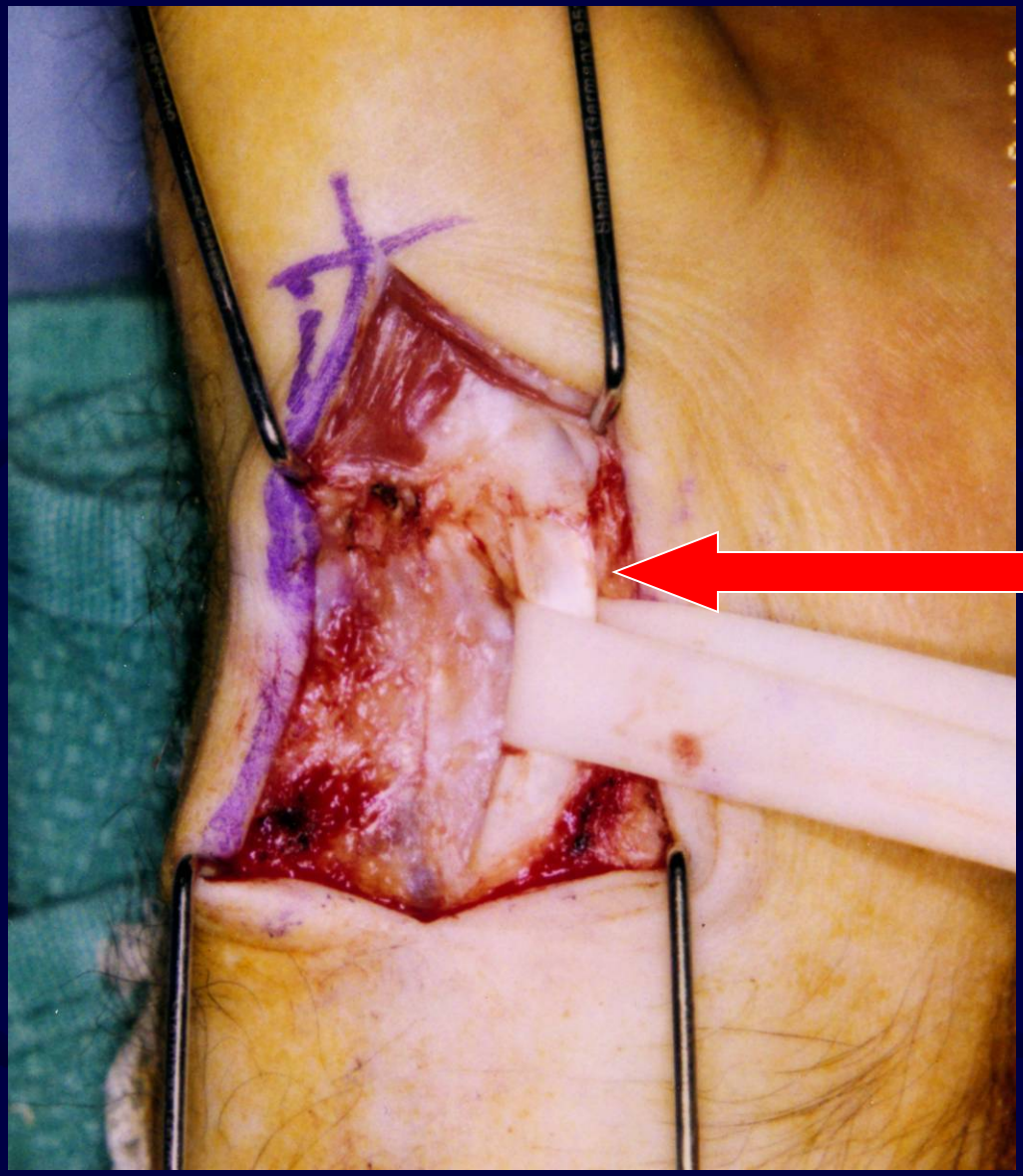
Scaphoid Non-union: How And When

- 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

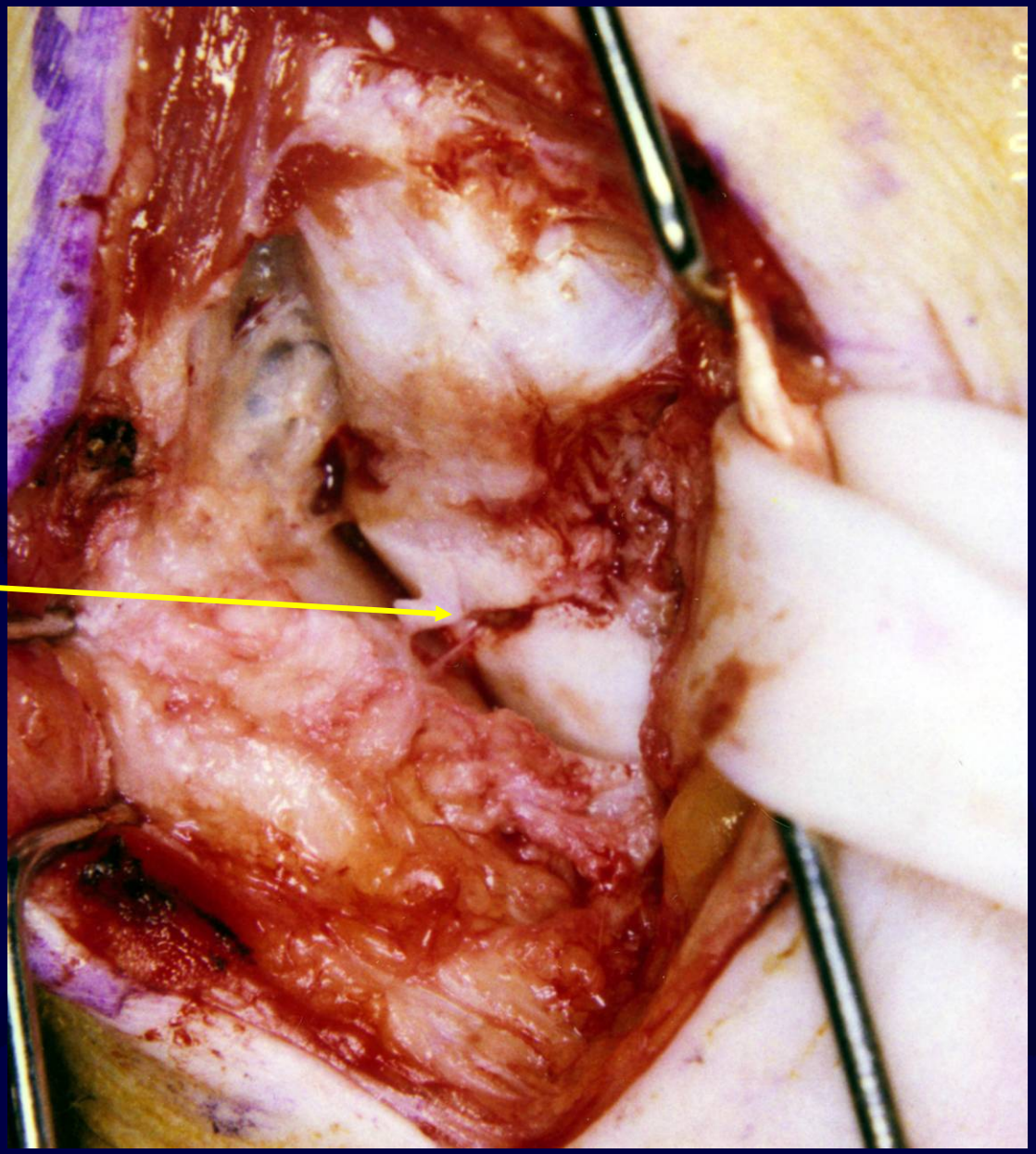
Exposure

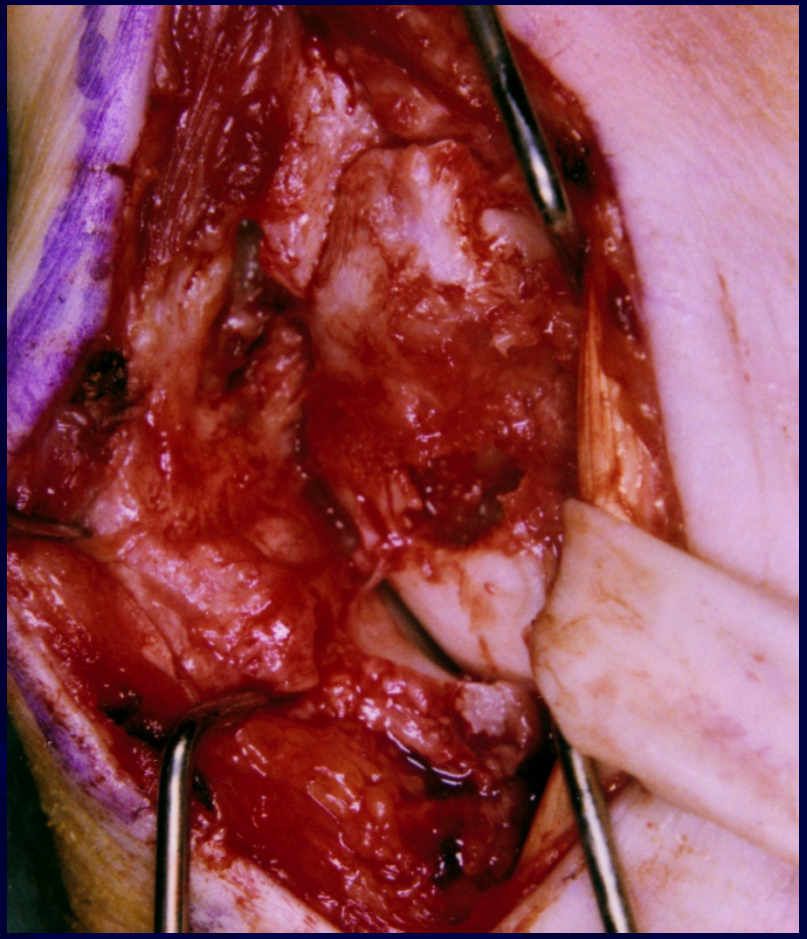
- Gentle zigzag incision directly over the course of the flexor carpi radialis tendon



