The Scaphoid

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12.6.19
NWT Speciality Teaching

Aims

- To consider the implications of scaphoid anatomy and biomechanics on fracture behaviour
- To provide evidence-based investigation and treatment algorithms for scaphoid fractures
- To describe a systematic approach to evaluate scaphoid nonunions
- To provide an evidence based algorithm for the management of scaphoid nonunions

Background

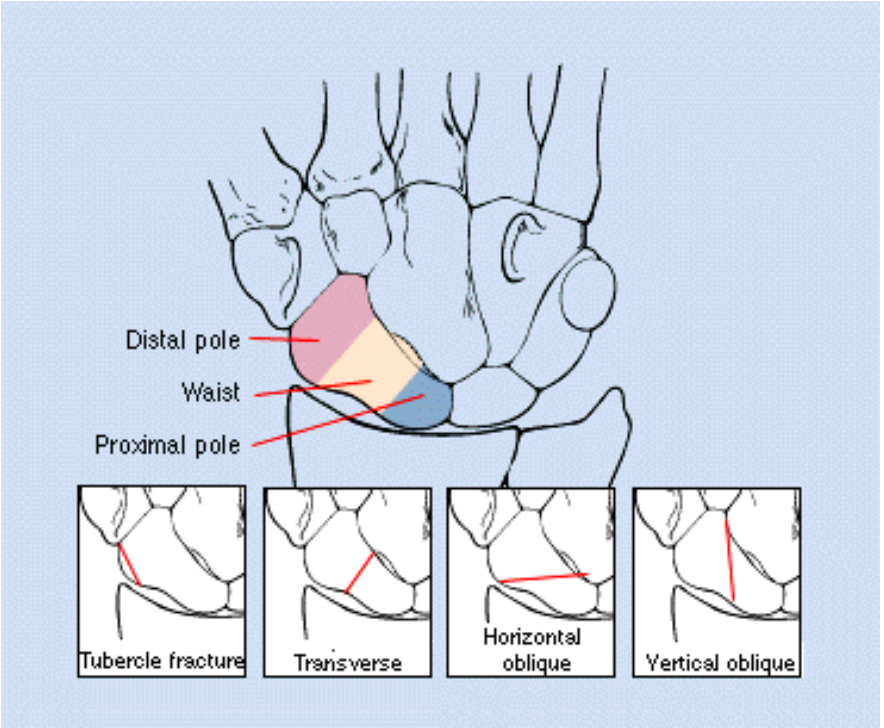
- Carpal Keystone
- Comprises 60-70% of carpal fractures
- Low energy, young adult

Anatomy

- Shape
  - Boat / Twisted Peanut / Bean
- 80% cartilage

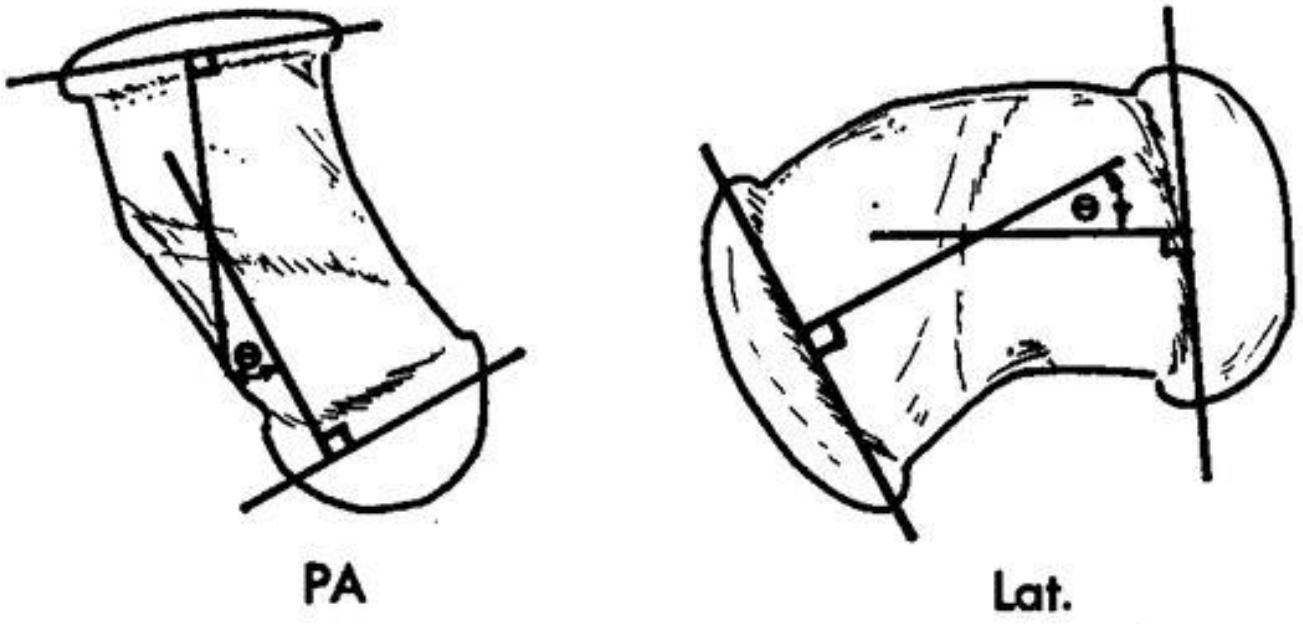
Anatomy

- Boat / Twisted Peanut / Bean
- 80% cartilage
- Divided into 3 segments



Anatomy

- Boat / Twisted Peanut / Bean
- 80% cartilage
- Interscaphoid angle =40deg cor & 30deg sag



Blood Supply & Implications

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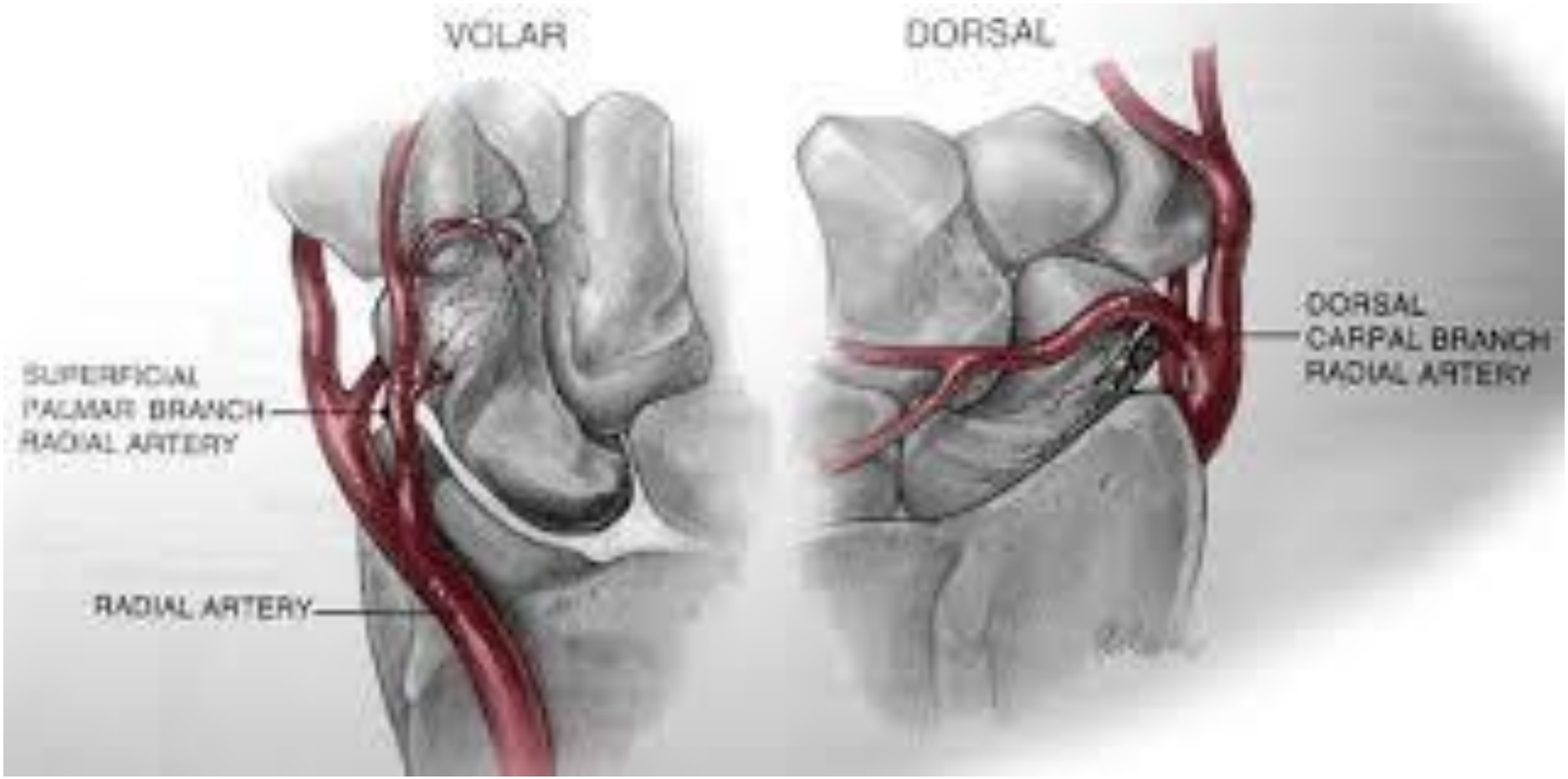


Biomechanics

- Hyperextension & axial Load > pure hyperextension > hyperflexion
- Biology vs Stability
- RF for Non-union:
  - Rx delay >4/52
  - PP
  - Displacement (>1mm)
  - AVN
  - Smoking

Natural History

- Union Rates
  - All scaphoid #'s 85-90%
  - Undisplaced + Cast (88-95%)
  - Displaced + Cast (<50%)
- Deformity
  - Flexion & DISI
- Arthritis
  - 50-90%

Clinical Assessment

- History
  - Traumatic – **beware the old injury**
- Examination
  - Palpate 3 main parts of scaphoid.
  - Sensitivity >90%, Specificity 74-80%

Investigations

Imaging

- XR
  - 6 views
  - Will miss up to 25%

- CT vs MRI vs BS

Mallee WH[1], Wang J, Poolman RW, Kloen P, Maas M, de Vet HC, Doornberg JN. Computed tomography versus magnetic resonance imaging versus bone scintigraphy for clinically suspected scaphoid fractures in patients with negative plain radiographs. Cochrane Database Syst Rev. 2015 Jun 5;(6):CD010023.

de Zwart AD[1,2], Beeres FJ[3], Rhemrev SJ[4], Bartlema K[5], Schipper IB[5]. Comparison of MRI, CT and bone scintigraphy for suspected scaphoid fractures. Eur J Trauma Emerg Surg. 2016 Dec;42(6):725-731. Epub 2015 Nov 10.

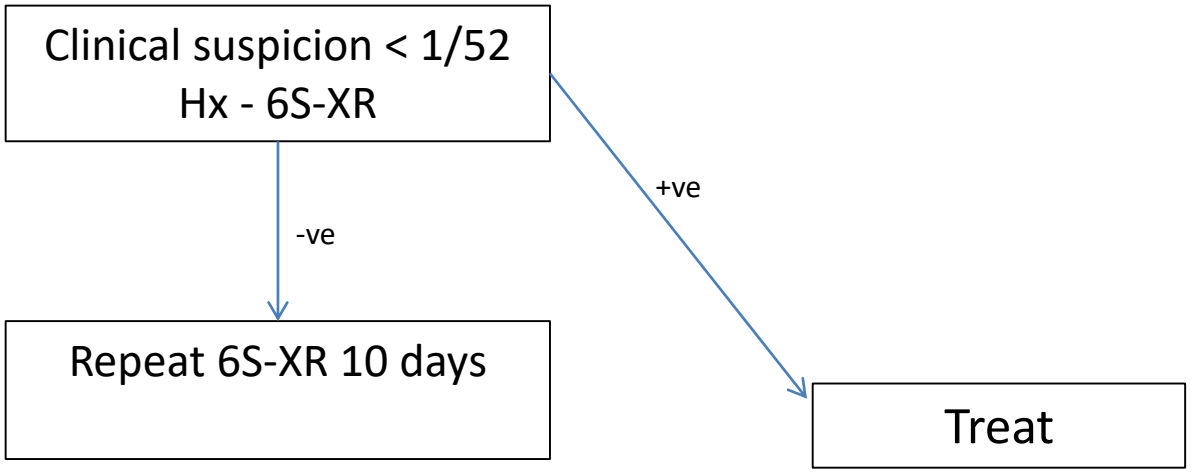
Mallee W[1], Doornberg JN, Ring D, van Dijk CN, Maas M, Goslings JC. Comparison of CT and MRI for diagnosis of suspected scaphoid fractures. J Bone Joint Surg Am. 2011 Jan 5;93(1):20-8.

My Summation

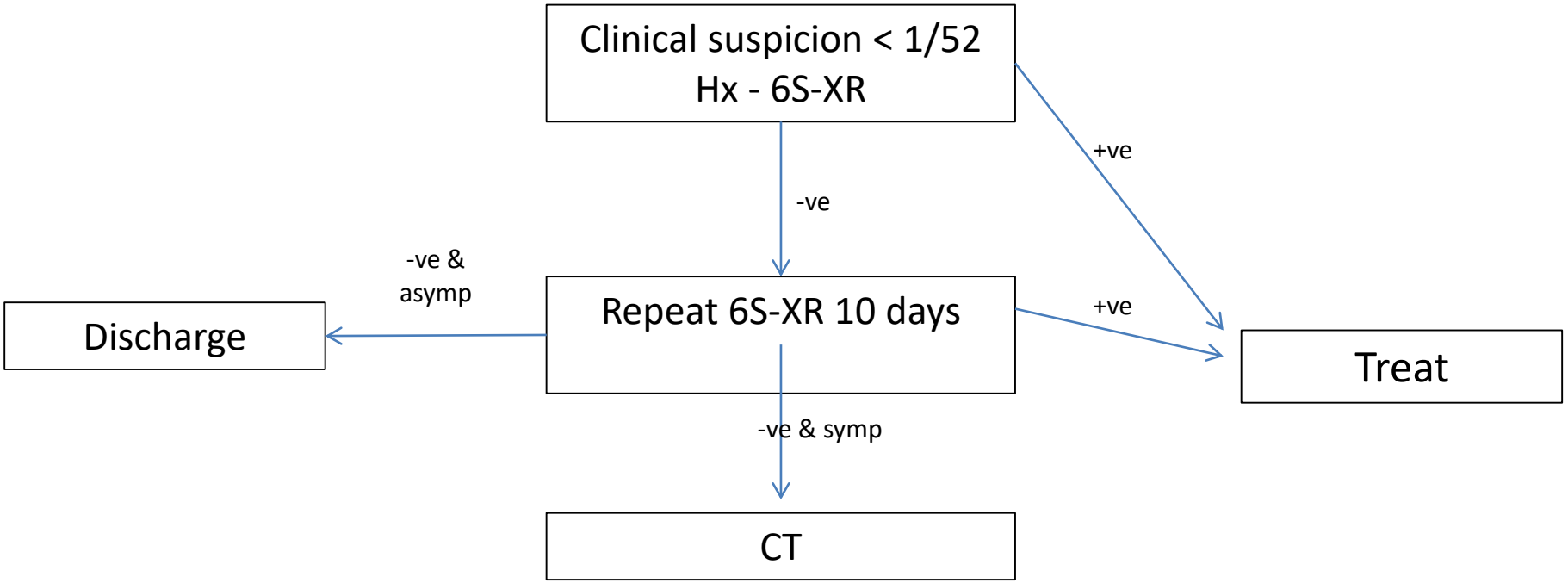
"Neither MRI, CT nor BS are 100 % accurate in diagnosing occult scaphoid fractures. MRI and CT miss fractures, and BS over-diagnose"

