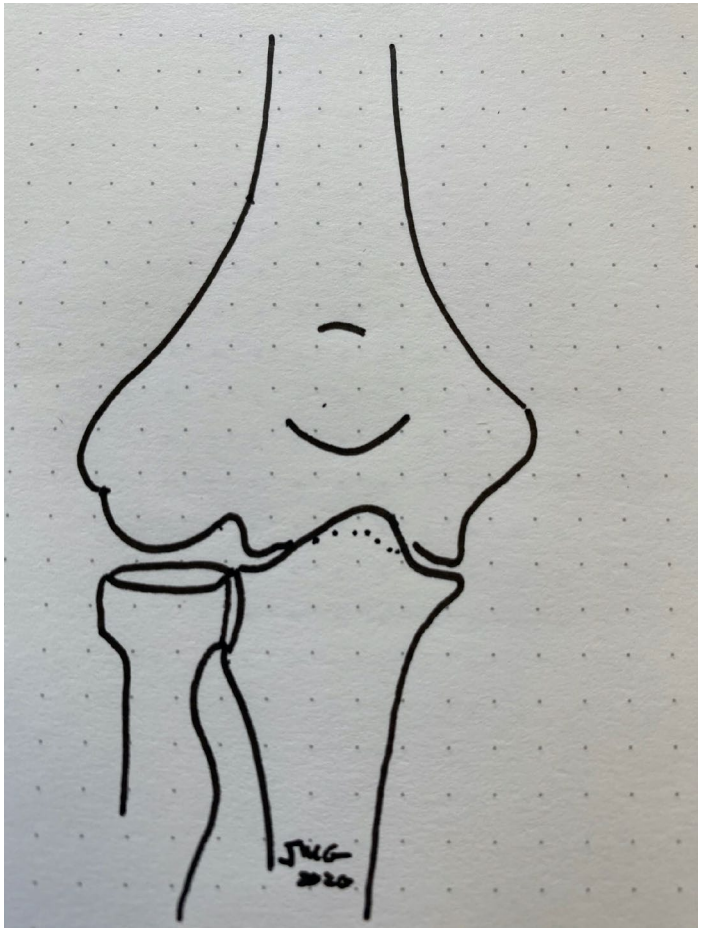
Olecranon Fractures – A Case Based Approach to Understanding Management

Jonathan M. Gross, MD
Director of Orthopedic Trauma
Staten Island University Hospital

Introduction and Objectives

- Design: Interactive Case Based
- Objectives
  - Review pertinent bone and soft tissue anatomy to understand fracture patterns and associated instability
  - Review indications and strategies to stabilize fractures and restore stability
  - Provide pearls to help minimize risk of surgical complications and illustrate key points of management