FCR TENDON:
stay on radial side

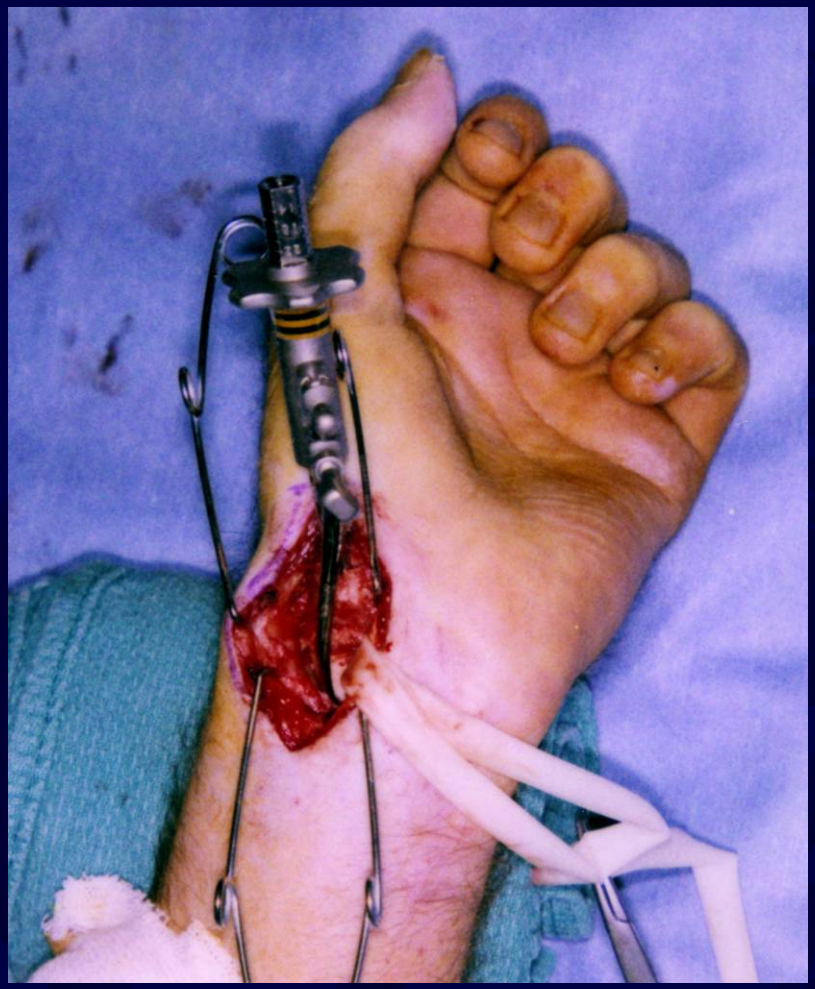
Non-union

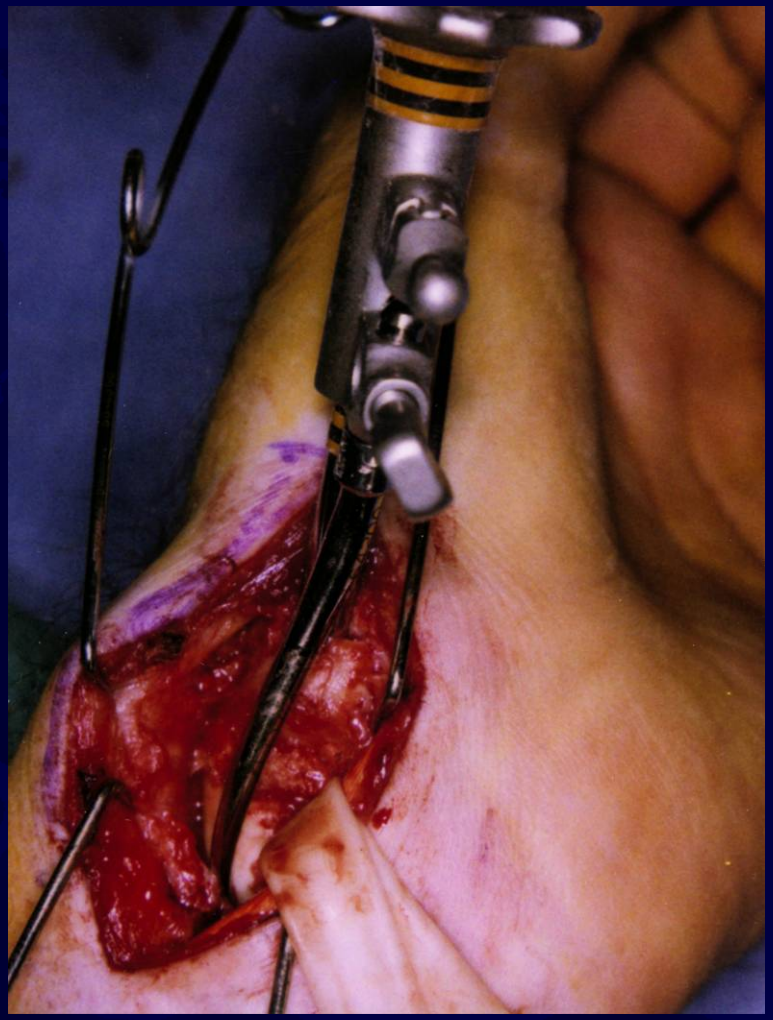




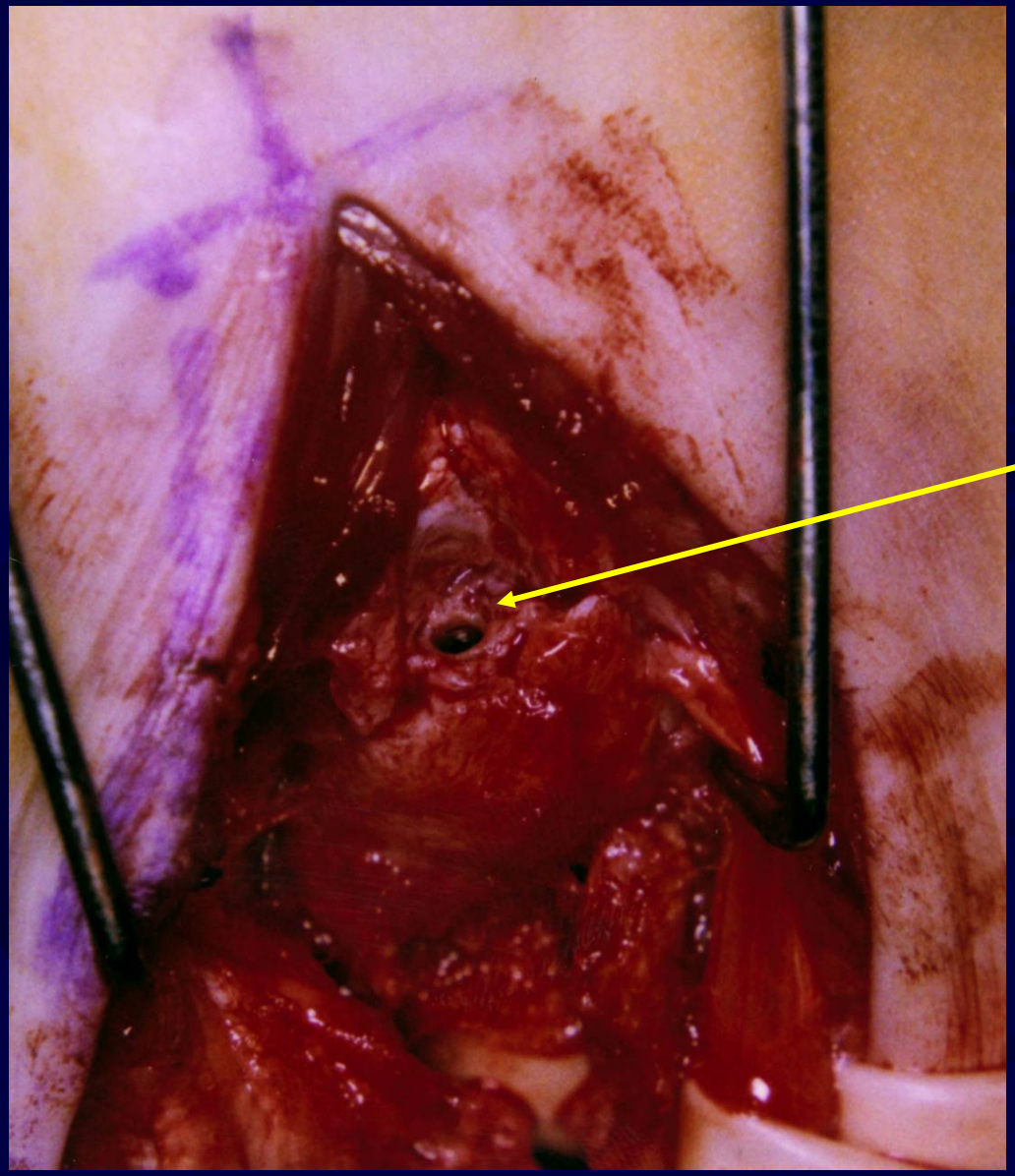
Fibrous non-union removed

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

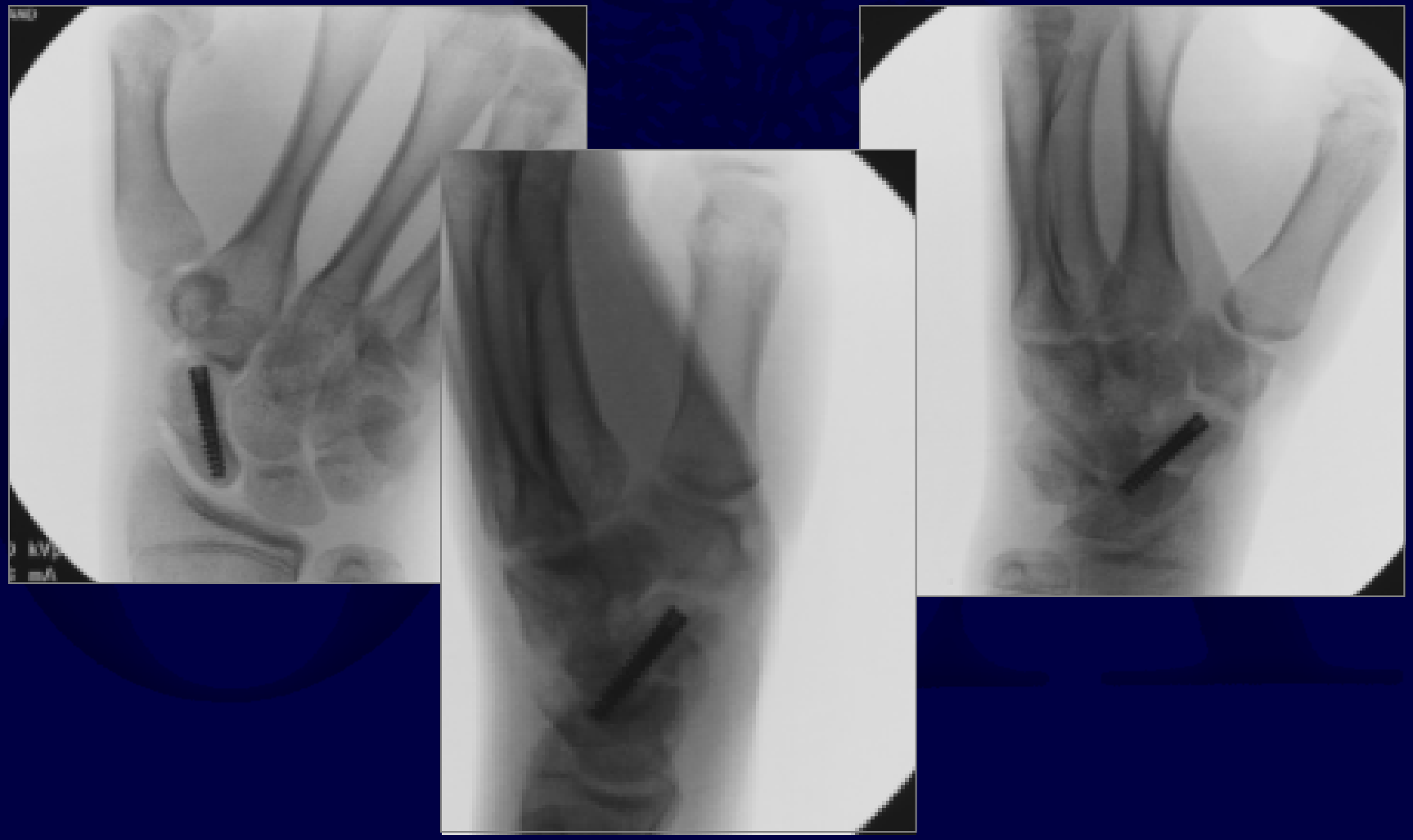
Mild cystic changes, minimal collapse