"CT will miss approx 5% of fractures. MRI will miss approx 2%. Bone scan will miss <0.5%. Bone scan will over treat 10% of fractures, CT 1%, and MRI 3%"

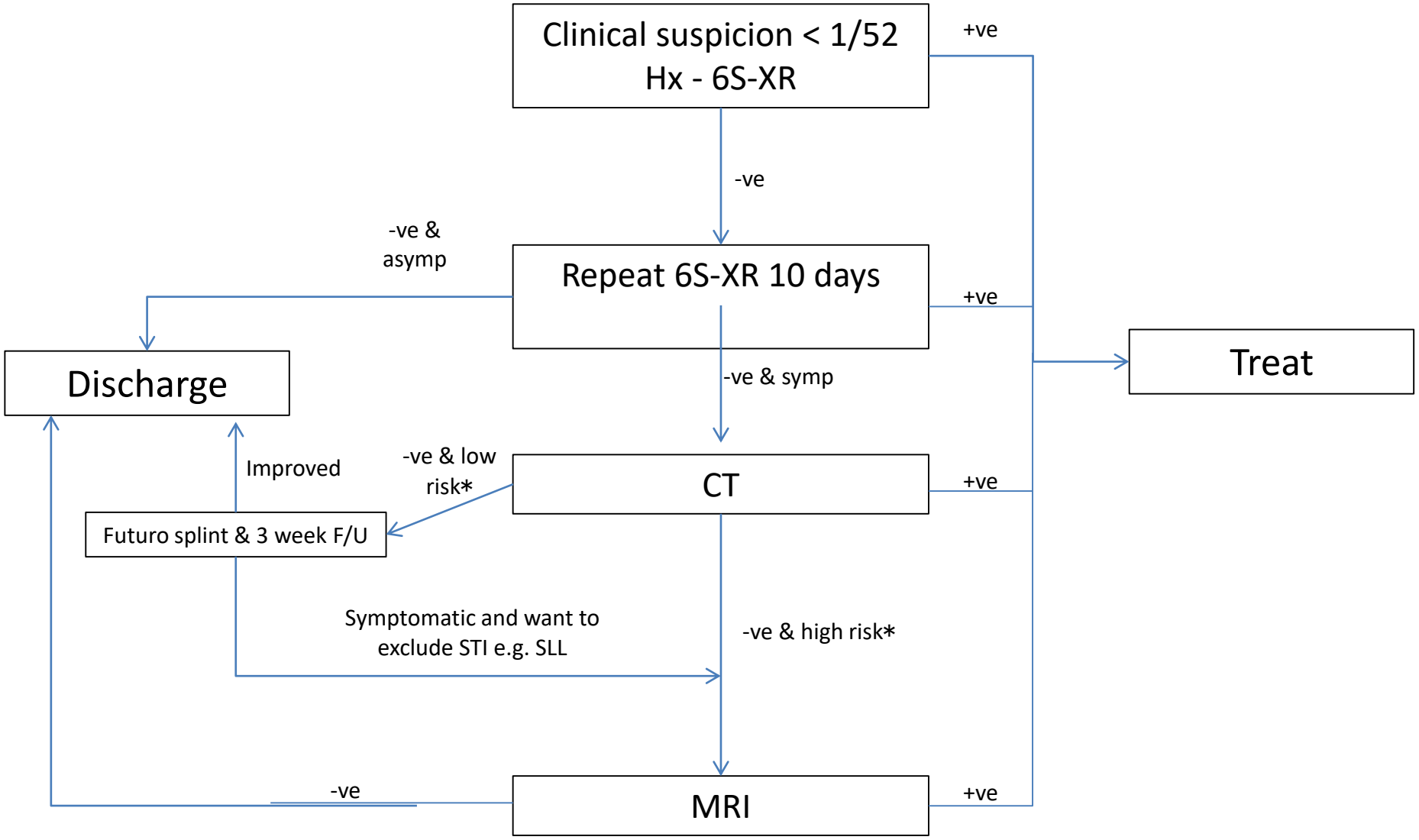
My Investigation Algorithm



My Investigation Algorithm



EBM Scaphoid Investigation Algorithm

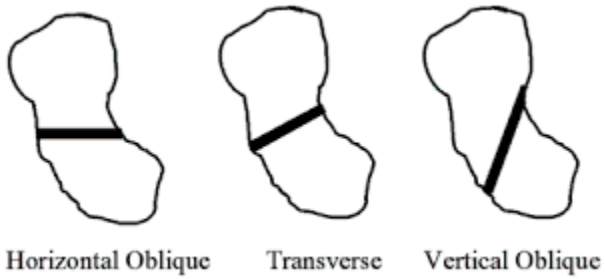


* High risk = high energy or sig symptoms suggesting STI e.g. SLLI

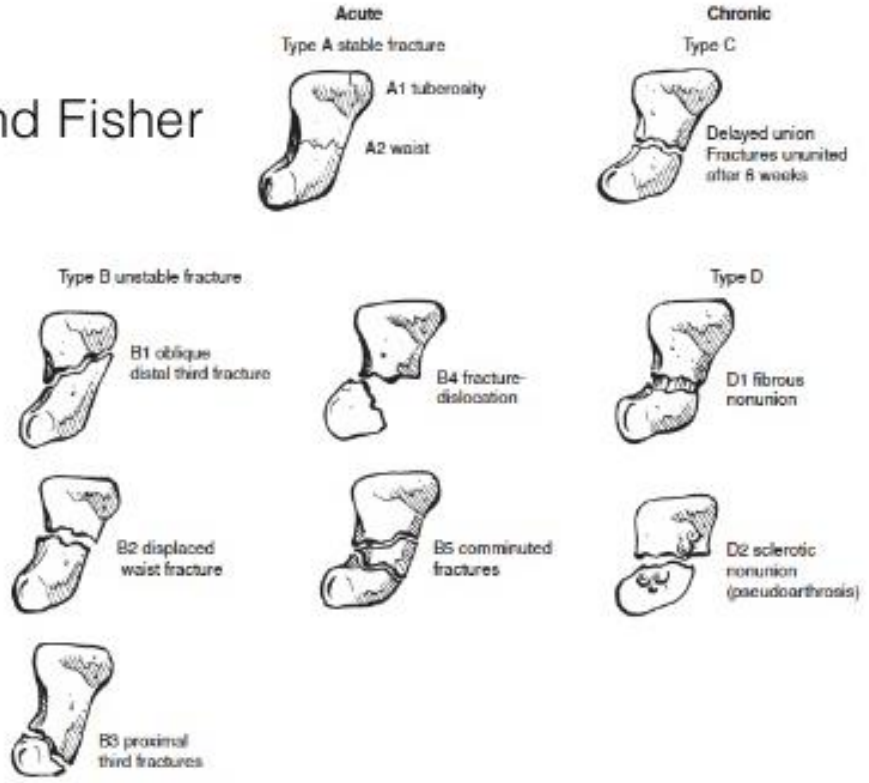
Classifications

Classification 1

- Russe



- Herbert and Fisher



Treatment of Scaphoid Fractures

Operative or Non-Operative

Acute Scaphoid # Treatment

Non Operative	Controversial	Operative
Tubercle Fracture	Undisplaced waist	Any visible displacement (>1mm)
Incomplete		Lateral interscaphoid angle >35 degrees
		Bone loss / comminution
		Perilunate # dislocation
		Undisplaced Proximal Pole

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Tubercle #	Undisplaced waist #	Any visible displacement (>1mm)
Incomplete #		Lateral interscaphoid angle >35 degrees
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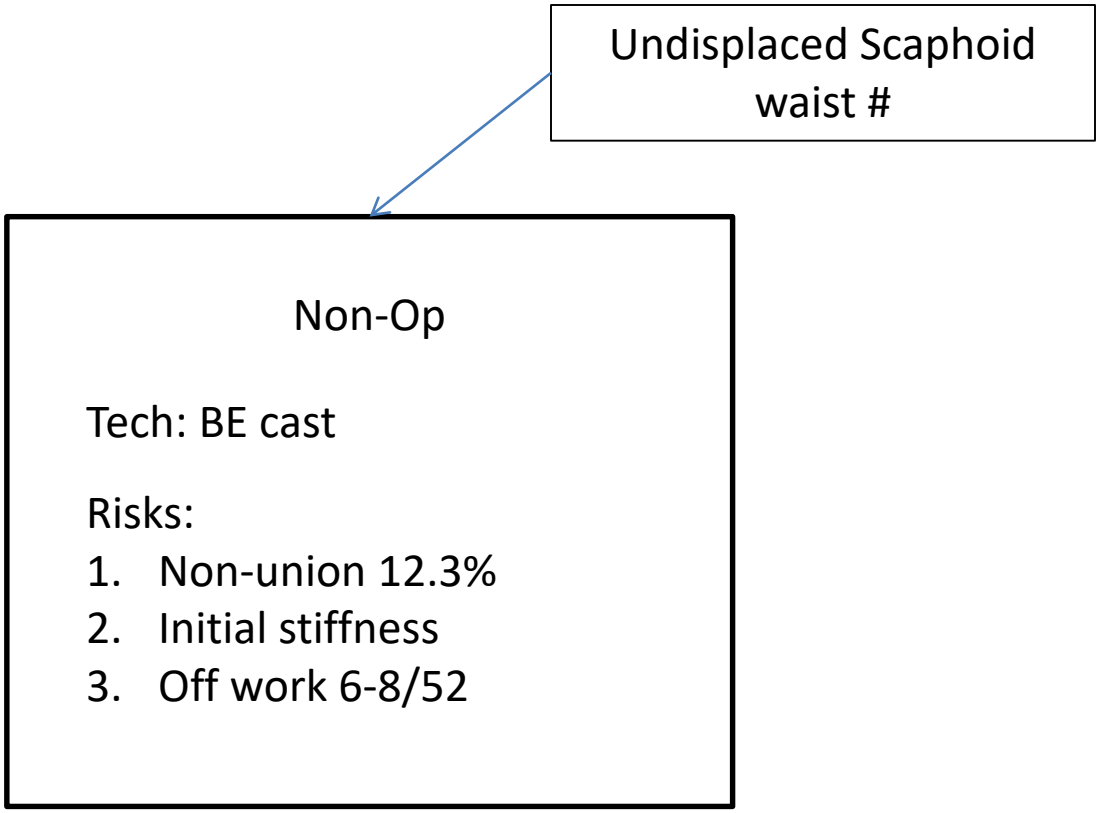
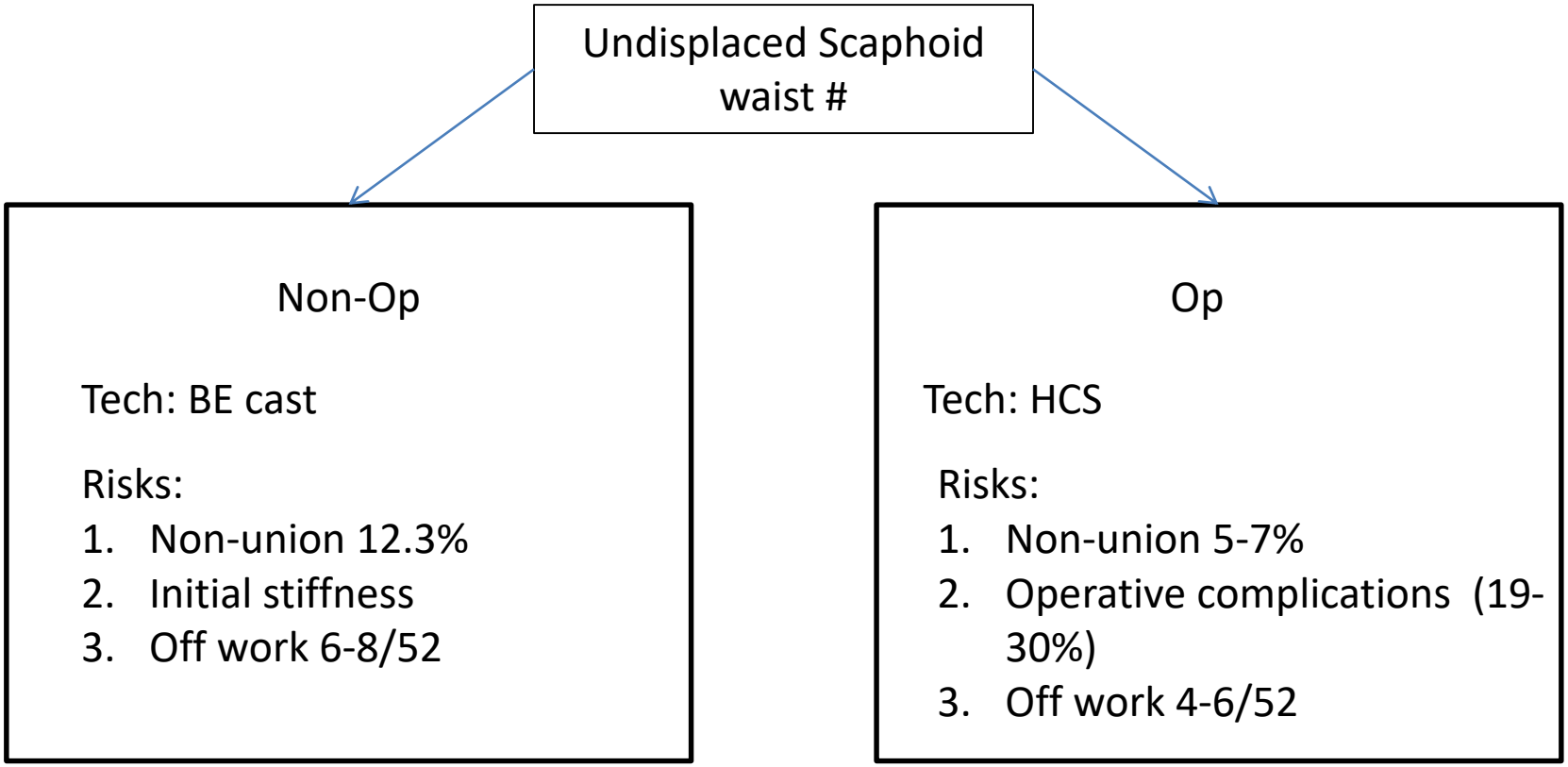
		Undisplaced Proximal Pole #