Elbow Anatomy

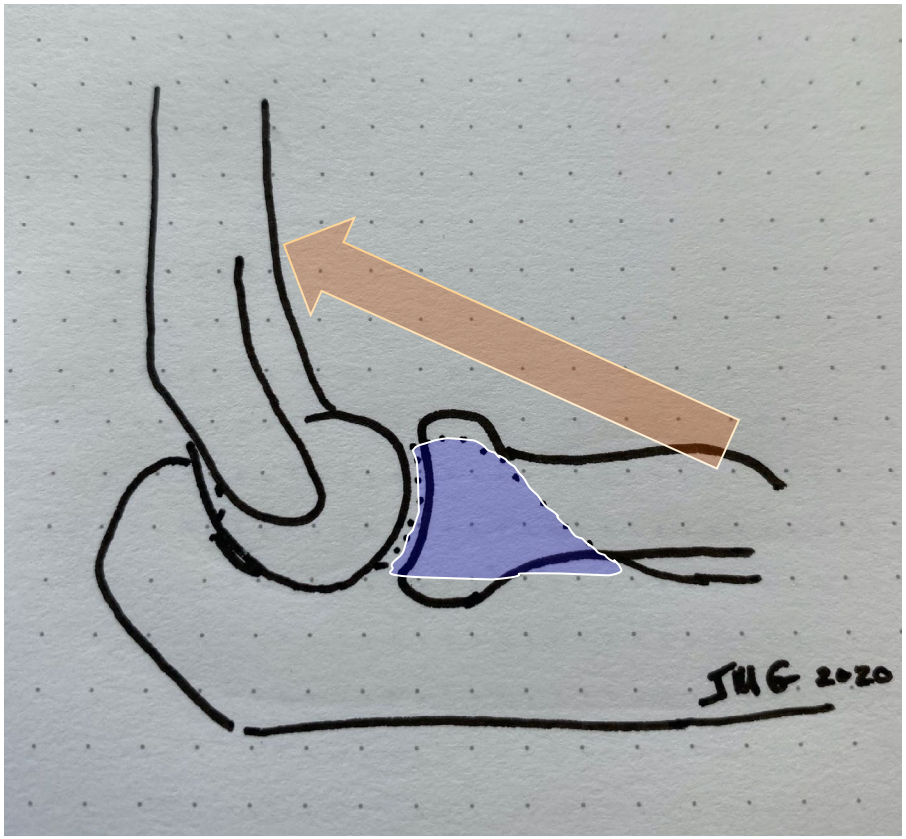


- Three distinct joints
  - humeral(trochlea) – ulnar
  - humeral(capitellar) – radial
  - proximal radial-ulnar(PRUJ)

Factors Responsible for Elbow Stability: *Bony Anatomy*

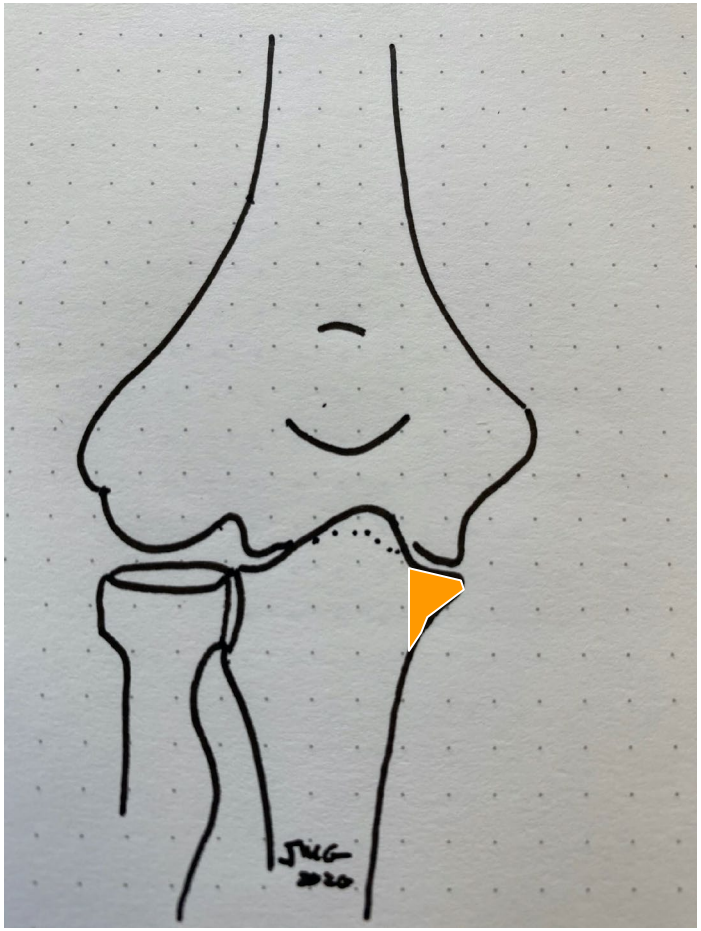
- Normal muscle forces drive elbow posteriorly
  - Brachialis: base coronoid
  - Biceps: radial tuberosity

- Boney restraints that Resist posteriorly directed forces:
  - Coronoid process
  - Radial Head