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

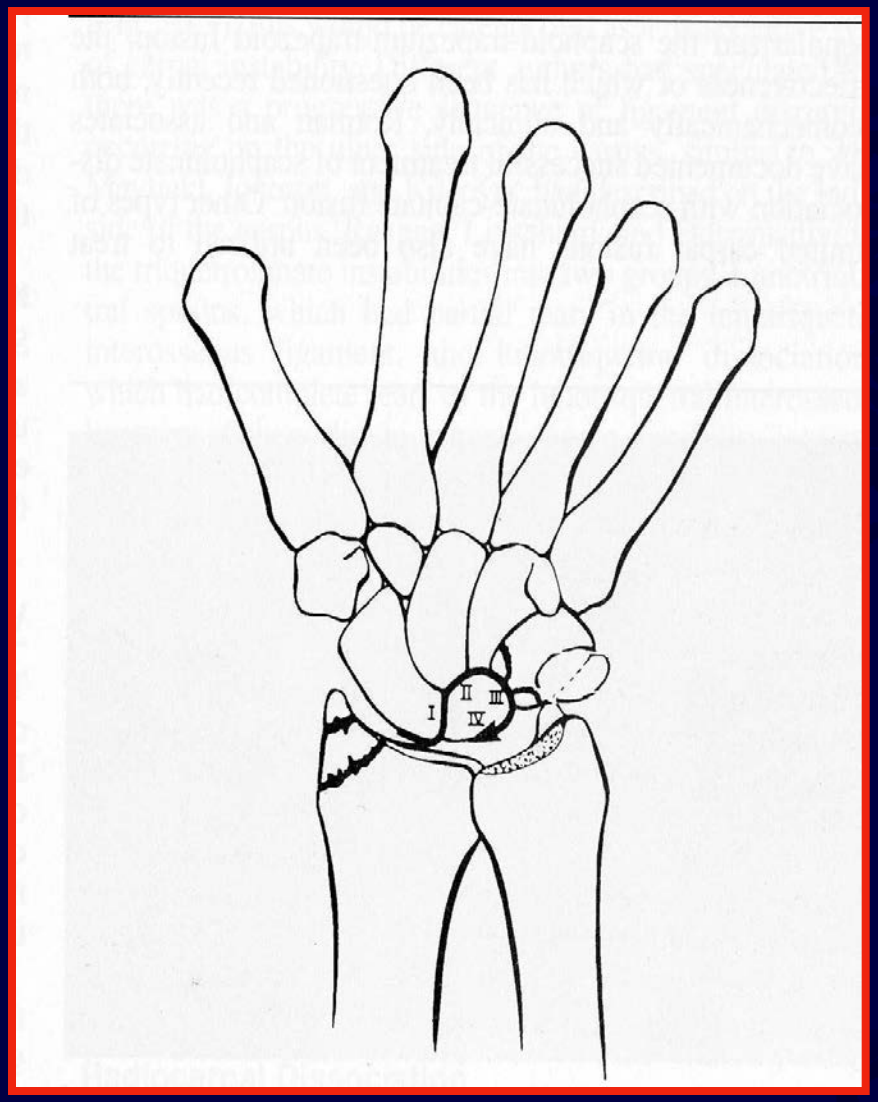
- Scaphoid non-union is challenging problem with significant risk for the wrist.
- Left untreated, scaphoid non-unions have a near 100% rate of degenerative disease.
- If approached appropriately scaphoid healing may be achieved