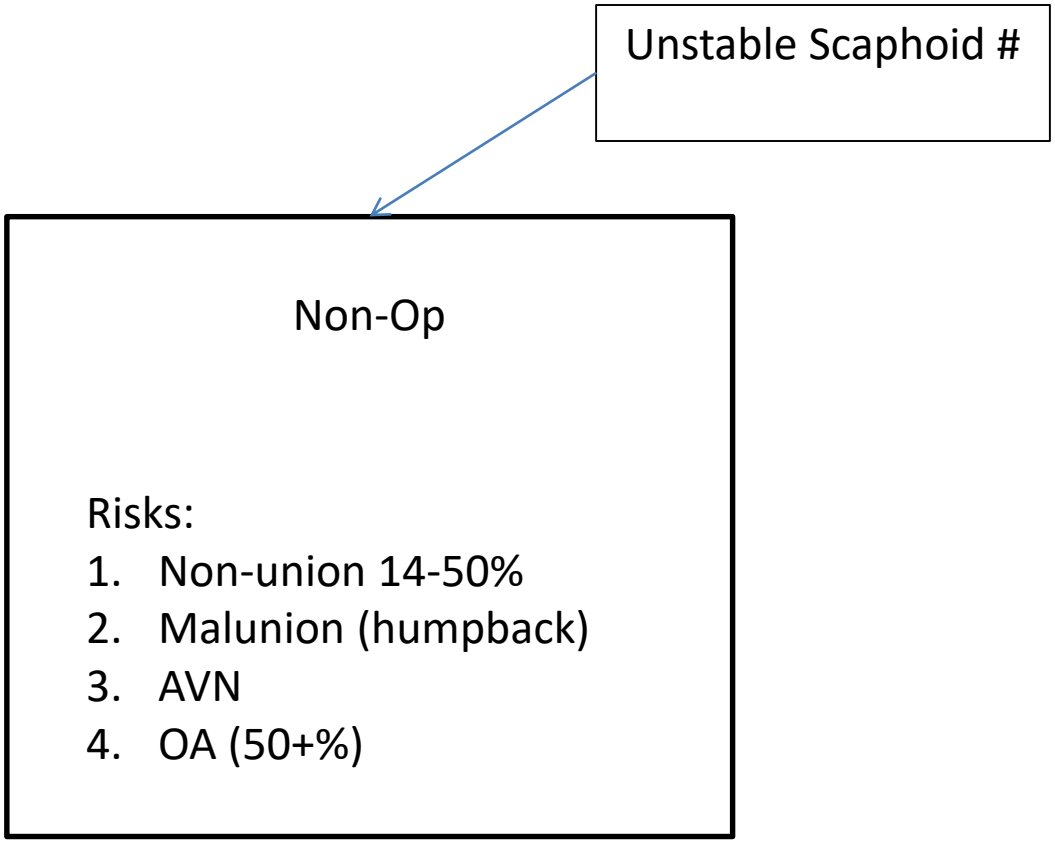
EBM Undisplaced Waist



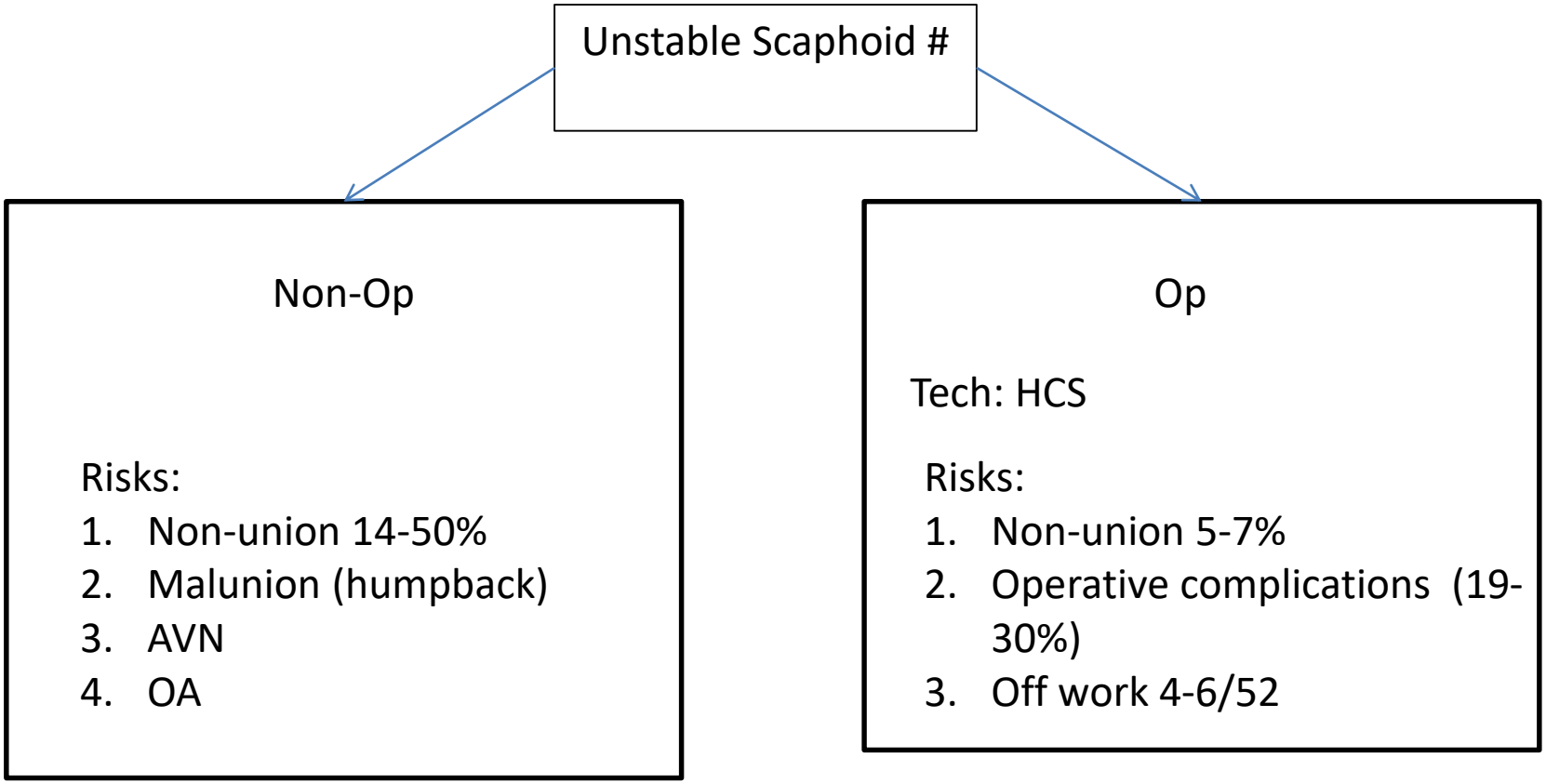
EBM Undisplaced Waist



EBM Unstable scaphoid



EBM Unstable Waist



Non-operative Management

- Cast Immobilization
  - Thumb free - wrist immobilisation prevents scaphoid ROM [1]
  - Long arm casts offer no benefit [2]
  - Position of wrist in cast does not affect healing [3]
  - 90-95% undisplaced scaphoid waist fractures will heal [4]

1. Clay NR, Dias JJ, Costigan PS, Gregg PJ, Barton NJ. Need the thumb be immobilised in scaphoid fractures? A randomised prospective trial. J Bone Joint Surg [Br] 1991;73-B:828-32.
2. McAdams TR, Spisak S, Beaulieu CF, Ladd AL. The effect of pronation and supination on the minimally displaced scaphoid fracture. Clin Orthop 2003-411:255-9
3. Hambidge JE, Desai VV, Schranz PJ, Compson JP, Davis TR, Barton NJ. Acute fractures of the scaphoid. Treatment by cast immobilisation with the wrist in flexion or extension? J Bone Joint Surg [Br] 1999;81-B:91-2.
4. Dias JJ, Taylor M, Thompson J, Brenkel IJ, Gregg PJ. Radiographic signs of union of scaphoid fractures. An analysis of inter-observer agreement and reproducibility. J Bone Joint Surg [Br] 1988;70-B:299-301

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  - 90-95% undisplaced scaphoid waist fractures will heal [4]
  - Inconvenience and work restrictions & Plaster Disease

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Operative Management

- Open/Closed Reduction + Internal Fixation

Operative Management

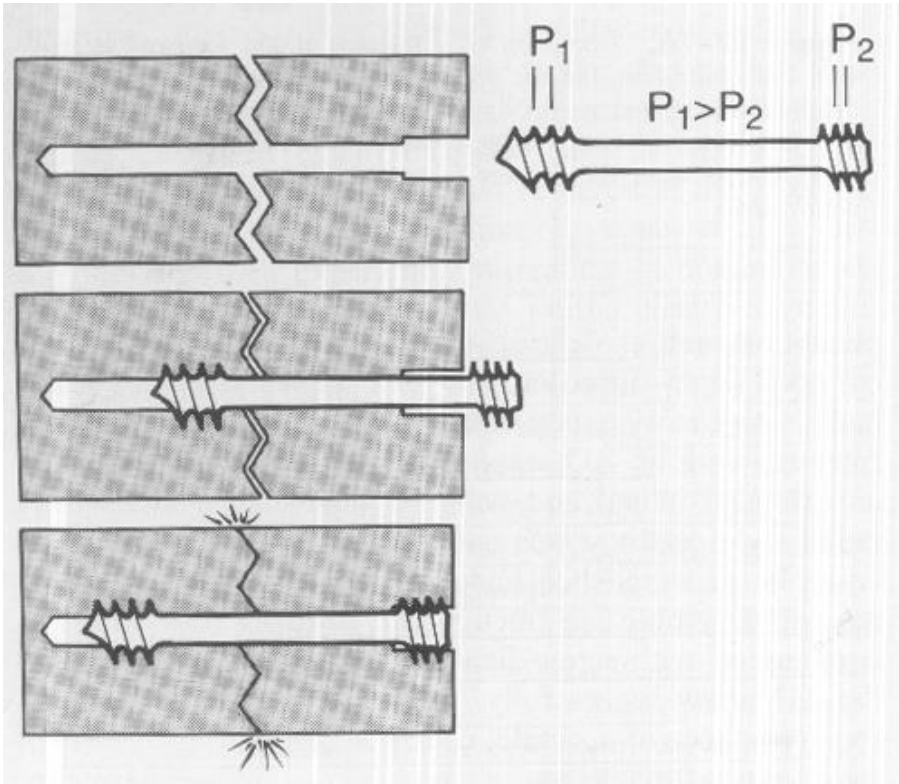
- Open/Closed Reduction + Internal Fixation
  - Kirschner Wire
  - Screw
  - Bioresorbable Screw
  - Staple
  - Plate

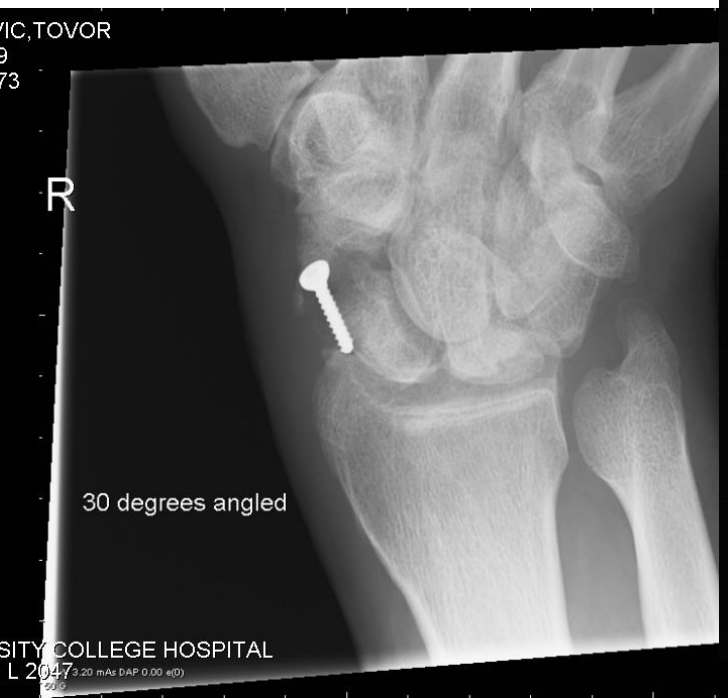
Operative Management

- Open/Closed Reduction + Internal Fixation
  - Kirschner Wire
  - **Screw**
  - Bioresorbable Screw
  - Staple
  - **Plate**

Headless Compression Screws

- Cartilage covered = No callous = primary bone healing = need for rigid stabilisation





59. Scaphoid R

Modifiable Factors

- Central Screw Placement
  - Shorter healing times
  - Greater stiffness, load, and load to failure

Modifiable Factors

Modifiable Factors

- Longer and wider screws = increased rigidity

Controversies

- Cost effectivness
  - Arora et al – quicker union and 7 week quicker return to work offset cost of procedure
  - Davis et al – ORIF cost effective & increased QALYs
- Children
  - Distal > W & PP. Surg indicated for NU
- Bone Growth Simulators
  - Mayr et al – Exogen healed non –op factures in 43 vs 62 days. 81% healed @ 6/52 vs 54.6%
- Biologic Stimulators
  - Bilic et al – OP-1 reduced healing times.