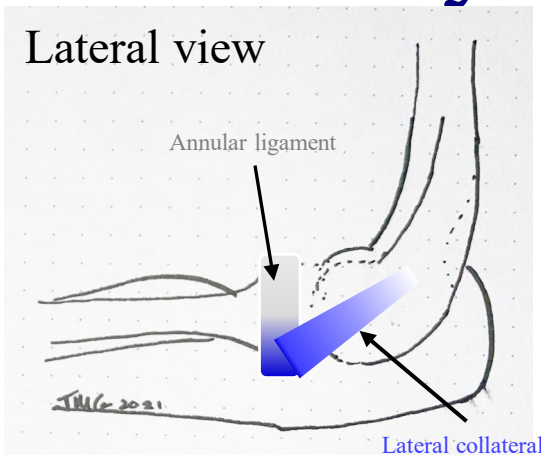
Factors Responsible for Elbow Stability: *Bony Anatomy*

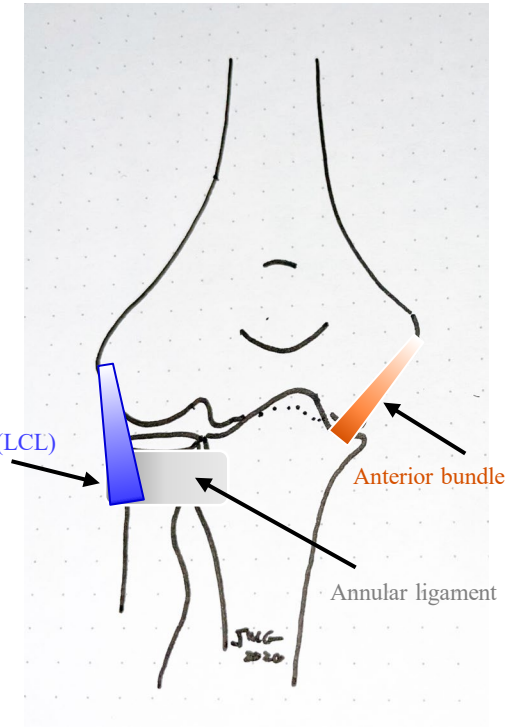
- Varus/Valgus
  - Radial Head
  - Trochlea
  - Medial coronoid facet

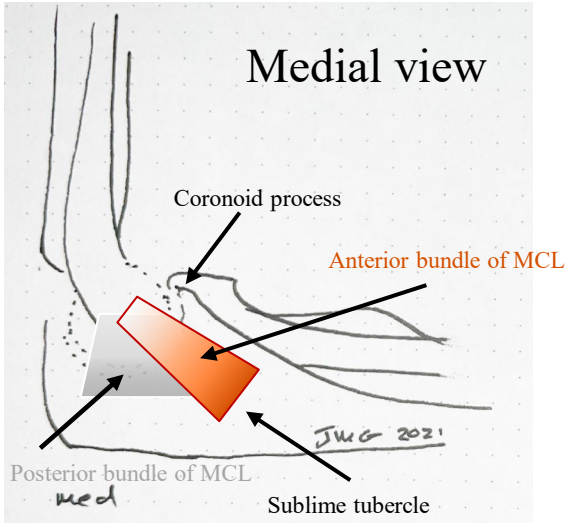


Ligamentous structures responsible for static stability…

- Laterally –ulna collateral ligament
- Medial – anterior bands of MCL
- Anteriorly – capsular tissues can be used to provide to stability