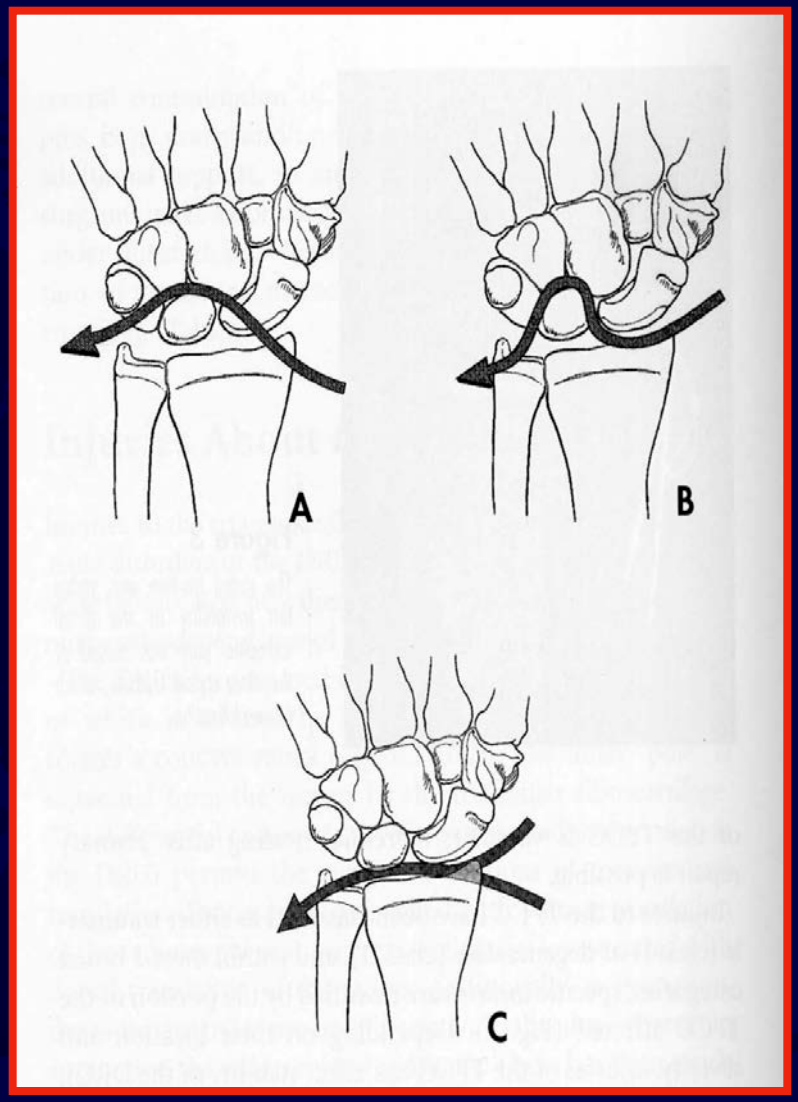
Perilunate Injuries

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

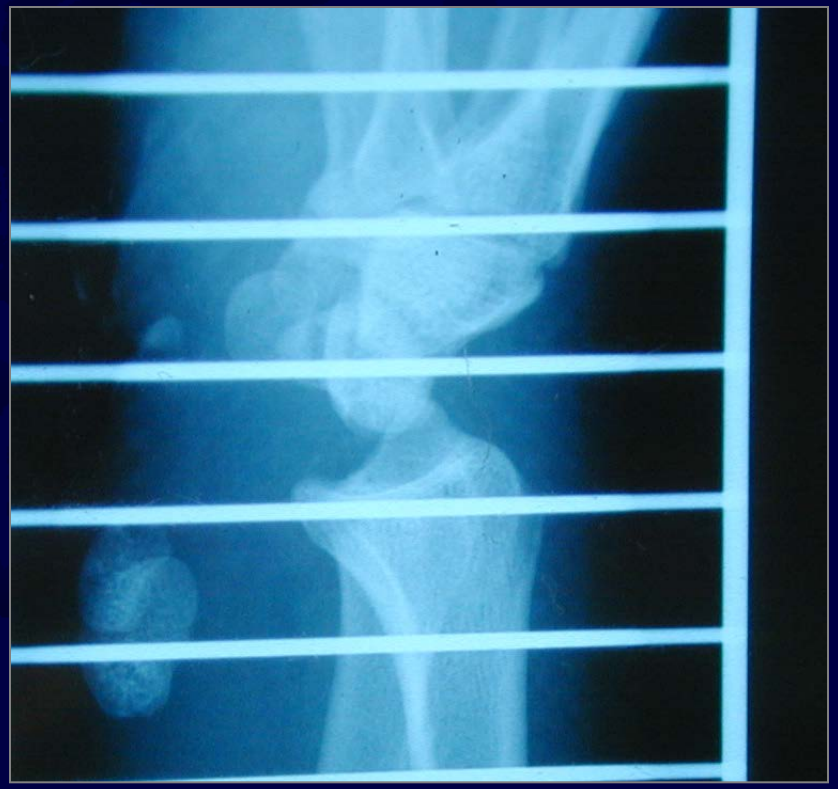
Imaging

- 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.