Useful Papers

- **Bond CD et al. Percutaneous screw fixation or cast immobilization for nondisplaced scaphoid fractures. J Bone Joint Surg. 2001**
  - Faster time to union and return to military duty. Same union rate
- **McQueen M et al. Percutaneous screw fixation versus conservative treatment for fractures of the waist of the scaphoid: a prospective randomized study. J Bone Joint Surg. 2008**
  - Surg = Faster time to union. Faster ret to work and sport. Non sig higher union rate in surg. Low complications
- **Davis TR, Prediction of outcome of non-operative treatment of acute scaphoid waist fracture, Ann RCS, 2013**
  - 6 in 1. POP has 89% union. Cant predict union on XR or MRI. >2mm dorsal gap on CT increases risk of NU. MRI vascularity of PP doesn not correlate with union. MU has no sig effect at 1yr
- **Dias et al, Displaced scaphoid waist fractures, JBJS 2011**
  - CT or will miss 40% of displaced #'s. NU = 50%. H:L best meaure of displ. NU = 50% OA.
- **SWIFFT**
  - On going
  - Pragmatic MC RCT of min displaced waist. POP v any surg. PRWE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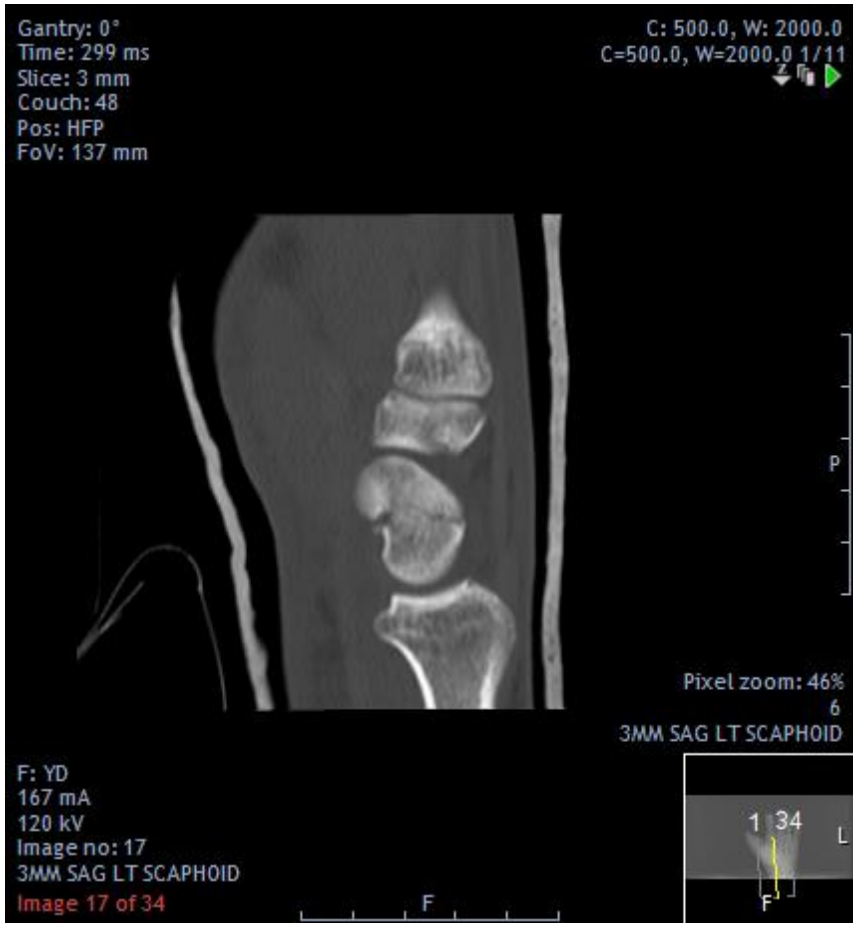
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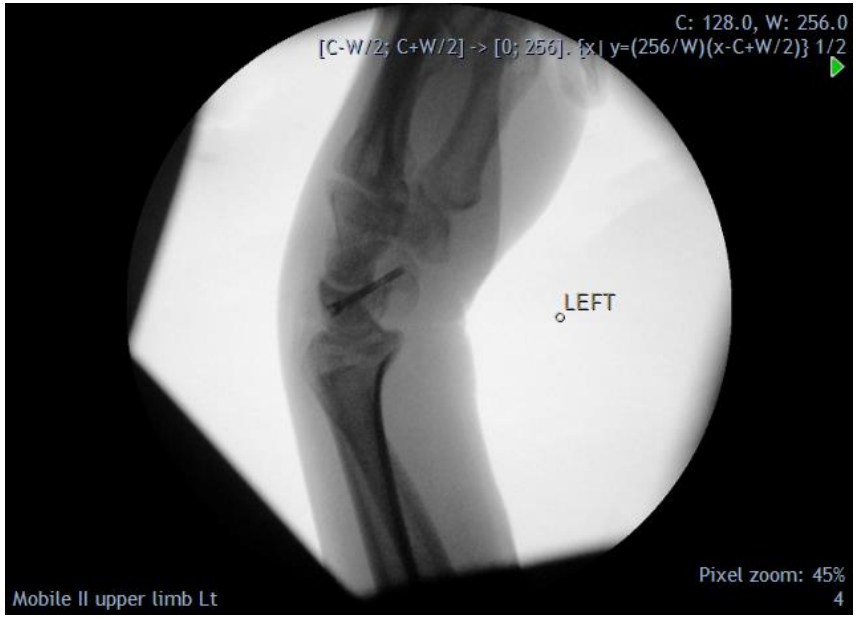
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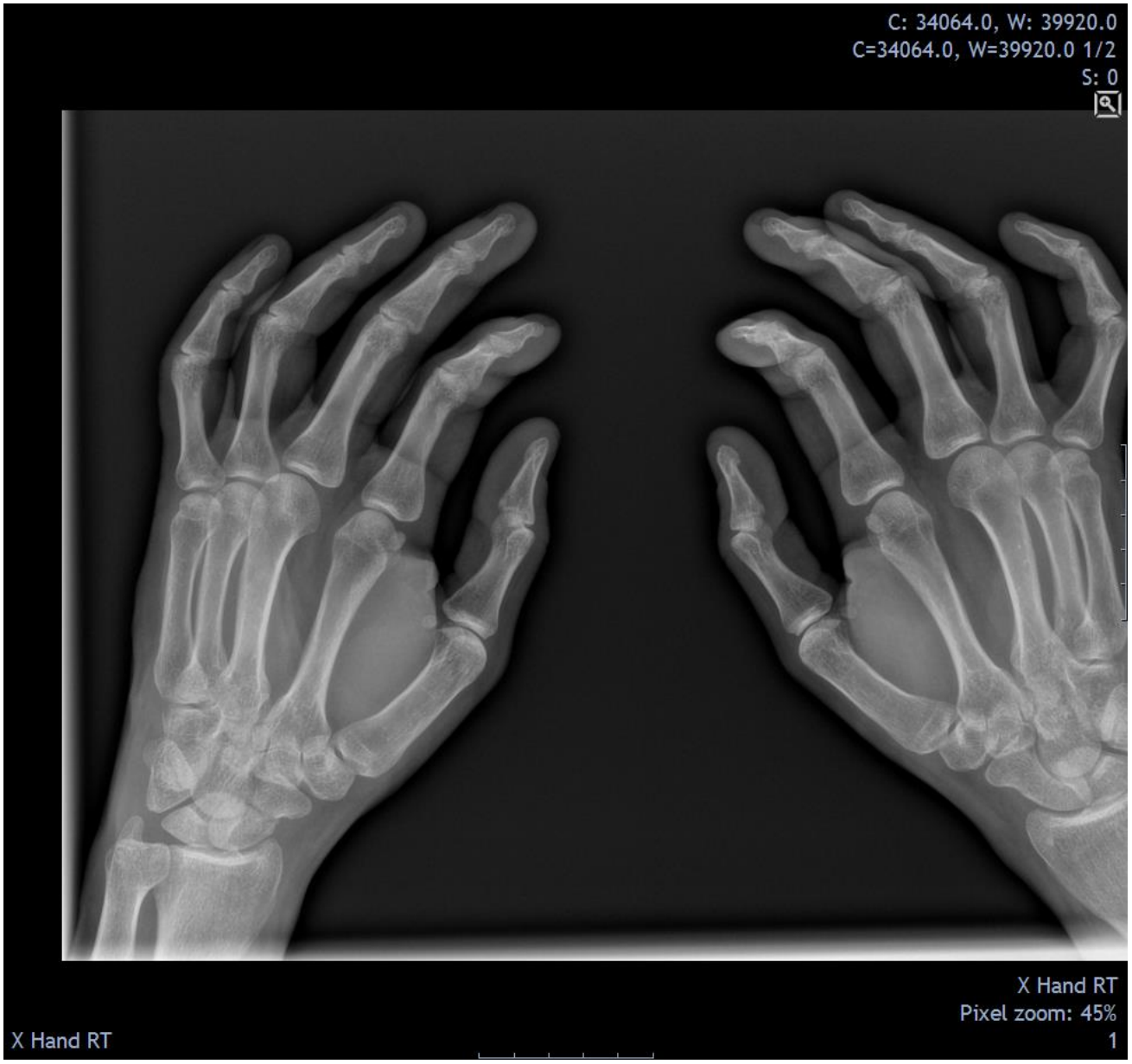
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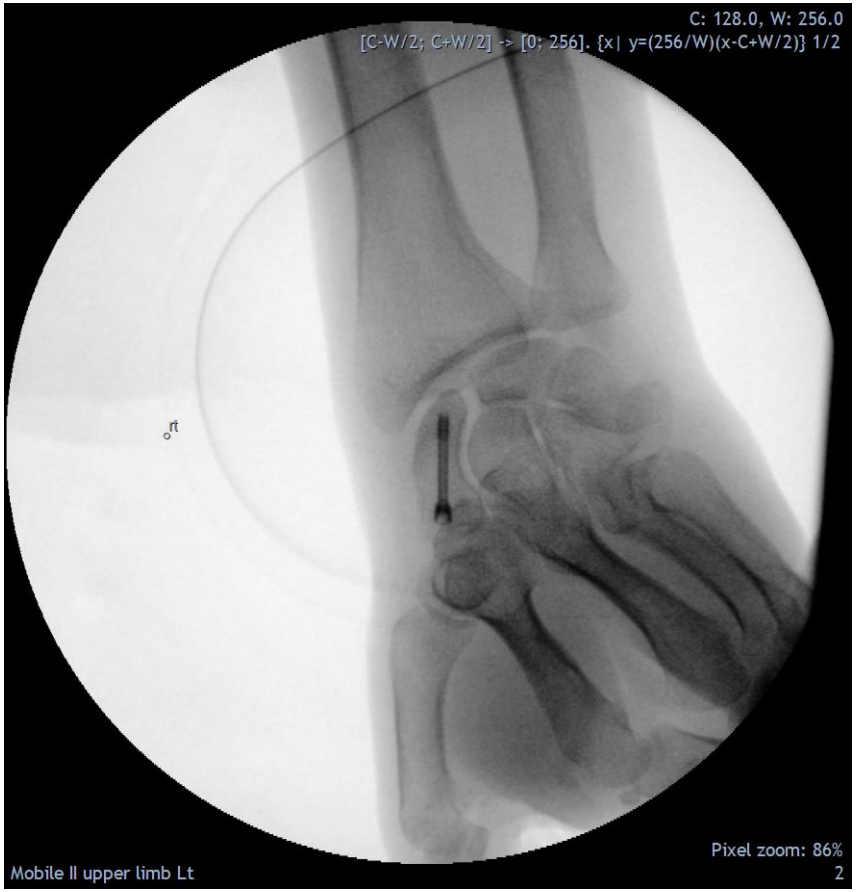
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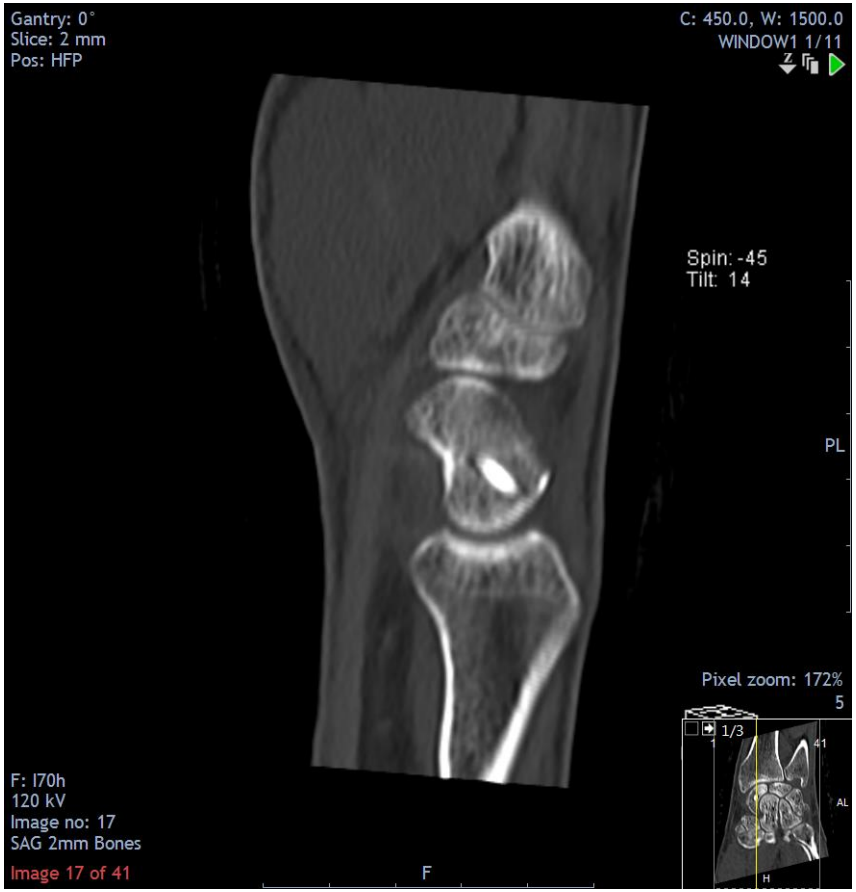
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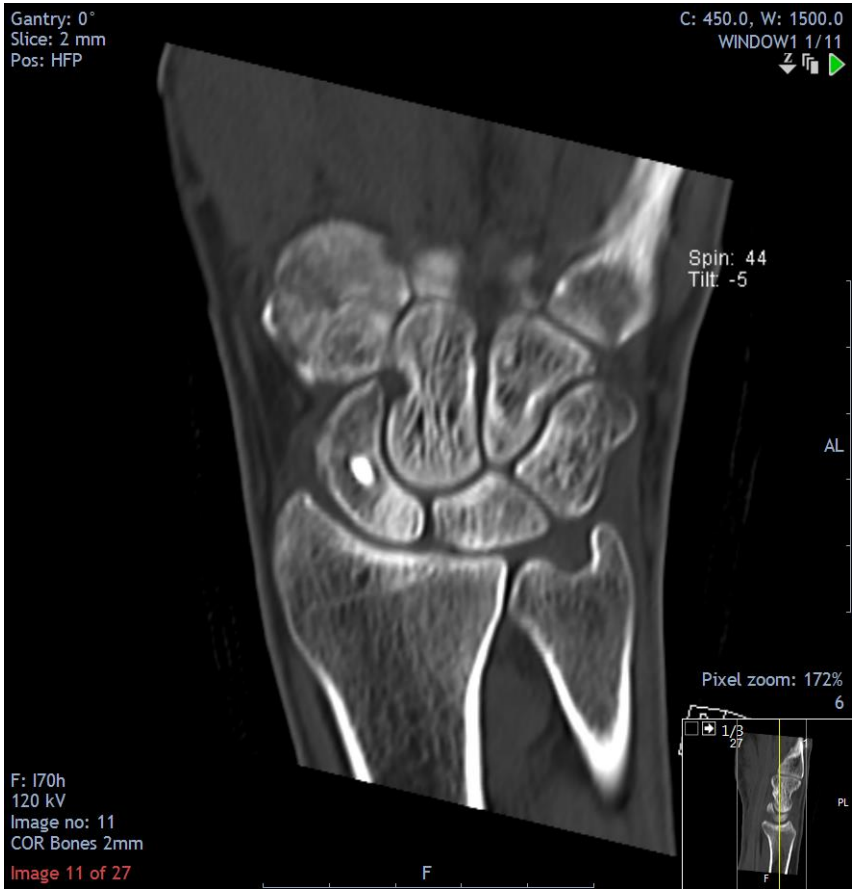
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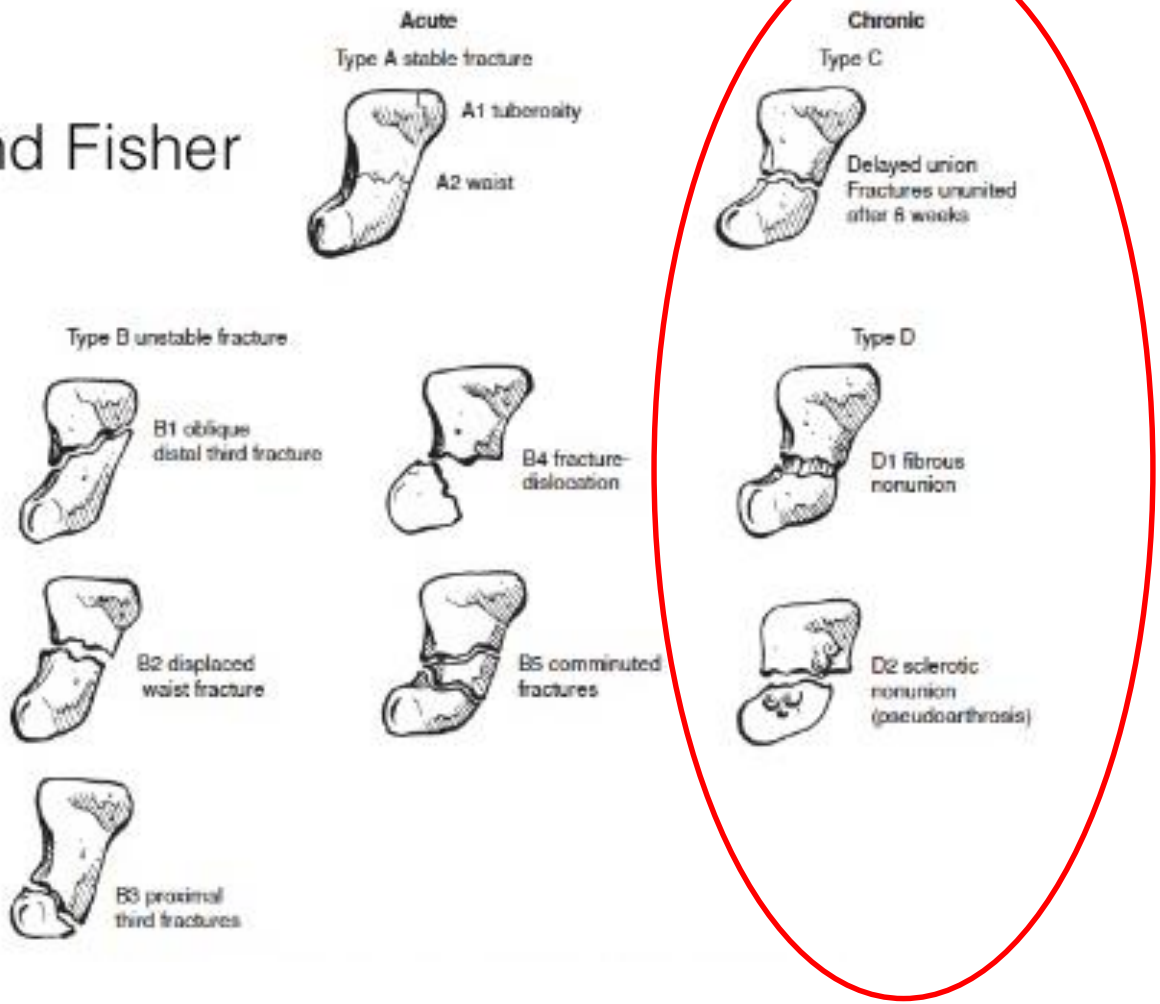
Scaphoid Nonunions