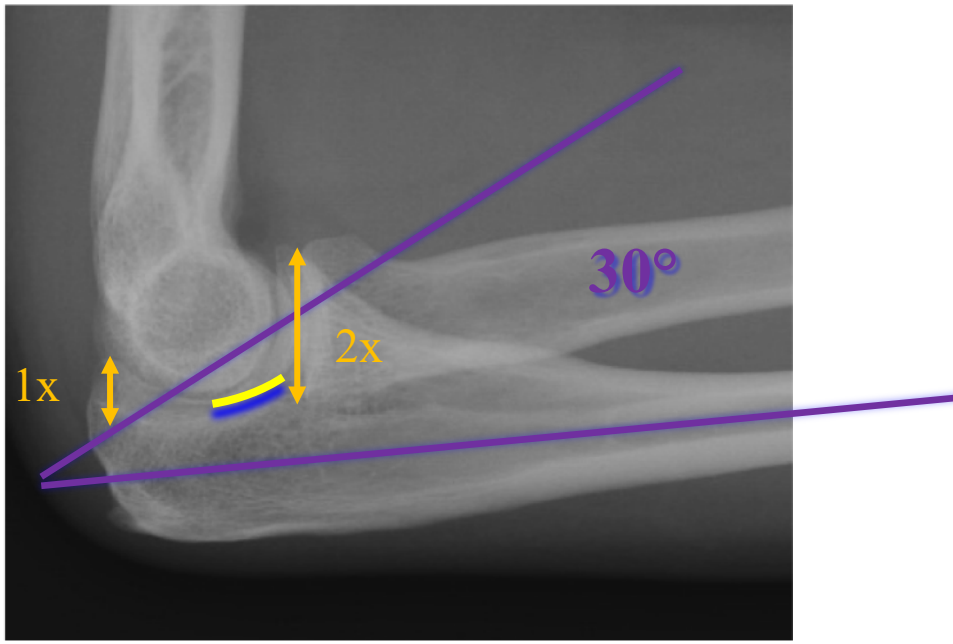






Surgical Anatomy

- **Articular cartilage**
  - Sigmoid notch of ulna: bare spot centrally between tip and coronoid
  - Pearl: Beware of narrowing sigmoid fossa when treating comminuted olecranon fx's.
- **Coronoid process**: *preserve height*
  - Coronoid Height ~ 2 x Olecranon height
  - Tip of Coronoid to tip of Olecranon subtends angle of ~30 degrees from long axis of ulnar shaft



Beser, C.G. et. al. *Redefining the proximal ulna anatomy* Surgical and Radiologic Anatomy 2014 (36):1023-1032

Surgical anatomy

- Olecranon Process
  - 96% of proximal ulna exhibit a ~ 4 degrees dorsal angulation (PUDA)
  - Proximally the ulna demonstrates ~ 12 degrees varus angulation
  - The articular surface extends beyond the "joint space" visualized on the lateral radiograph

Rouleau, D. M. et. al. *the proximal ulna dorsal angulation: A radiographic study* J Shoulder and Elbow Surg. 2010 (19): 26-30

Yoon, W.J. *Morphometric analysis of the proximal ulna using three dimensional computer tomography and computer aided design: varus, dorsal and torsional angulation* Surg. Radiology Anat 2014(36):763-768

Githens, T.C, et. al. *Understanding the Radiographic Anatomy of the proximal Ulna and Avoiding Inadvertent Intra-articular Screw Placement.* J. Ortho Trauma 2020: 34 (2) 102-107

Olecranon Fractures

Mechanism of Injury

- Acute Tension overload: Tension applied by the triceps with flexion of the elbow
- Direct Trauma
- Chronic overload: eg. stress fractures seen commonly with osteopaenic or pediatric patients

Evaluation

- Check integrity of skin
- Check extension of elbow
- Evaluate neurovascular status, especially ulnar nerve
- X-rays - three views (AP, Lateral and Oblique, which shows radial head in profile)

Imaging

AP View

Lateral View

Oblique View
(sometimes helpful,
good for Radial Head)

Classification

- Many Classifications:
  - Colton
  - Morrey
  - Schatzker
  - AO/ASIF
  - OTA
- Criteria
  - Displacement
  - Direction of fracture
  - Degree of comminution
  - Percent involvement
  - Associated injuries

Mayo Clinic (Olecranon) Classification

Type I: Nondisplaced 12%

Type II: Displaced/ elbow stable 82%

Type III: Elbow unstable 6%

- Both types II and III subdivided into:
  - –A: *noncomminuted*
  - –B: *comminuted*

Morrey BF, JBJS 77A: 718-21, 1995

Treatment Objectives

- Restoration of elbow motion and prevention of stiffness
  - Goal is to begin early ROM
- Restoration and preservation of the elbow extensor mechanism.
- Restoration of the articular surface.
- Prevention of complications.