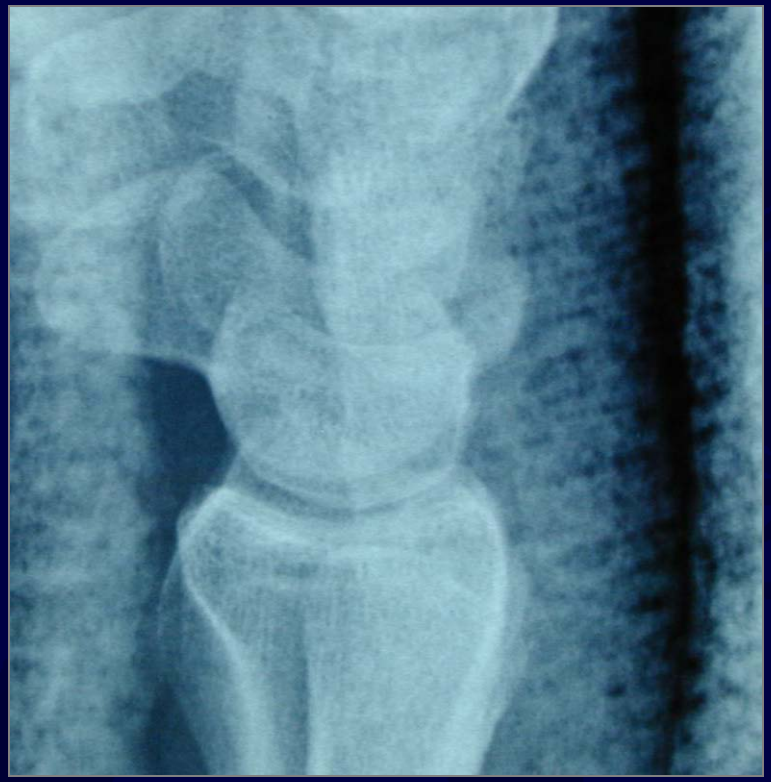
Closed Reduction and Pinning

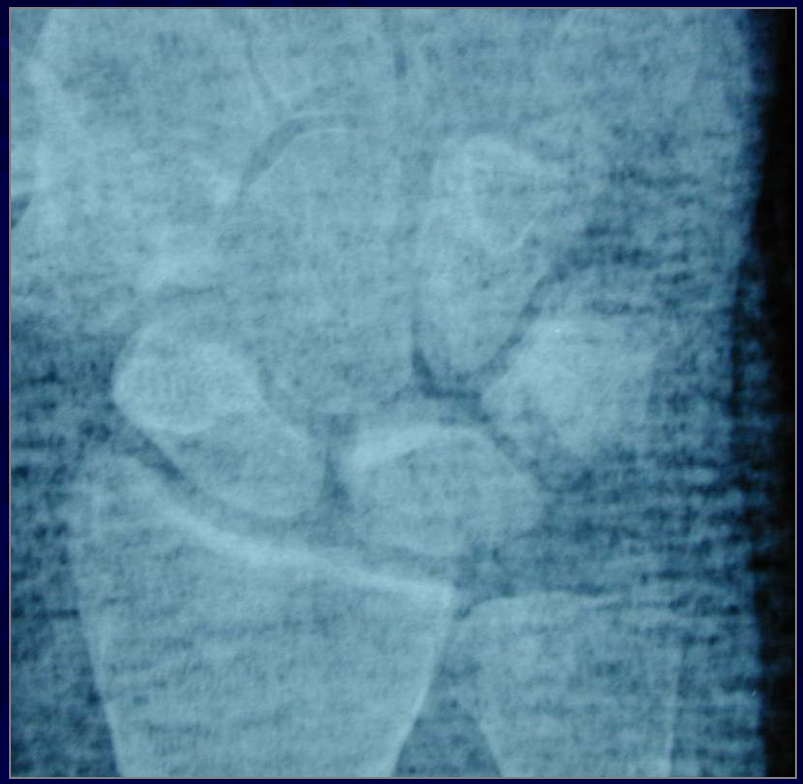
- Poor results with closed reduction and pinning alone