Scaphoid Nonunions

- Herbert and Fisher



Scaphoid NU Background

- Definition = 6-9 months
- Delayed presentation common – ‘sprain’
- Natural History = carpal collapse and degenerative arthritis (Scaphoid Nonunion Advanced Collapse / SNAC)

- Do all nonunions progress to SNAC wrists?

Background

- 56% of nonunions will develop symptomatic osteoarthritis
- 2% of unions will develop symptomatic osteoarthritis
- Treatment objective = healed scaphoid with anatomical alignment

H Duppe, O Johnell, G Lundborg, et al.: Long-term results of fracture of the scaphoid. A follow-up study of more than thirty years. *J Bone Joint Surg Am.* 76 (2):249-252 19948113260

How to evaluate scaphoid nonunions

Scaphoid Non Union Evaluation

- Patient characteristics

Scaphoid Non Union Evaluation

- Patient Characteristics
- Fracture characteristics

Patient Evaluation

1. Duration

Patient Evaluation

1. Duration
   - Chronicity increases chances of OA / Deformity / Carpal Instability

Patient Evaluation

1. Duration
2. Age

Patient Evaluation

1. Duration
2. Age
   - Treatment differs between the classic young pt and elderly low demand pt

Patient Evaluation

- Duration
- Age
- Pain / Dysfunction

Patient Evaluation

- Duration
- Age
- Pain / Dysfunction
  - Established arthritis with tolerable pain / dysfunction should be considered for non-operative management

Patient Evaluation

- Duration
- Age
- Pain / Dysfunction
- Activity level / Requirements

Patient Evaluation

- Duration
- Age
- Pain / Dysfunction
- Activity level / Requirements
  - No mandate for operative repair – salvage procedures available later

Patient Evaluation

- Duration
- Age
- Pain / Dysfunction
- Activity level / Requirements
- Co-morbidities

Patient Evaluation

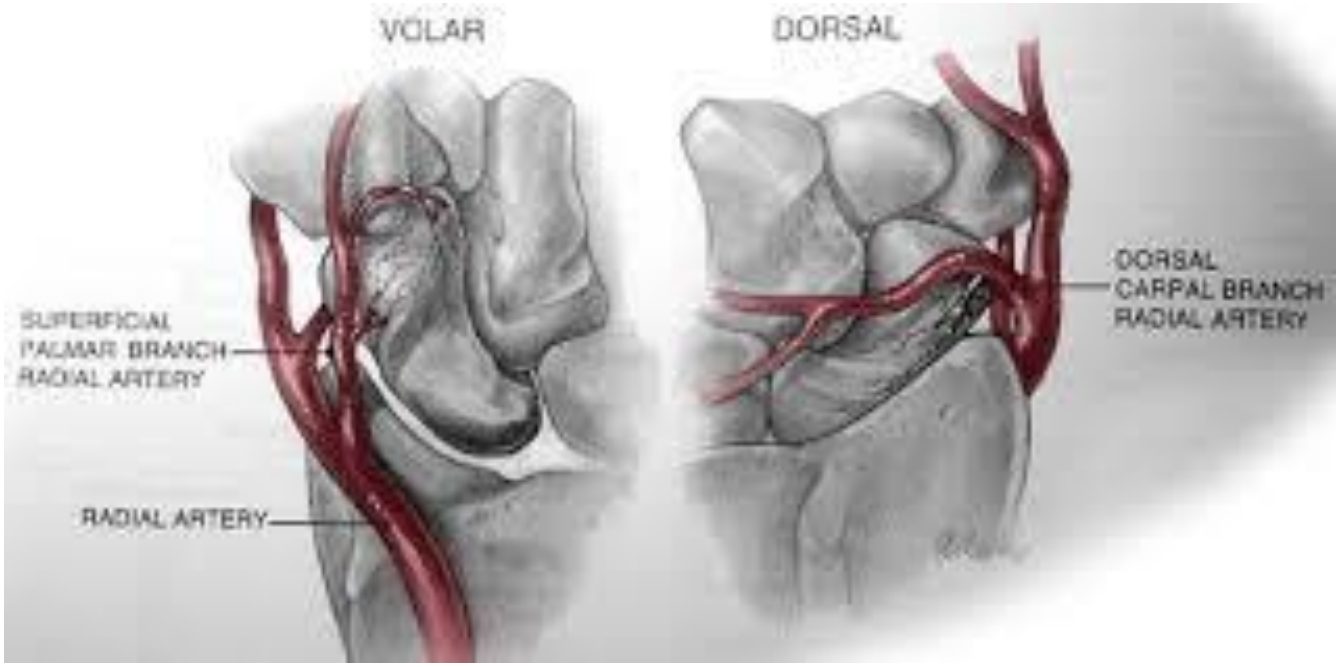
- Duration
- Age
- Pain / Dysfunction
- Activity level / Requirements
- Co-morbidities
  - Complex surgery further disadvantaged by smoking, poor compliance, DM, IA steroids etc

Fracture Evaluation

1. Where is the non-union?

Fracture Evaluation

1. Where is the non-union?
   - More proximal = higher risk of dysvascular /AVN



Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
   - Humpback
   - DISI

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
   - Humpback
   - DISI
     - Try to correct deformity at the time of surgery

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation
   - Suggest instability with bone loss
   - May require structural graft

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery
   - Existing metalwork? Space for new screw / plate?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery
6. PP dysvascular?

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery
6. PP dysvascular?
   - Vascularity is important
   - Determining vascularity is controversial
   - Punctate bleeding / Histology

Fracture Evaluation

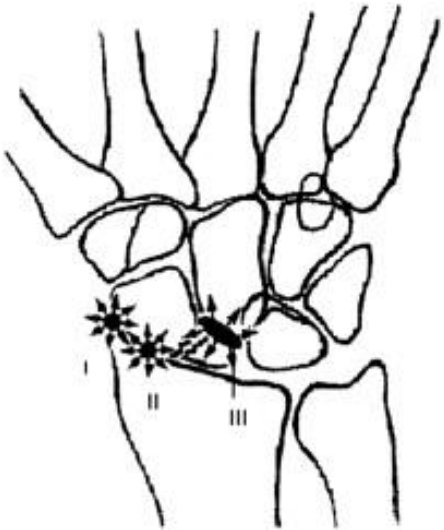
1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery?
6. PP dysvascular?
7. Salvageability of fragment

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation
5. Previous Surgery
6. PP dysvascular?
7. Salvageability of fragment
   - Cant repair an irreparable fragment

Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation?
5. Previous Surgery
6. PP dysvascular?
7. Salvagebility of fragment
8. SNAC?



Fracture Evaluation

1. Where is the non-union?
2. Displaced vs Undisplaced?
3. Deformity?
4. Comminution / Cyst Formation
5. Previous Surgery
6. PP dysvascular?
7. Salvagebility of fragment
8. SNAC?
   - Radiocarpal / Midcarpal /DRUJ

Stratification

- Delayed Union
- Waist nonunion
- Proximal Pole nonunion
- Dysvascular nonunion

Delayed Union

Delayed Union

Delayed Union

Delayed Union

- NU without substantial bone loss require rigid fixation only if adequate perfusion

- Presentation >4/52 have poor union rates with casting alone

Delayed Union

Delayed Union

Percutaneous / Mini Open HCS

Waist Nonunion

Waist Nonunion

Waist Nonunion

Waist Nonunion

- Shah et al – fibrous non unions heal well with rigid stabilisation alone
- Slade et al – NU with minimal resorption and <2mm sclerosis heal well without BG
  - NU with varying degrees of deformity / bone loss / resorption (most common) require BG
- Cohen et al - Degree of malunion is tolerable
- Merrell et al - no diff in iliac crest v distal radius BG & screw superior to K wire

1. J Shah, WA Jones: Factors affecting the outcome in 50 cases of scaphoid nonunion treated with Herbert screw fixation. *J Hand Surg [Br].* 23 (5):680-685 1998 9821620
2. JF Slade 3rd, WB Geissler, AP Gutow, et al.: Percutaneous internal fixation of selected scaphoid nonunions with an arthroscopically assisted dorsal approach. *J Bone Joint Surg Am.* 85 (Suppl 4):20-32 2003
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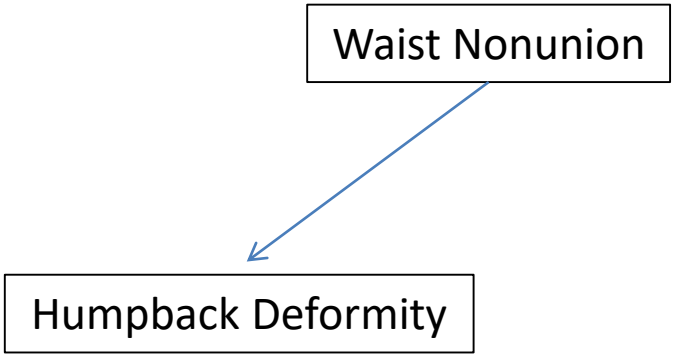
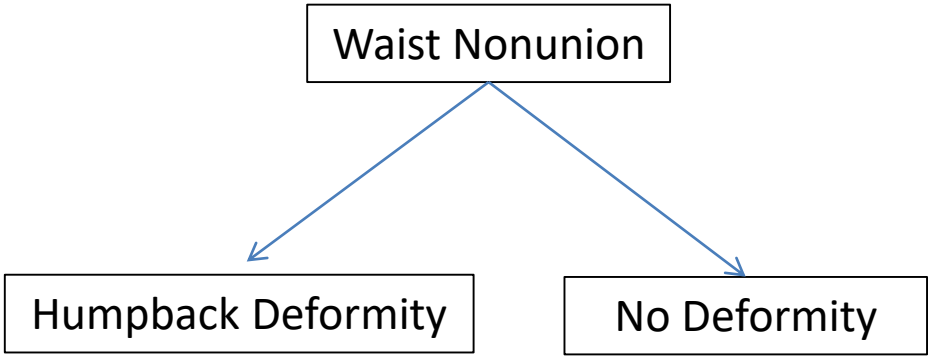
4. 145**GA Merrell, SW Wolfe, JF Slade 3rd**: Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Hand Surg [Am].* 27 (4):685-691 2002 12132096

Waist Nonunion



Waist Nonunion



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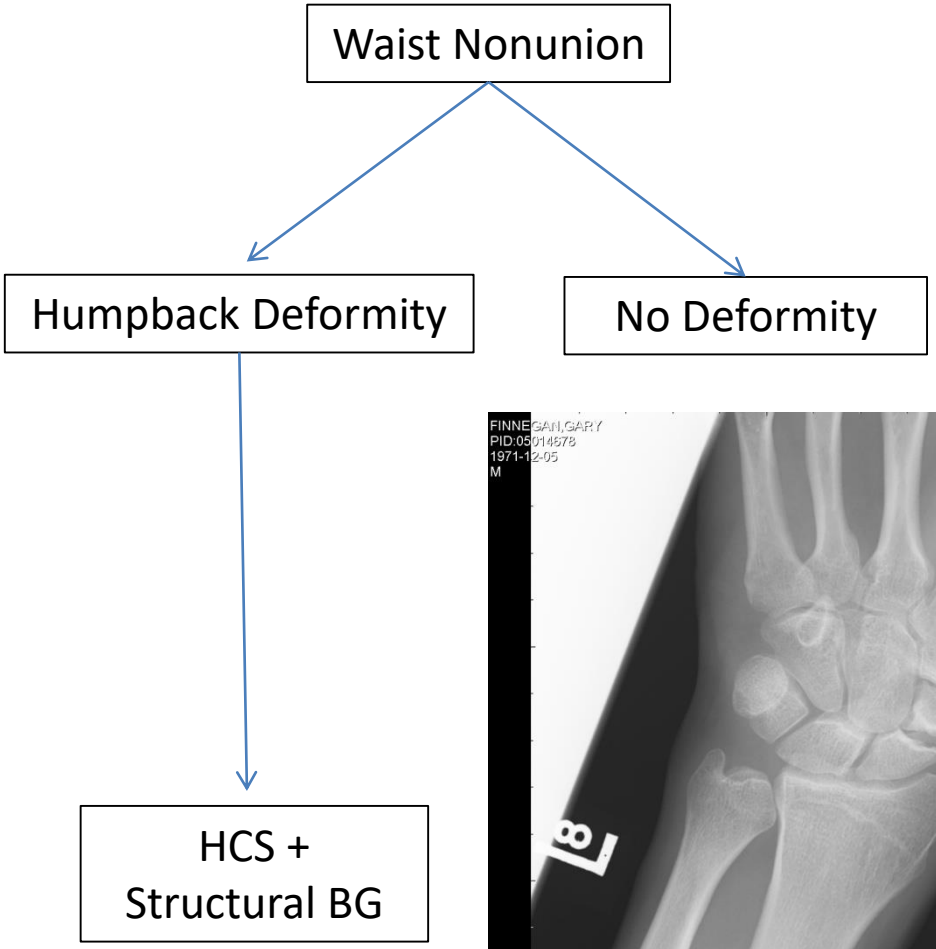
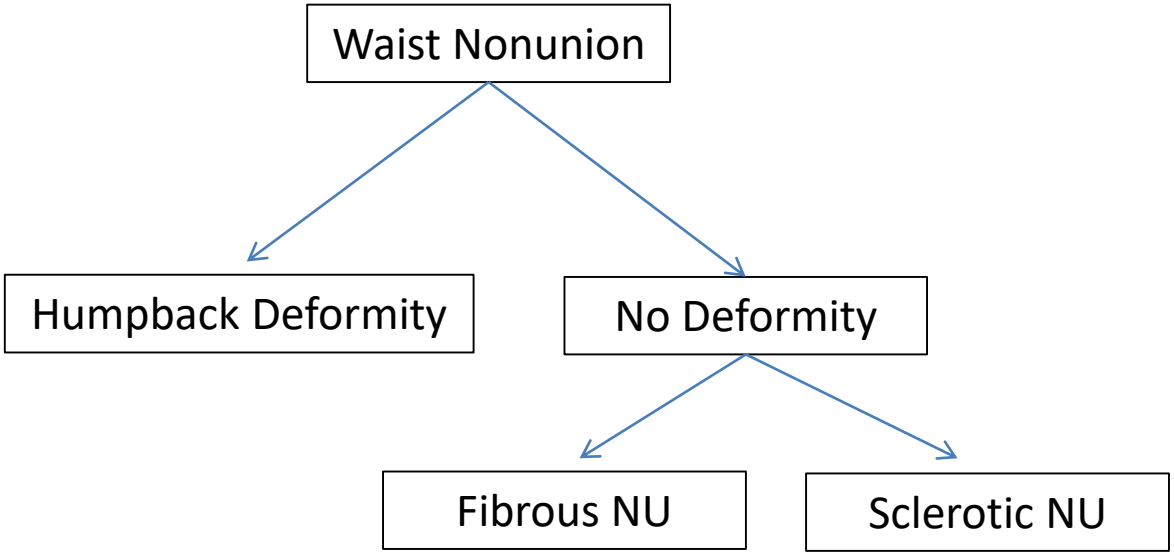