Treatment Methods

- Nonoperative
  - Indicated in low demand individual with stable elbow joint.
    - (*Duckworth, et. al.* JBJS AM 2014:96,67-72)
    - (*Marot, V, et. al.* Orthopedics & Traumatology: Surgery & Research 2018:104, 79-82)

- Operative
  - **Open reduction and internal fixation**
    - Tension band wire with pins or intramedullary screws
    - Plate
  - **Excision of olecranon and triceps repair**
    - Comminuted, unreconstructable fractures
    - Typically, Elderly patients with loss of active elbow extension

Nonoperative Treatment

- Classically Reserved for nondisplaced fractures
- Historically - Prolonged long arm cast was complicated by stiffness
- More Recent – short duration of "immobilization" provided reasonable results in low demand elderly...
  - Duckworth, et. al. (2017) 2 weeks collar and cuff, followed by supervised ROM with physiotherapist
  - Immobilization prolonged for pain
  - Although loss of reduction, similar functional results to ORIF group

Indications for Surgery

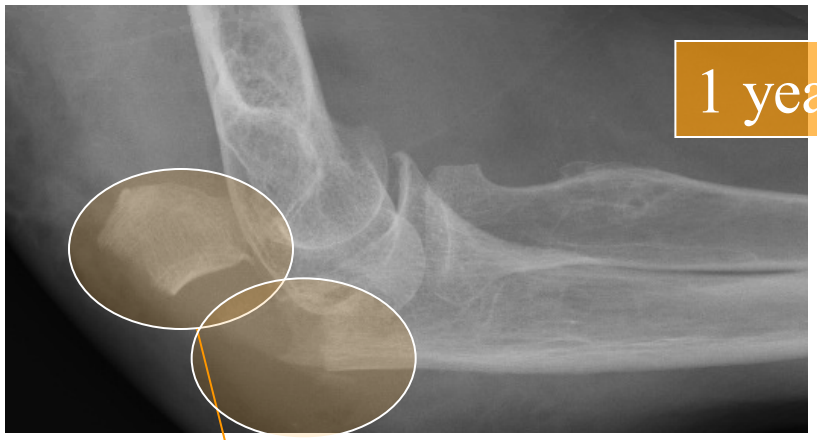
- Disruption of extensor mechanism
  - Unable to actively extend elbow
- Articular incongruity
  - Any displaced fracture

Case Example…

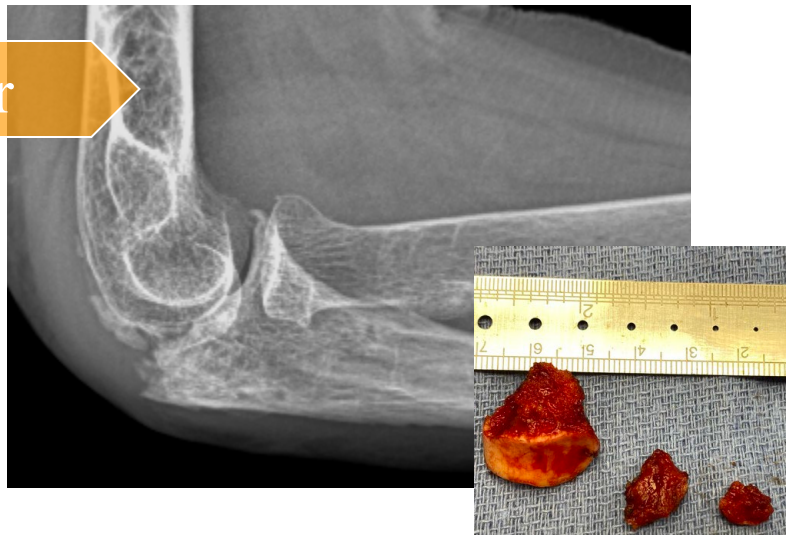
Elderly woman, moderate demand, multiple medical problems, falls and cannot not extend her elbow…

What are your options?