- 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*

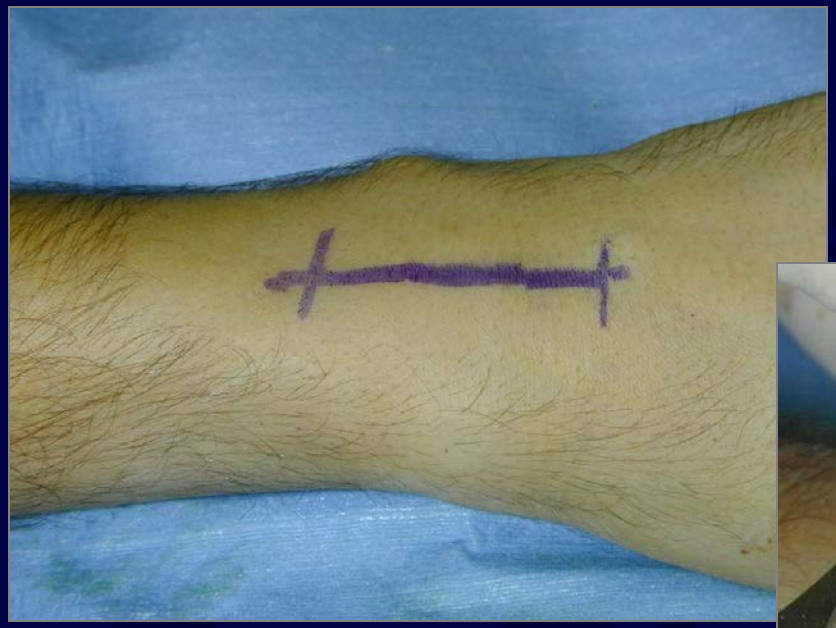
ORIF with volar and dorsal approaches

Procedure of Choice

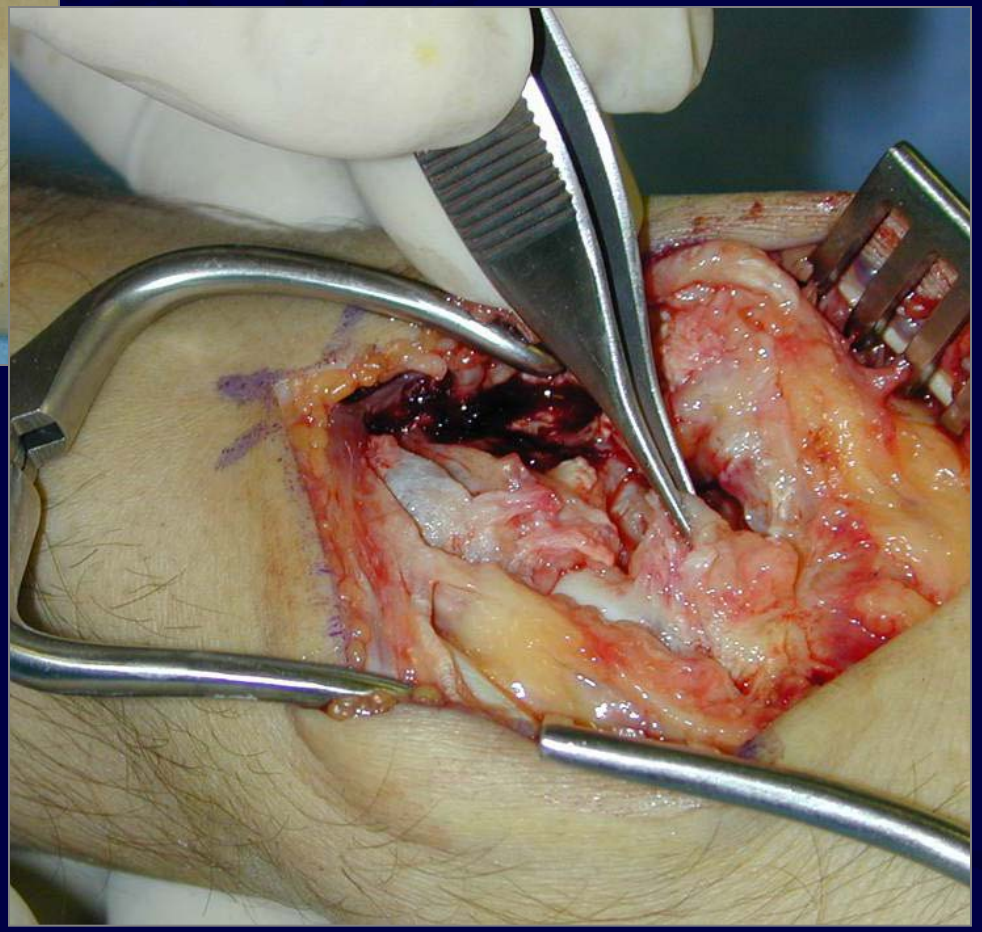




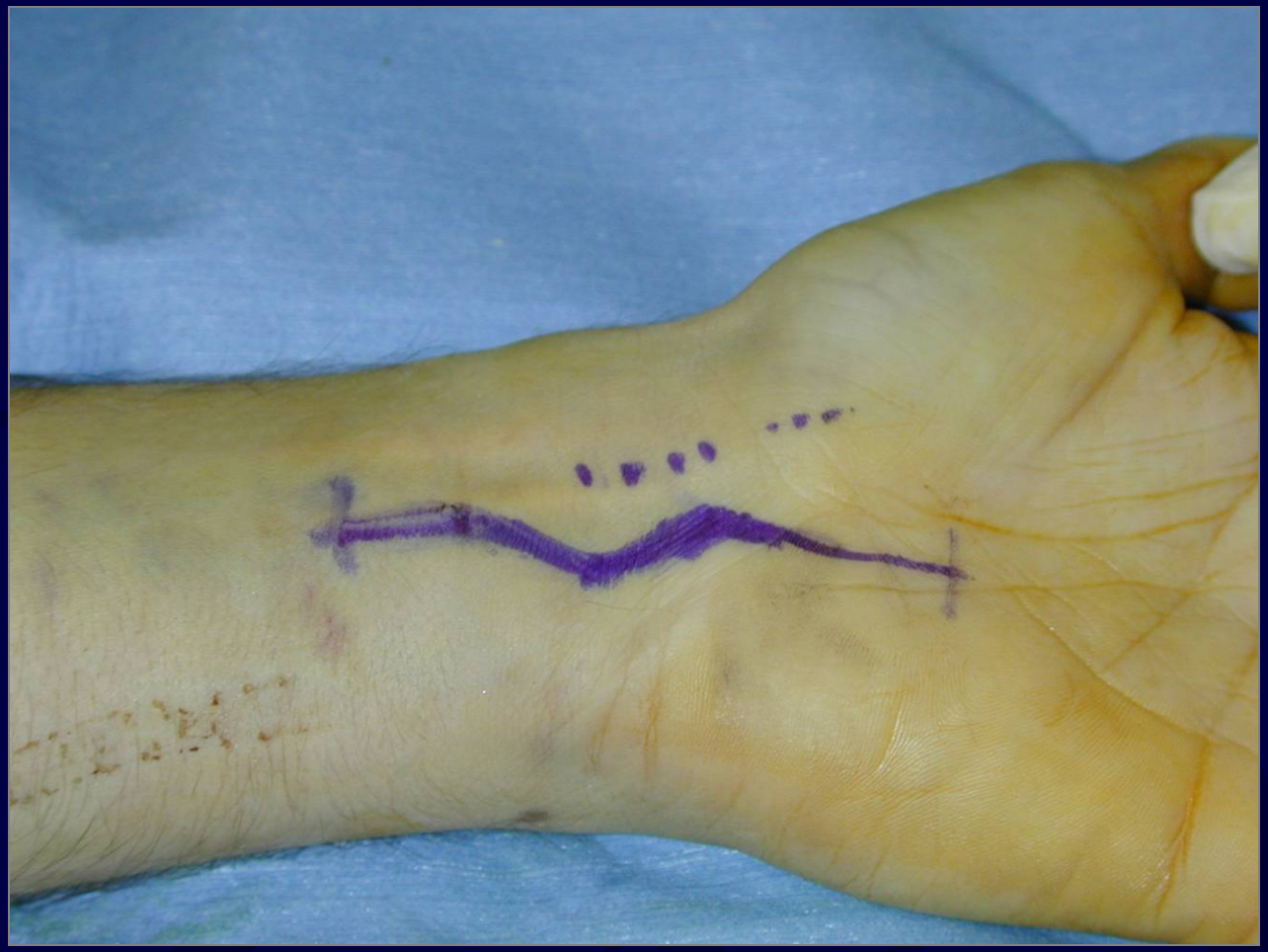
Provisional closed reduction



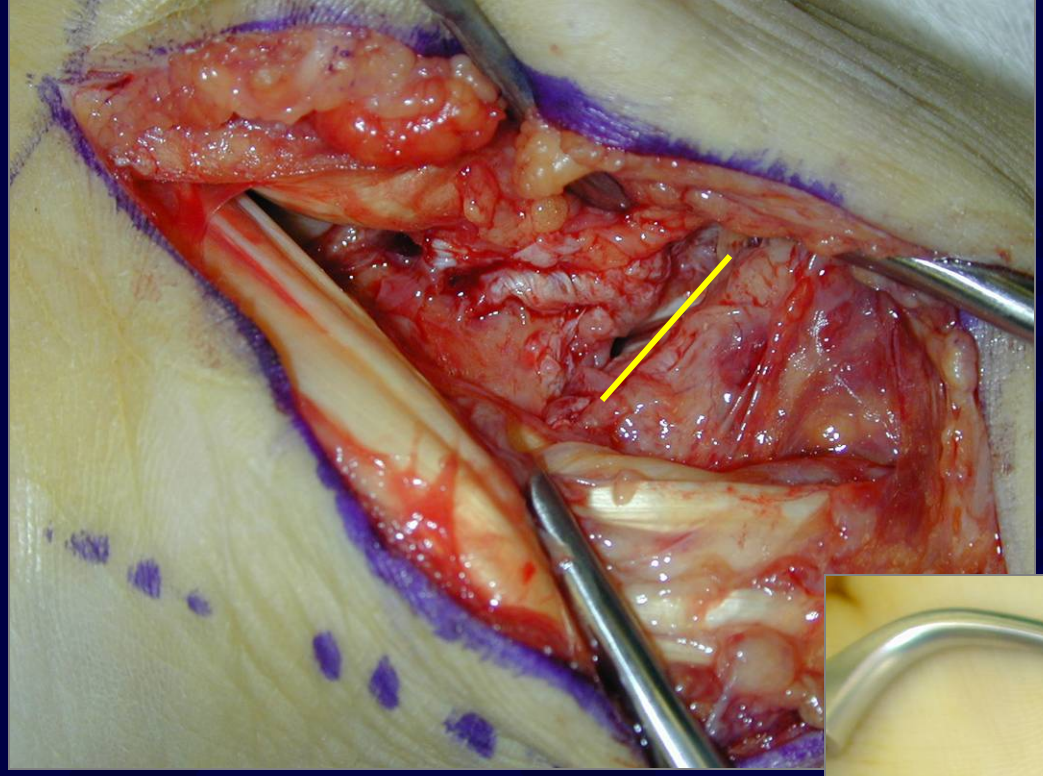
Dorsal Approach