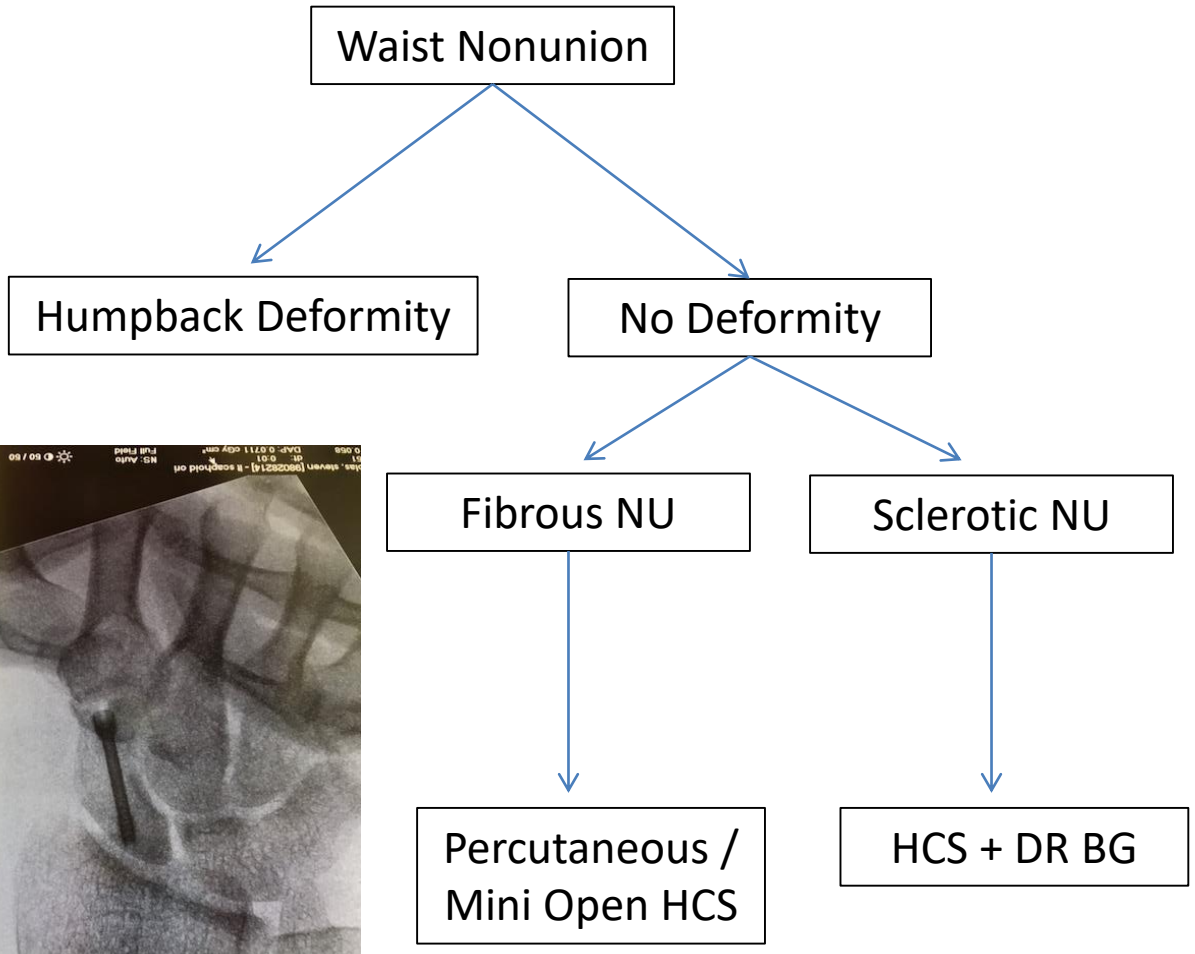
Waist Nonunion



Waist Nonunion

- Waist Nonunion
  - Humpback Deformity
  - No Deformity
    - Fibrous NU
      - Percutaneous / Mini Open HCS
    - Sclerotic NU

Waist Nonunion



Proximal Pole Nonunion

Prox Pole Nonunion

Proximal Pole Nonunion

- Minimal displacement / deformity – open dorsal + cancellous bone graft.

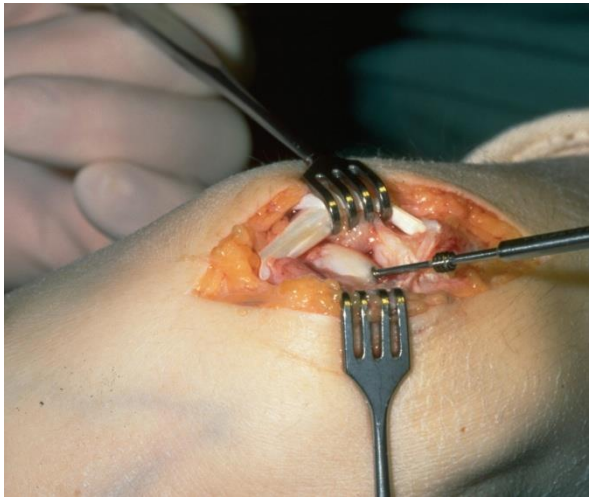
- Growing body of evidence for percutaneous bone grafting

Prox Pole Nonunion

JF Slade 3rd, T Gillon: Retrospective review of 234 scaphoid fractures and nonunions treated with arthroscopy for union and complications. *Scand J Surg.* 97 (4):280-2892008 19211381
W Geissler, JF Slade: Fractures of the carpal bones. **SW Wolfe RN Hotchkiss WCPederson et al.** *Green's operative hand surgery.* ed 6 2011 Elsevier/Churchill Livingstone Philadelphia
Chu PJ, JT Shih: Arthroscopically assisted use of injectable bone graft substitutes for management of scaphoid nonunions. *Arthroscopy.* 27 (1):31-37 2011 20934844

Proximal Pole Nonunion

Prox Pole Nonunion



Percutaneous / Mini Open (dorsal) HCS + DR BG

Dysvascular Nonunion (AVN)

Dysvascular Nonunion

Dysvascular Nonunion (AVN)

- No evidenced based guideline on which cases most benefit from VBG

Dysvascular Nonunion

1. 97Y Hori, S Tamai, H Okuda, et al.: Blood vessel transplantation to bone.*J Hand Surg [Am].* 4 (1):23-33 1979
2. 197T Sunagawa, AT Bishop, K Muramatsu: Role of conventional and vascularized bone grafts in scaphoid nonunion with avascular necrosis: a canine experimental study. *J Hand Surg [Am].* 25 (5):849-859 2000

Dysvascular Nonunion

•No evidenced based guideline on which cases most benefit from VBG

Dysvascular Nonunion

•We don't know;
- •Histology of treated nonunions
- •How to assess vascularity
- •Is internal fixation more important than ischaemia

Dysvascular Nonunion

- No evidenced based guideline on which cases most benefit from VBG

Dysvascular Nonunion

- We dont know;
  - Histology of treated nonunions
  - How to assess vascularity
  - Is internal fixation more important than ischaemia

- Original research came from canine models
  - 1986 – Shi – Fasciosteal flap
  - 1991 – Zaidemberg – 1,2 ICSRA
  - Mathoulin – volar carpal artery
  - Sotereanos – dorsal capsular pedicle
  - Doi – Free medial femoral condyle

1. 97Y Hori, S Tamai, H Okuda, et al.: Blood vessel transplantation to bone.*J Hand Surg [Am].* 4 (1):23-33 1979
2. 197T Sunagawa, AT Bishop, K Muramatsu: Role of conventional and vascularized bone grafts in scaphoid nonunion with avascular necrosis: a canine experimental study. *J Hand Surg [Am].* 25 (5):849-859 2000
3. 228**C Zaidemberg, JW Siebert, C Angrigiani**: A new vascularized bone graft for scaphoid nonunion. *J Hand Surg [Am].* 16 (3):474-478 1991 1861030
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6. 188**DG Sotereanos, NA Darlis, ZH Dailiana, et al.**: A capsular-based vascularized distal radius graft for proximal pole scaphoid pseudarthrosis. *J Hand Surg [Am].* 31 (4):580-587 2006 16632051
7. 53**K Doi, T Oda, T Soo-Heong, et al.**: Free vascularized bone graft for nonunion of the scaphoid. *J Hand Surg [Am].* 25 (3):507-519 2000 10811756

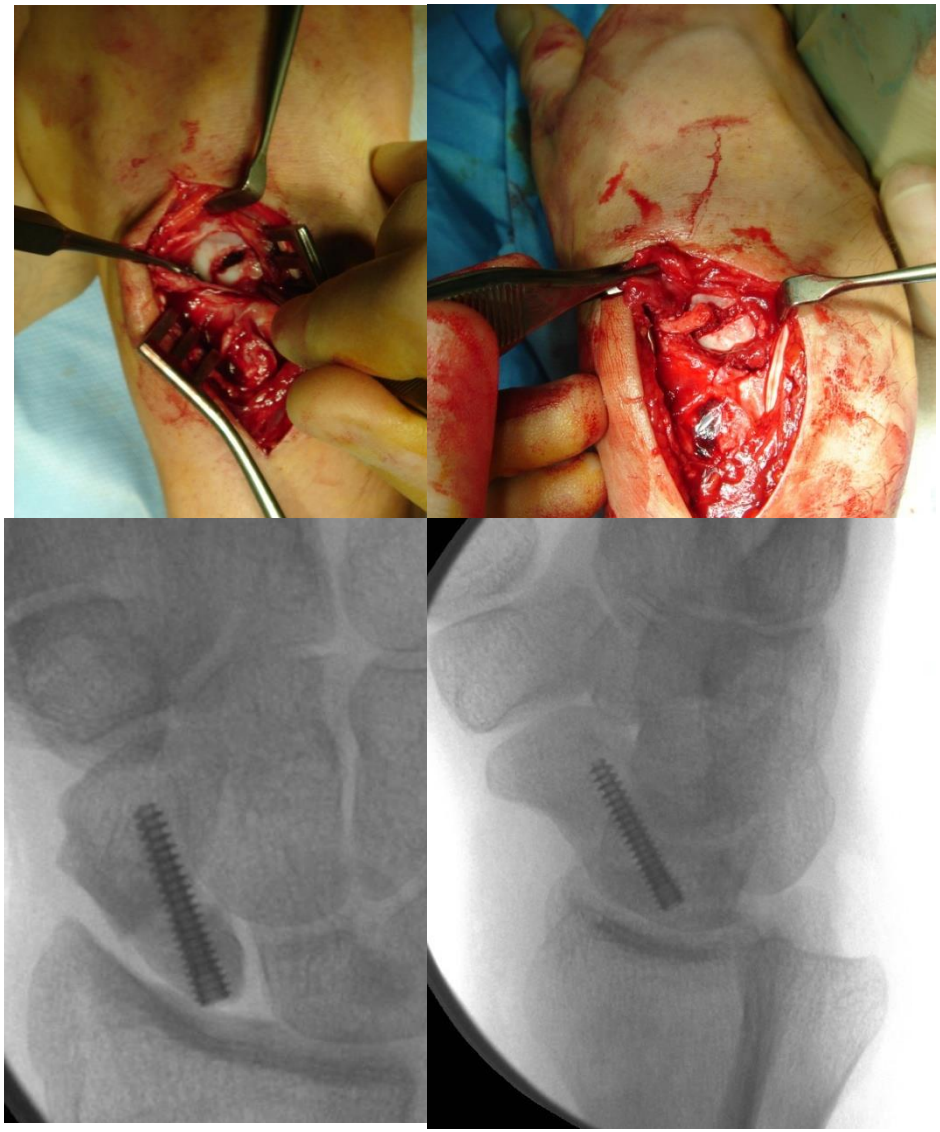
Nonunion Management Algorithm

- Consensus of use;
  - Lack of punctate bleeding intraoperatively
  - Persistent NU following previous surgery

Dysvascular Nonunion

1. 97Y Hori, S Tamai, H Okuda, et al.: Blood vessel transplantation to bone.*J Hand Surg [Am].* 4 (1):23-33 1979
2. 197T Sunagawa, AT Bishop, K Muramatsu: Role of conventional and vascularized bone grafts in scaphoid nonunion with avascular necrosis: a canine experimental study. *J Hand Surg [Am].* 25 (5):849-859 2000

Nonunion Management Algorithm



Dysvascular Nonunion

↓

ORIF + BG (?VBG)