Consider…Olecranon excision and triceps advancement



1 year later



Fragment much smaller when exposed…

Oblique fracture in frontal plane with comminution about sigmoid notch

Functional result…

Able to range and use elbow without pain

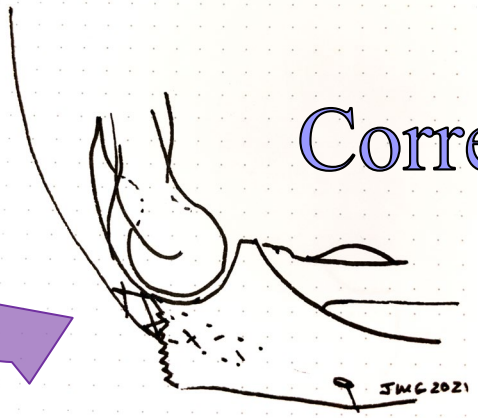
Olecranon Excision

Pearl… advance tendon anteriorly adjacent to distal humeral articular surface

- *Elderly patients*
  - –those with osteoporosis
  - –involving <50% of joint
- *Re-attach triceps anteriorly*
  - –At joint surface
- *No difference in isometric strength but fewer complications in the excision group*

  Gartsman et al, JBJS 63A:718, 1981-

Incorrect



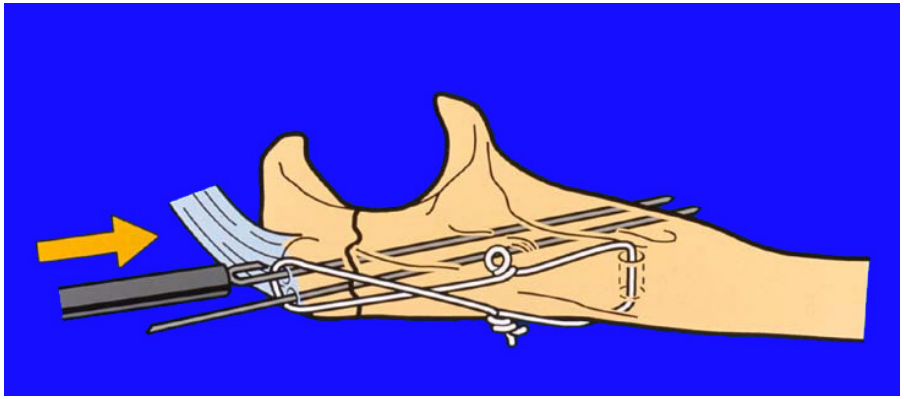
Correct

Positioning

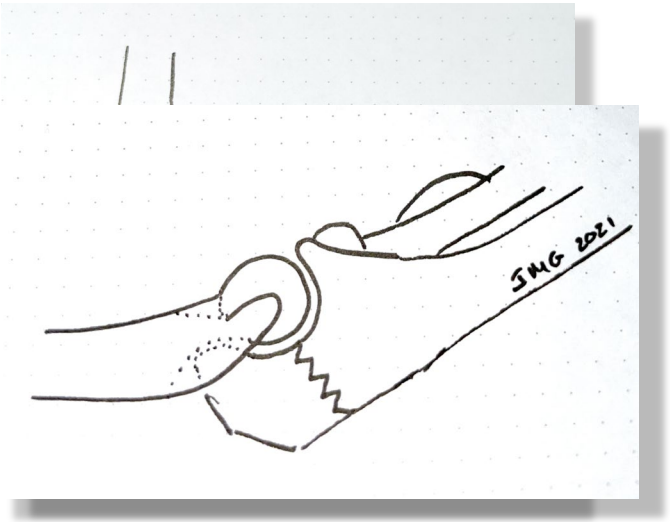
- Posterior approach
- Arm position
  - Supine with arm across chest.
  - Lateral or prone also may be used.
  - Supine with arm on hand table
- Can Use Tourniquet (but may tighten extensor mechanism)
- Regional or general anesthesia