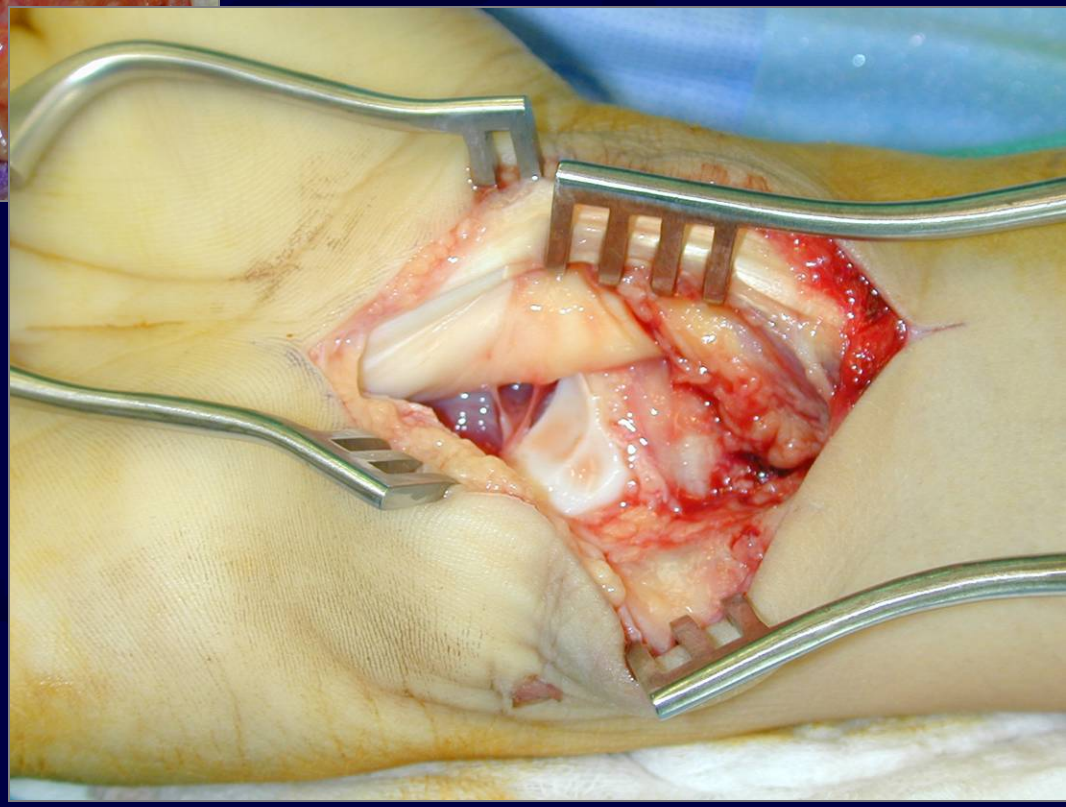
Repair S-L ligament



Volar Approach

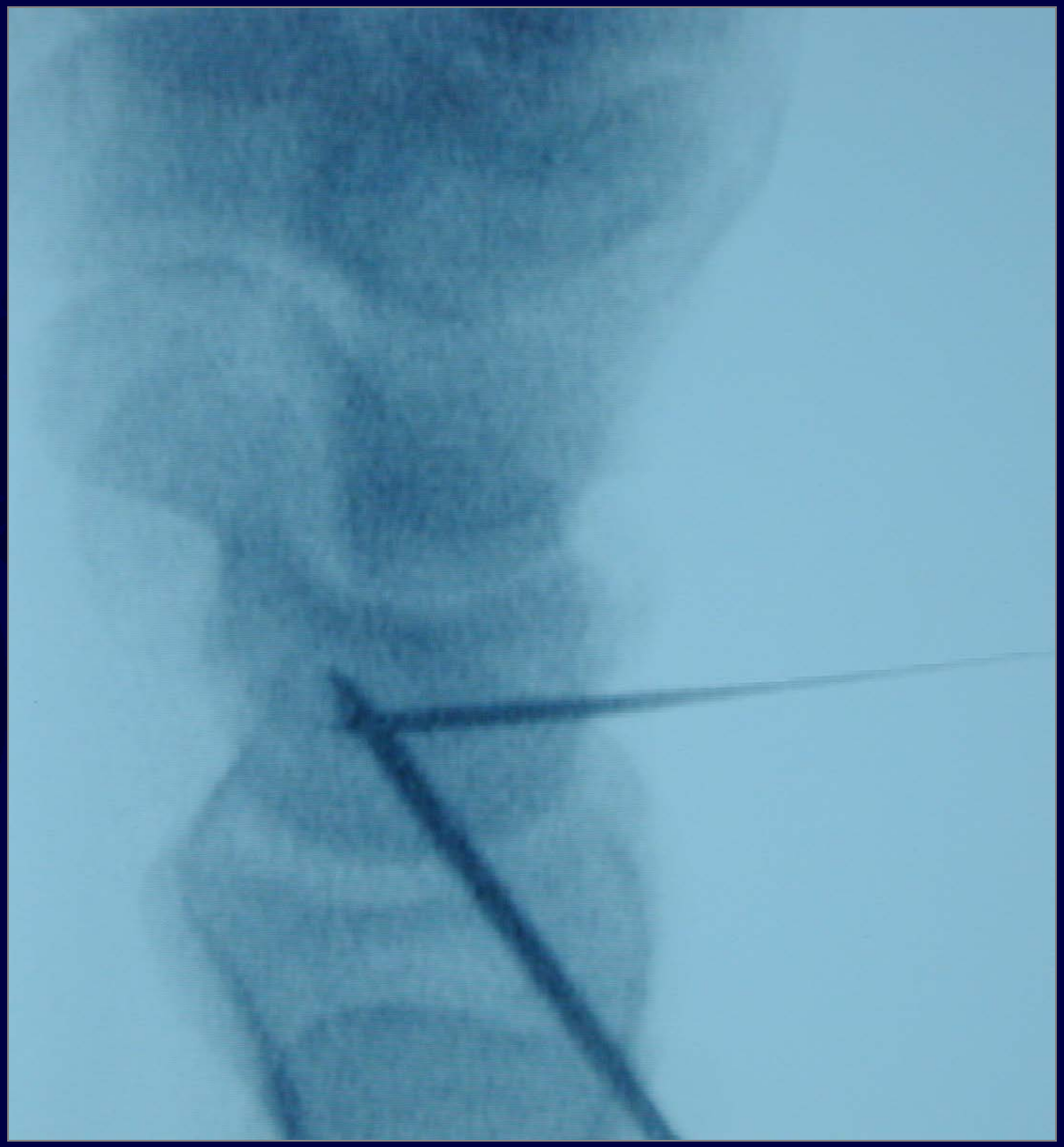


Volar mid-carpal ligament tear



Lunate may be dislocated volarly

Reduce lunate first- may need to temporary pin to radius

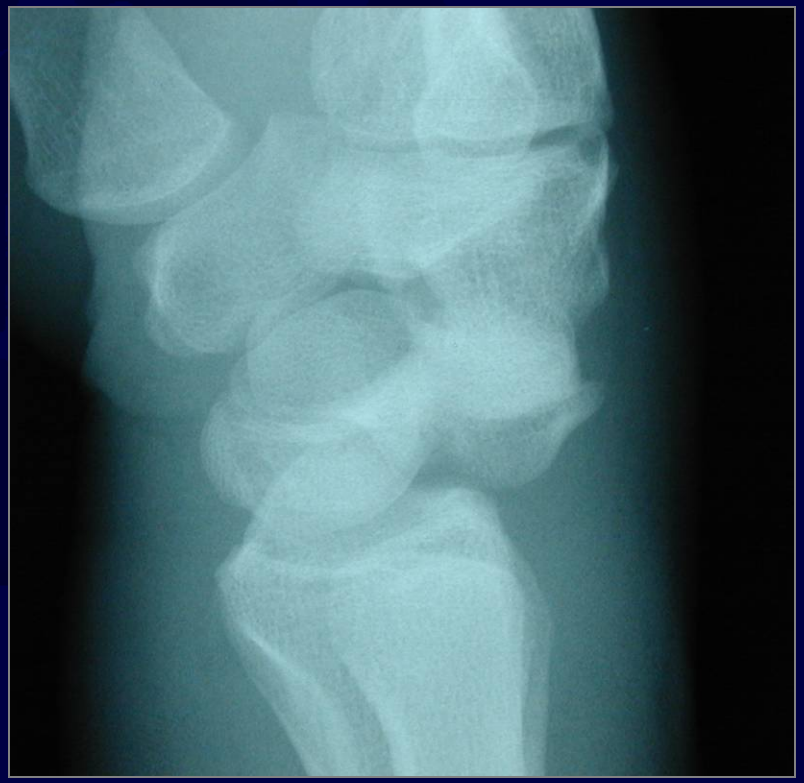


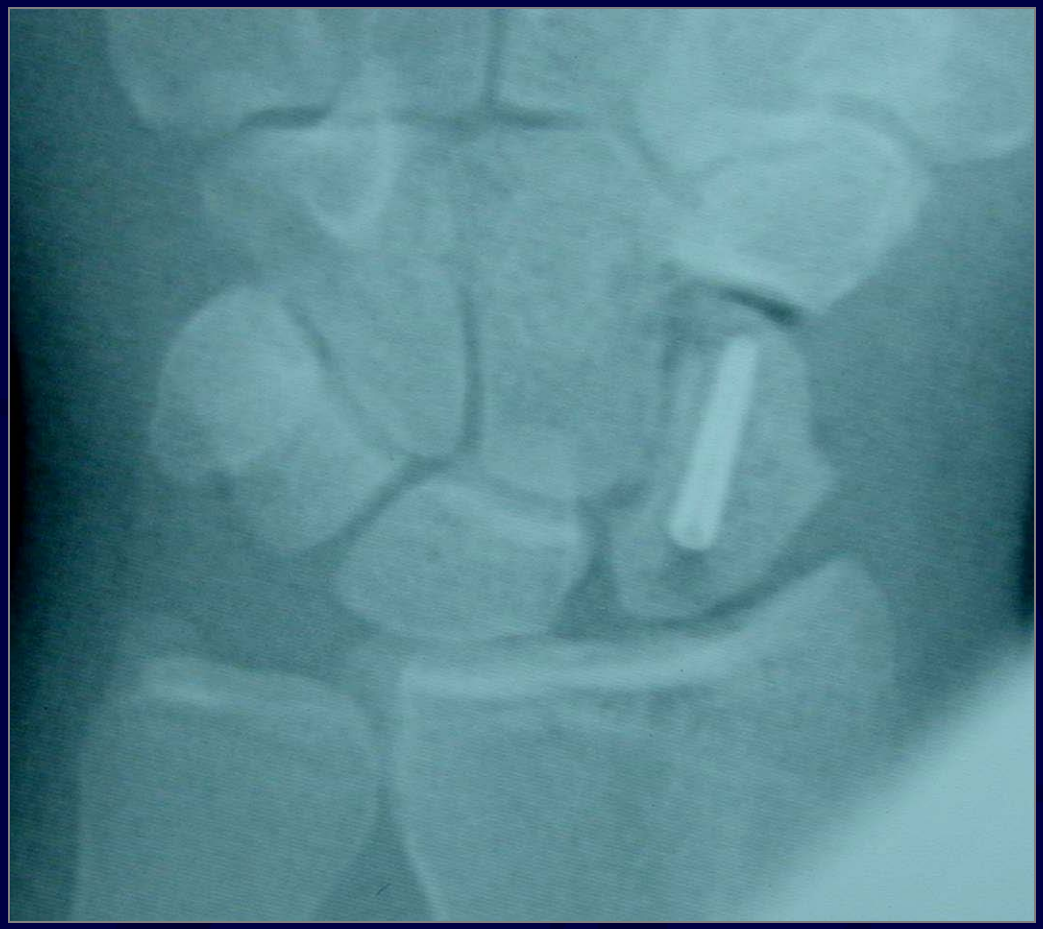
Pin Carpus: S-L, L-T and mid-carpal joints