Additional Considerations

Additional Considerations

- SNAC 1

Additional Considerations

- SNAC 1
  - Radial styloidectomy

Additional Considerations

- SNAC 1
  - Radial styloidectomy
- SNAC 2

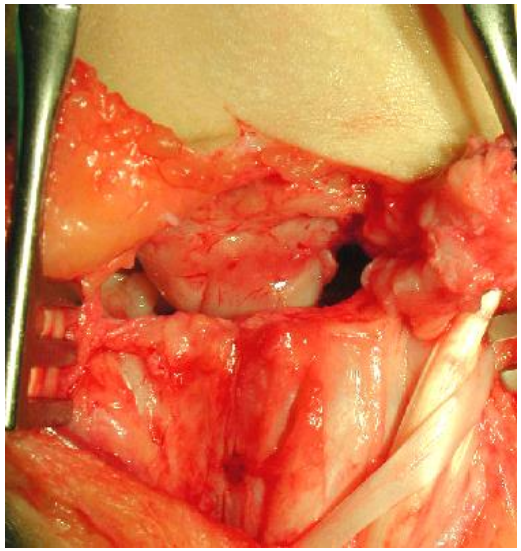
Additional Considerations

- SNAC 1
  - Radial styloidectomy

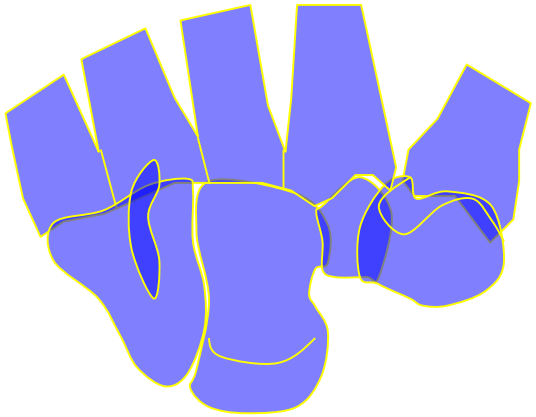
- SNAC 2
  - Scaphoidectomy
    - 4CF / PRC

Additional Considerations

- SNAC 1
  - Radial styloidectomy



- SNAC 2
  - Scaphoidectomy + 4CF
  - PRC

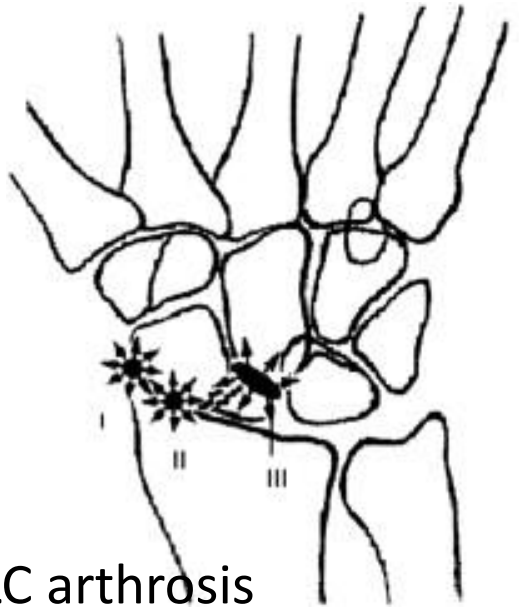


Additional Considerations

- SNAC 1
  - Radial styloidectomy
- SNAC 2
  - Scaphoidectomy + 4CF
  - PRC
  - Distal pole excision if no SC / LC arthrosis

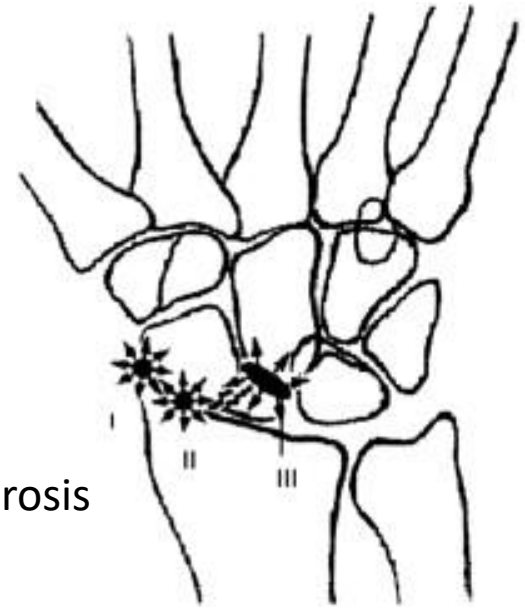
Additional Considerations

- SNAC 1
  - Radial styloidectomy
- SNAC 2
  - Scaphoidectomy + 4CF
  - PRC
  - Distal pole excision if no SC / LC arthrosis
- Prox Pole <5mm
  - Scaphoidectomy + 4CF
  - PRC
  - Osteochondral medial free femoral flap



Additional Considerations

- SNAC 1
  - Radial styloidectomy
- SNAC 2
  - Scaphoidectomy + 4CF
  - PRC
  - Distal pole excision if no SC / LC arthrosis
- Prox Pole <5mm
  - Scaphoidectomy + 4CF
  - PRC
  - Osteochondral medial free femoral flap
- Previous Surgery
  - Place new screw from opposite side



Evidence – Based Scaphoid Nonunion Algorithm

1. Define

No formal consensus. "Failure of the scaphoid to heal after 9 months with no evidence of radiological healing within the last 3 months" [1, 2]

2. Assess

History, Examination, Imaging (Scaphoid series, CT +/- MRI

Patient Factors:

1. Duration
2. Pain / Dysfunction
3. Age
4. Activity levels
5. Co-morbidities

Nonunion Factors:

1. Location?
2. Displacement?
3. Deformity
4. Comminution / Cyst Formation?
5. Prior Surgery?
6. Proximal pole AVN?
7. SNAC?
8. Fragment salvagability?

3. Stratify

- Delayed Union
- Waist non-union
  - Fibrous v Sclerotic?
  - Humpback deformity?
- Proximal Pole non-union
  - No evidence AVN
  - Possible AVN

Abbreviations

- SNAC – scaphoid nonunion advanced collapse
- AVN – avascular necrosis
- PP – proximal Pole
- 4CF – 4 corner fusion
- PRC – proximal row carpectomy
- OC MFCG – osteochondral medial femoral condyle graft
- DR – distal radius
- BG – bone graft
- HCS – headless compression screw

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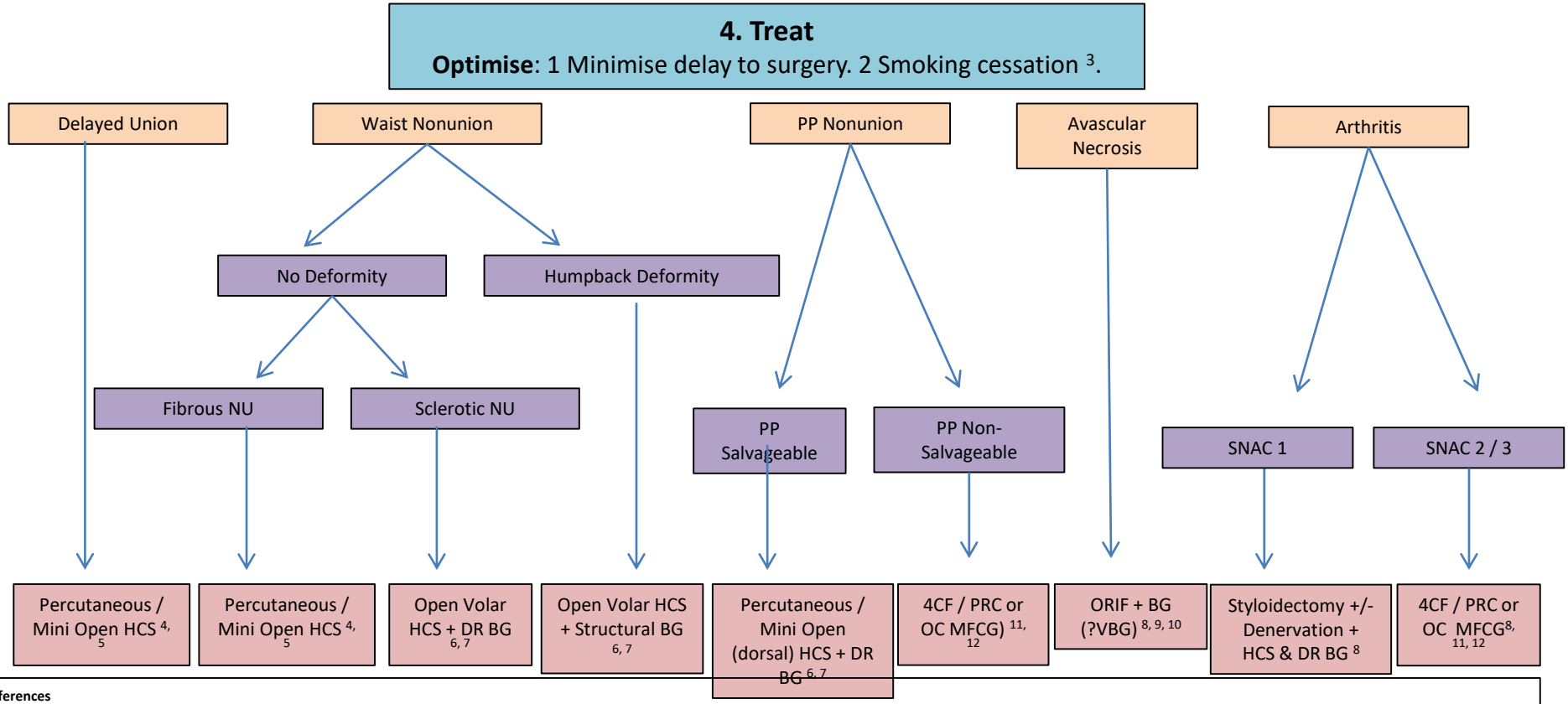

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Useful Papers

- **K. Rancy et al. Success of scaphoid nonunion surgery is independent of proximal pole vascularity JHS Eu 2018**
  - 35 Nus treated with NV autograft. Looked at pre op MRI, intra op bleed and histo. 9 had ischamia on MRI. 28/35 had decreased intraop bleeding. 4/33 had tissue necrosis. 33/35 healed by 12 weeks. Conc = pp infarction is rare and VBG rarely required.
- **Kim J et al. Non-vascularized iliac bone grafting for scaphoid nonunion with avascular necrosis. Journal of Hand Surgery (European Volume) 2018,**
  - 24 pt with pp #'s with MRi showing AVN had NV IC BG. Sever humpback had fisk wedge. Others simple cancellous graft. 22/24 united. DISC -, no high-quality randomized trial or prospective study has compared vascularized and non-vascularized bone grafts in scaphoid fractures with AVN. Conc – can use NVBG for MRI proven AVN.
- **Mathoulin C, Treatment of the scaphoid humpback deformity – is correction of the dorsal intercalated segment instability deformity critical? JHS E 2018**
  - Nice summary on all research on effect of DISI. No consensus or evidence base on whether to correct but lots of theoretical benefits. Op trchinique involves flexing wrist and driving a perc RL wire.

Prognosis for Scaphoid NU Healing

- Merrell et al
  - Unstable NU = 94% union with HCS & corticocancellous graft (vs 77% k wire)
  - No diff b/n immediate ROM & 6/52 cast
  - AVN – 88% union with VBG vs 47% BG

- Inoue et al
  - 90% union with HCS & BG at 2 yr
  - RF failure = AVN pp, delay to surgery, instability, prox #

1. GA Merrell, SW Wolfe, JF Slade 3rd: Treatment of scaphoid nonunions: quantitative meta-analysis of the literature. *J Hand Surg [Am].* 27 (4):685-691 2002
2. 104**G Inoue, K Shionoya**: Herbert screw fixation by limited access for acute fractures of the scaphoid. *J Bone Joint Surg Br.* 79 (3):418-421 1997

BSSH Scaphoid Nonunion Study Group 2018

- Smoking
  - combined analysis of all scaphoid nonunions revealed that smoking status did not affect the risk of nonunion (p=0.13). By contrast,
  - Smoking affected the outcome of proximal pole fractures (union rates for non-smokers v smokers = 77% v 43%: P=0.01) but not waist fractures (union rates for non-smokers v smokers = 72% v 64%: P=0.47).
- Delay to Surgery
  - When all scaphoid nonunion locations were analysed together it was found that a delay to surgery had a significant adverse effect on the rate of union (P=0.02).
  - When investigated delay influenced the outcome for waist nonunions (P=0.004), but not proximal nonunions (p=0.6).
  - An interval of more than 1 year appeared deleterious for scaphoid waist nonunions.
- Bone Graft
  - Our findings suggest that currently in the United Kingdom non-vascularised iliac crest bone graft remains the most popular choice for scaphoid non-union surgery, utilized in 42% of all cases (50% of scaphoid waist nonunions and 21% of proximal pole nonunions).
  - Non-vascularised local graft was the second most popular for scaphoid waist non unions (27%) followed by local vascularised graft (17%).
  - Vascularised local bone graft influenced the union rate of proximal pole fractures nonunions (vascularised v non vascularised = 82% v 58%: P= 0.04) but it did not affect the union rate for waist fractures nonunions (vascularised v non vascularised = 70% v 69-74%: P= 0.39).
  - We found no significant difference between the union rates for either waist or proximal nonunion cases treated with non-vascularised distal radius or iliac crest bone graft.

1


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C=8192.0, W=16383.0 1/2
WRIST
Pixel zoom: 88%
R


Gantry: 0°
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Pos: HFS
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Pixel zoom: 59%
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3 MM COR R WRIST
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Mobile II upper limb Rt
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HAND
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Pixel zoom: 114%
HAND
3