Trans-scaphoid Perilunate Injuries

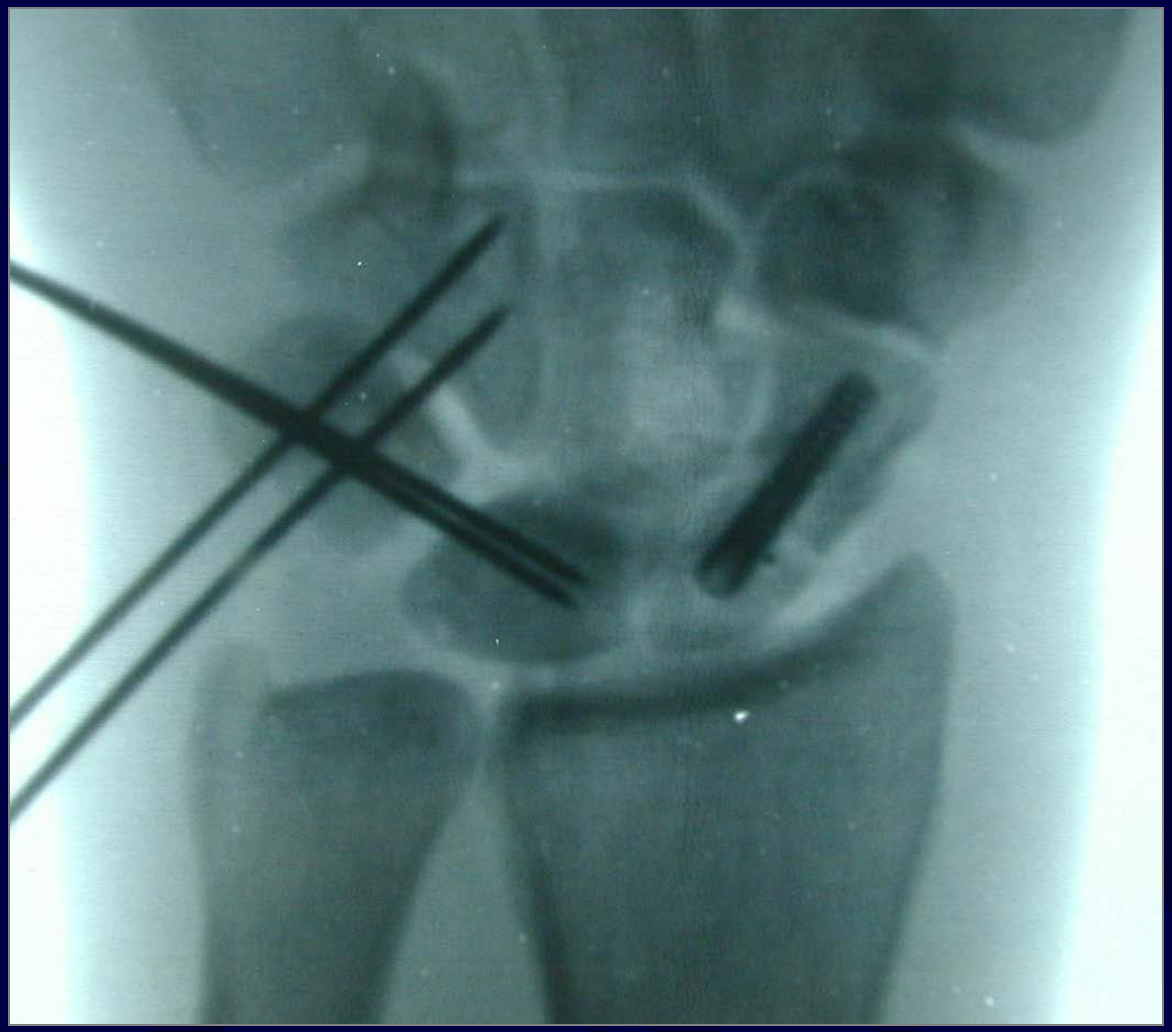
- Require reduction and fixation of the fractured scaphoid.
- Most of these injuries best treated
  - ORIF with volar and dorsal approaches
  - repair of injured structures.
- Open repair supplemented by pin and screw fixation.

Trans-scaphoid Perilunate Dislocations





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.

Herzberg & Forissier, J Hand Surg Br 27: 498-502, 2002

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*

If you would like to volunteer as an author for the Resident Slide Project or recommend updates to any of the following slides, please send an e-mail to ota@ota.org

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Bibliography

1: Forli A, Courvoisier A, Wimsey S, Corcella D, Moutet F. Perilunate Dislocations and Transscaphoid Perilunate Fracture-Dislocations: A Retrospective Study With Minimum Ten-Year Follow-Up. J Hand Surg Am. 2009 Nov 19.

2: Herzberg G. Perilunate and axial carpal dislocations and fracture-dislocations. J Hand Surg Am. 2008 Nov;33(9):1659-68.

3: Souer JS, Rutgers M, Andermahr J, Jupiter JB, Ring D. Perilunate fracture-dislocations of the wrist: comparison of temporary screw versus K-wire fixation. J Hand Surg Am. 2007 Mar;32(3):318-25.

4: Knoll VD, Allan C, Trumble TE. Trans-scaphoid perilunate fracture dislocations: results of screw fixation of the scaphoid and lunotriquetral repair with a dorsal approach. J Hand Surg Am. 2005 Nov;30(6):1145-52. Erratum in: J Hand Surg [Am]. 2006 Feb;31(2):328.

5: Trumble T, Verheyden J. Treatment of isolated perilunate and lunate dislocations with combined dorsal and volar approach and intraosseous cerclage wire. J Hand Surg Am. 2004 May;29(3):412-7.

6: Hildebrand KA, Ross DC, Patterson SD, Roth JH, MacDermid JC, King GJ. Dorsal perilunate dislocations and fracture-dislocations: questionnaire, clinical, and radiographic evaluation. J Hand Surg Am. 2000 Nov;25(6):1069-79.

7: Rettig ME, Raskin KB. Long-term assessment of proximal row carpectomy for chronic perilunate dislocations. J Hand Surg Am. 1999 Nov;24(6):1231-6.

8: Sotereanos DG, Mitsionis GJ, Giannakopoulos PN, Tomaino MM, Herndon JH. Perilunate dislocation and fracture dislocation: a critical analysis of the volar-dorsal approach. J Hand Surg Am. 1997 Jan;22(1):49-56.

9: Minami A, Kaneda K. Repair and/or reconstruction of scapholunate interosseous ligament in lunate and perilunate dislocations. J Hand Surg Am. 1993 Nov;18(6):1099-106.

10: Herzberg G, Comtet JJ, Linscheid RL, Amadio PC, Cooney WP, Stalder J. Perilunate dislocations and fracture-dislocations: a multicenter study. J Hand Surg Am. 1993 Sep;18(5):768-79.

11: Vinnars B, Pietreanu M, Bodestedt A, Ekenstam F, Gerdin B. Nonoperative compared with operative treatment of acute scaphoid fractures. A randomized clinical trial. J Bone Joint Surg Am. 2008 Jun;90(6):1176-85.

12: McQueen MM, Gelbke MK, Wakefield A, Will EM, Gaebler C. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomised study. J Bone Joint Surg Br. 2008 Jan;90(1):66-71.

13: Papaloizos MY, Fusetti C, Christen T, Nagy L, Wasserfallen JB. Minimally invasive fixation versus conservative treatment of undisplaced scaphoid fractures: a cost-effectiveness study. J Hand Surg Br. 2004 Apr;29(2):116-9.

14: Rettig ME, Kozin SH, Cooney WP. Open reduction and internal fixation of acute displaced scaphoid waist fractures. J Hand Surg Am. 2001 Mar;26(2):271-6.

15: Rettig ME, Raskin KB. Retrograde compression screw fixation of acute proximal pole scaphoid fractures. J Hand Surg Am. 1999 Nov;24(6):1206-10.

16: Robbins RR, Ridge O, Carter PR. Iliac crest bone grafting and Herbert screw fixation of nonunions of the scaphoid with avascular proximal poles. J Hand Surg Am. 1995 Sep;20(5):818-31.

17: Fernandez DL. Anterior bone grafting and conventional lag screw fixation to treat scaphoid nonunions. J Hand Surg Am. 1990 Jan;15(1):140-7.

18: Gellman H, Caputo RJ, Carter V, Aboulafia A, McKay M. Comparison of short and long thumb-spica casts for non-displaced fractures of the carpal scaphoid. J Bone Joint Surg Am. 1989 Mar;71(3):354-7.

19: Bond CD, Shin AY, McBride MT, Dao KD. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. J Bone Joint Surg Am. 2001 Apr;83-A(4):483-8.