Gantry: 0°
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Slice: 3 mm
Couch: 42
Pos: HFS
FoV: 127 mm
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C=500.0, W=2000.0 1/11
PL
Pixel zoom: 61%
4
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167 mA
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Image 19 of 33
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Gantry: 0°
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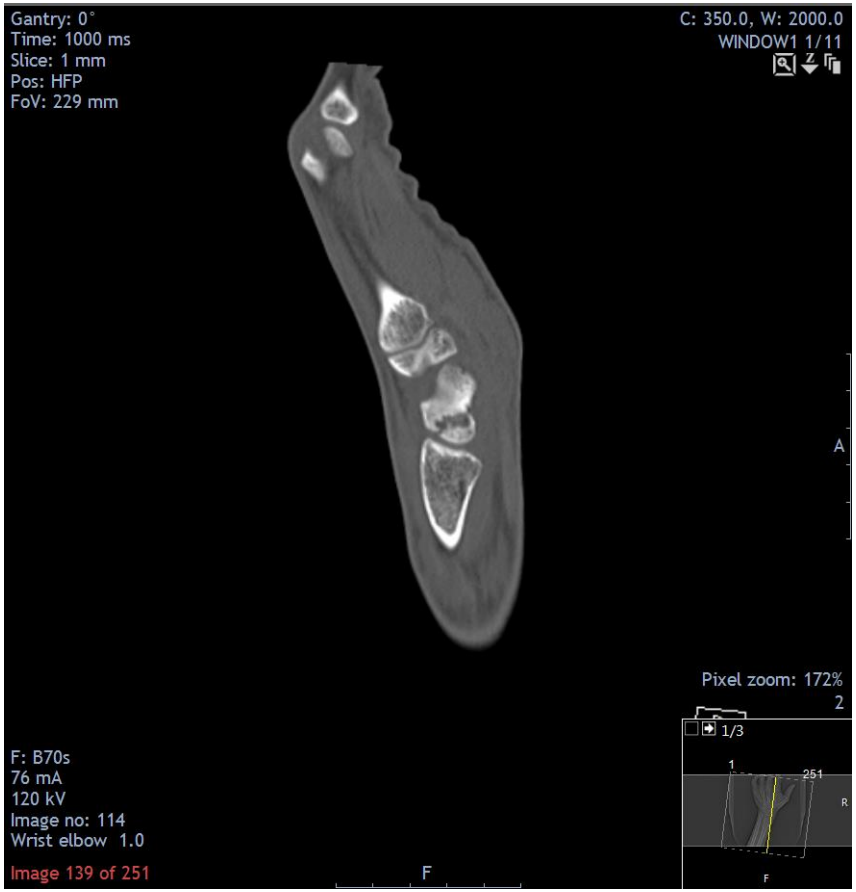
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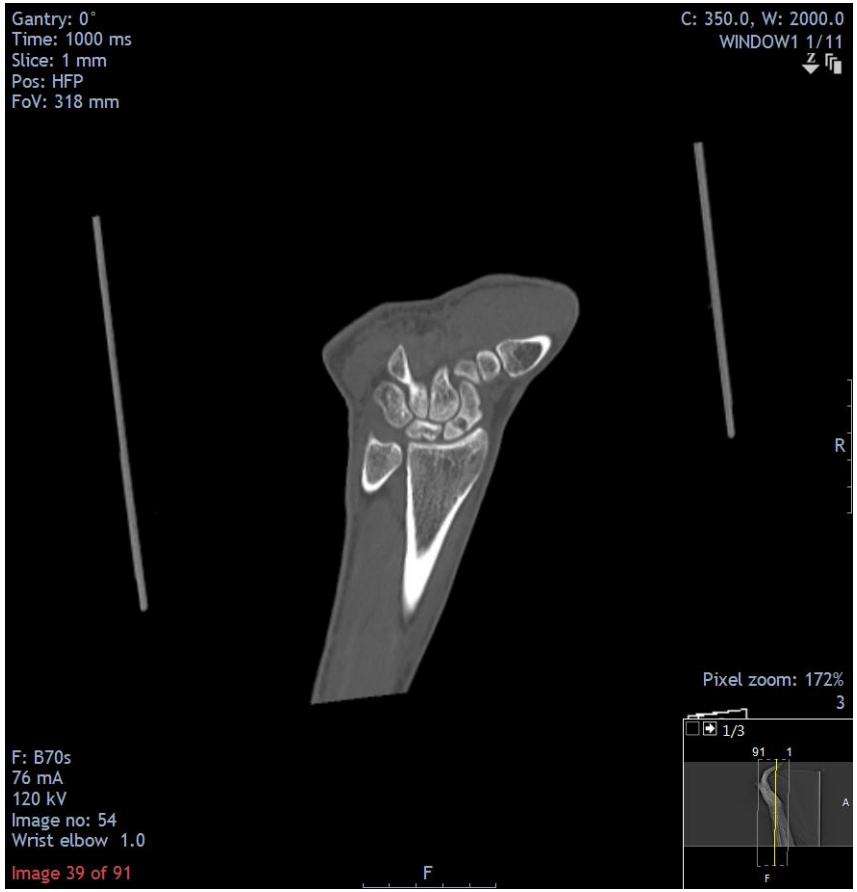
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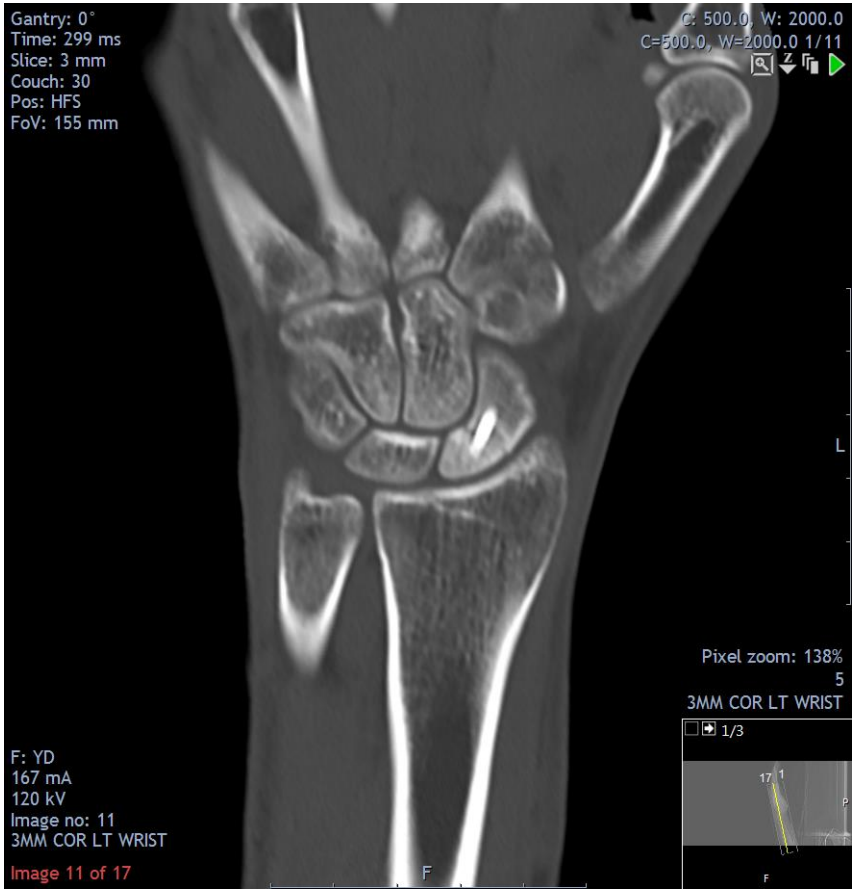
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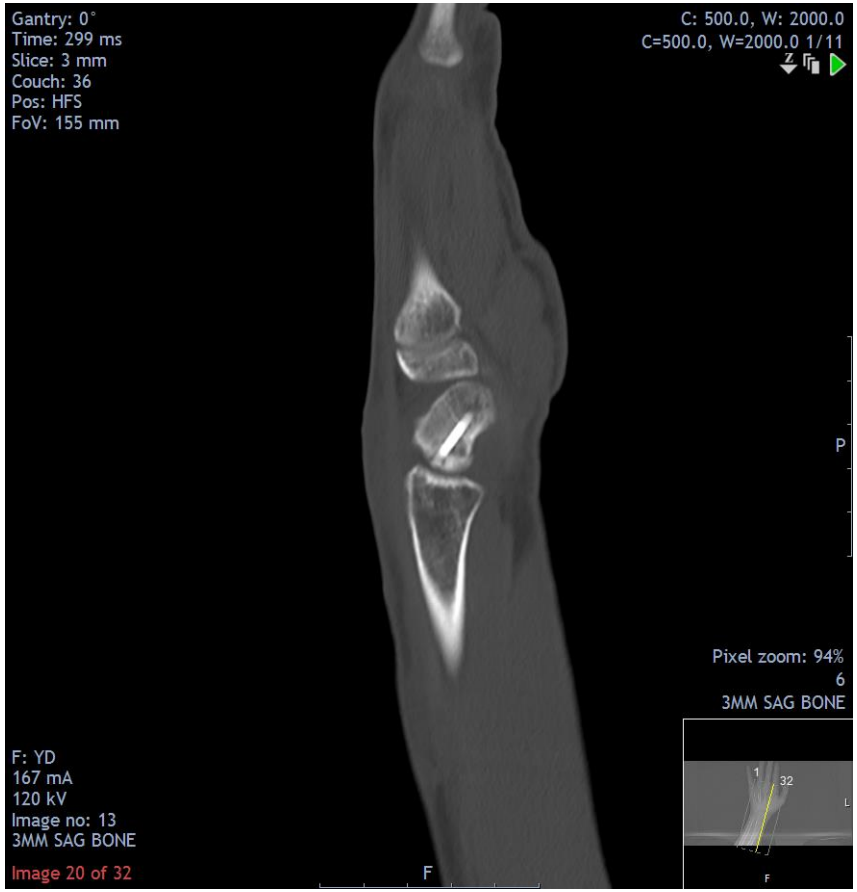
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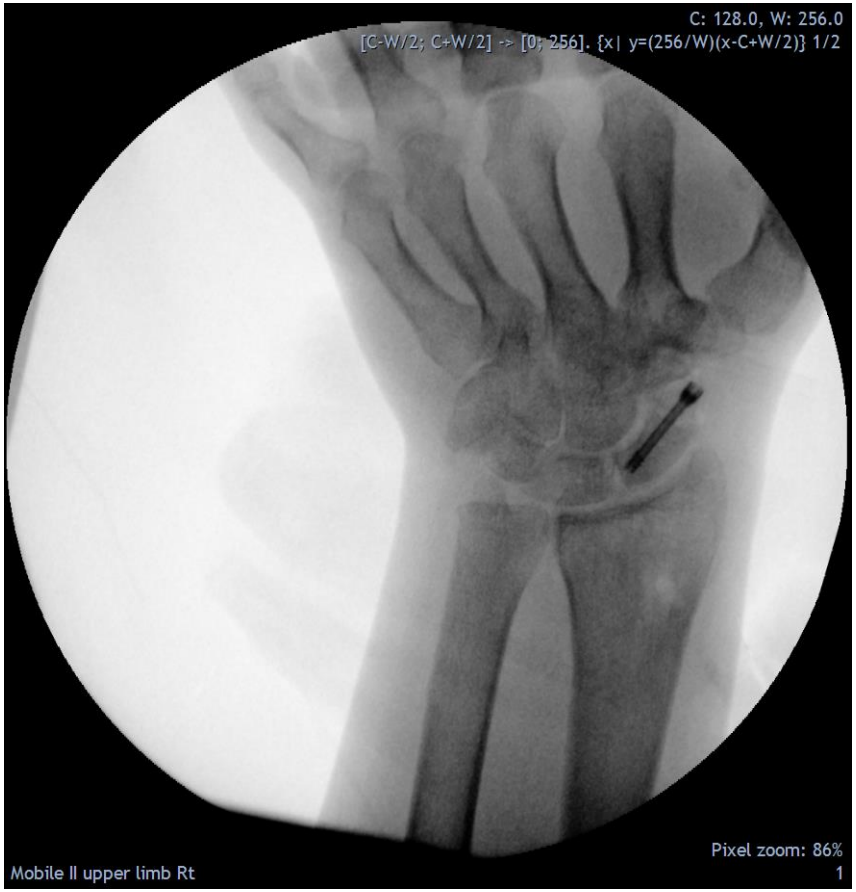
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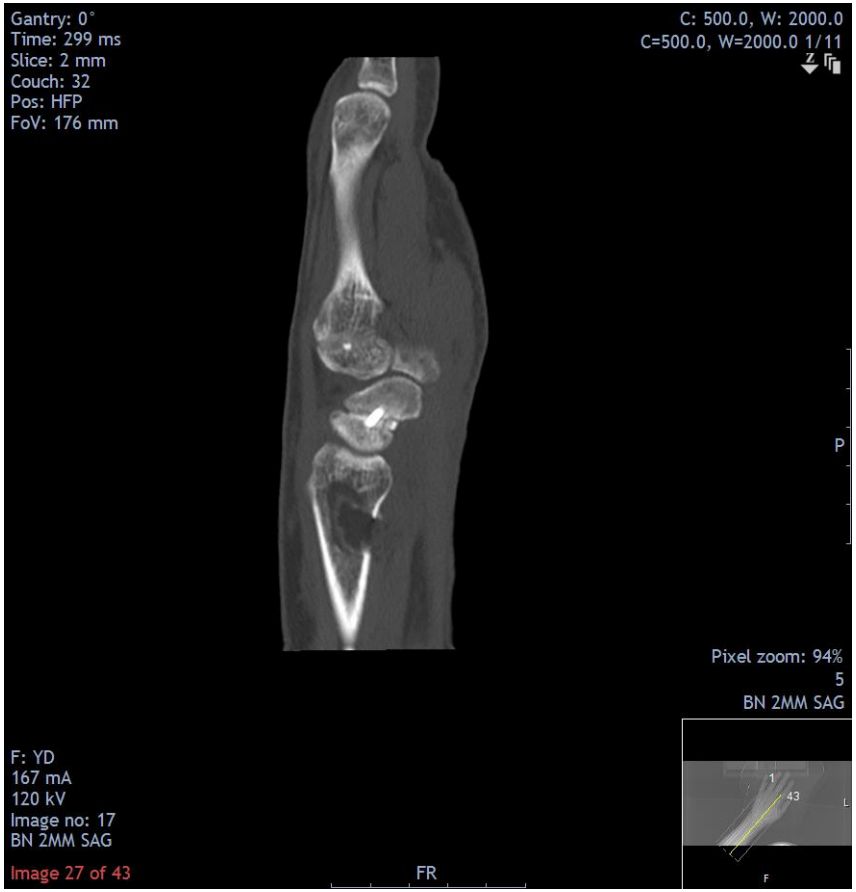
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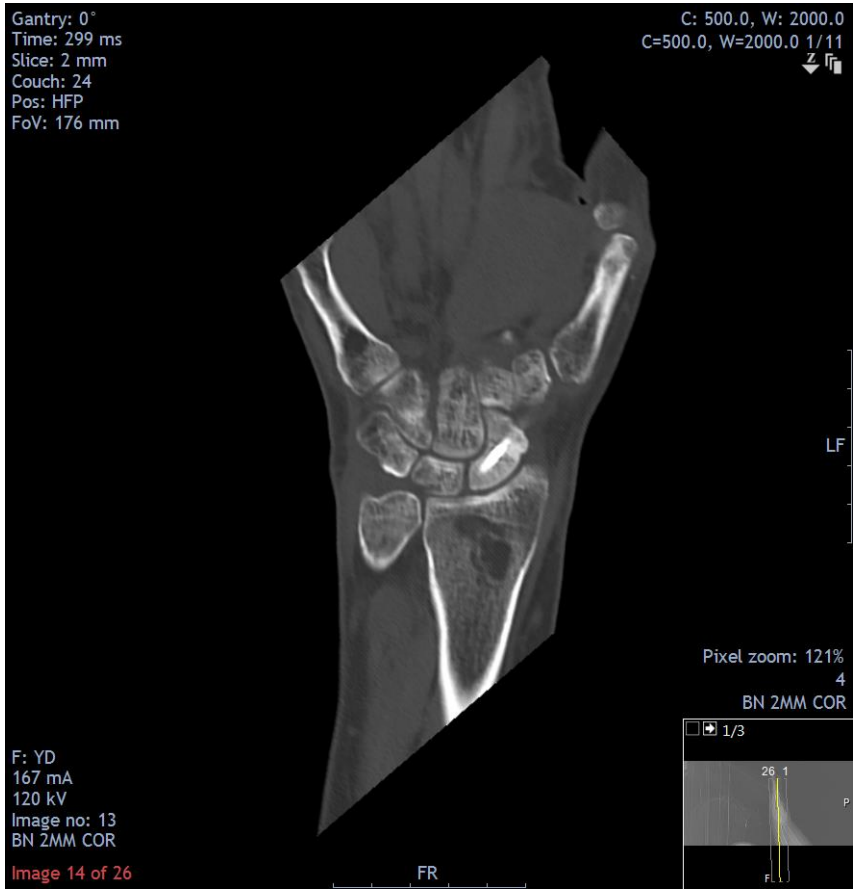
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Image 14 of 26
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Summary

- Risk of nonunion for undisplaced acute fractures is 9-12%.
- Risk of nonunion for displaced acute fractures is <50%
- 56% of scaphoid nonunions progress to SNAC wrist
- 2% of scaphoid unions progress to SNAC wrists
- Consider all fracture and patient characteristics before embarking on treatment