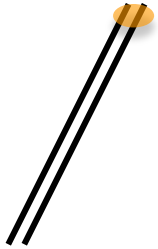
Tension Band Wire

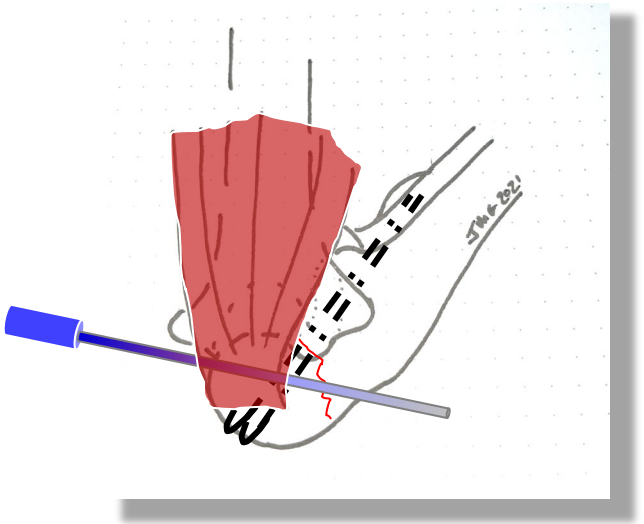
- For most simple, transverse, non-comminuted fractures
- Use 18- or 20-gauge steel wire or small braided cable.
  - Be sure wires cross over dorsal cortex.
  - 2 smaller (22 gauge) wires may be less prominent
- May use with either parallel K-wires or an intramedullary screw.



Tension Band Wire







Reduce fracture

- Reduce w/ tenaculum

- Or extend elbow to bring olecranon to shaft

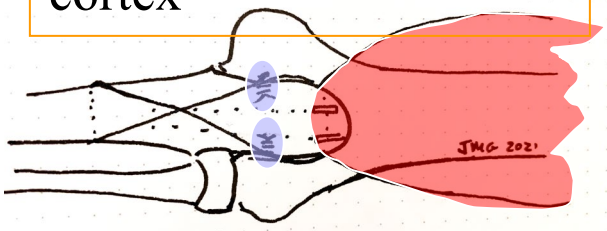
Place K-wires across fracture

- Engage anterior cortex

- Pearl Can use provision K-wires, arm extension or clamp to hold reduction while placing definitive wires

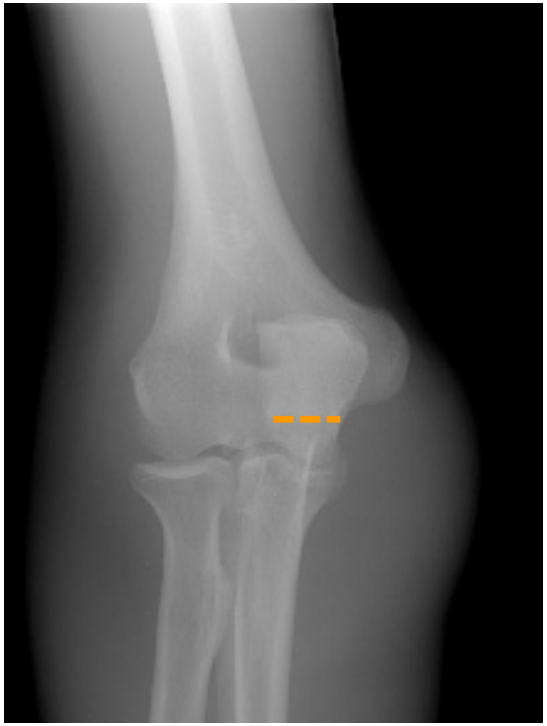
Pass Tension wire deep to tendon with angiocath

– Two knots over dorsal cortex



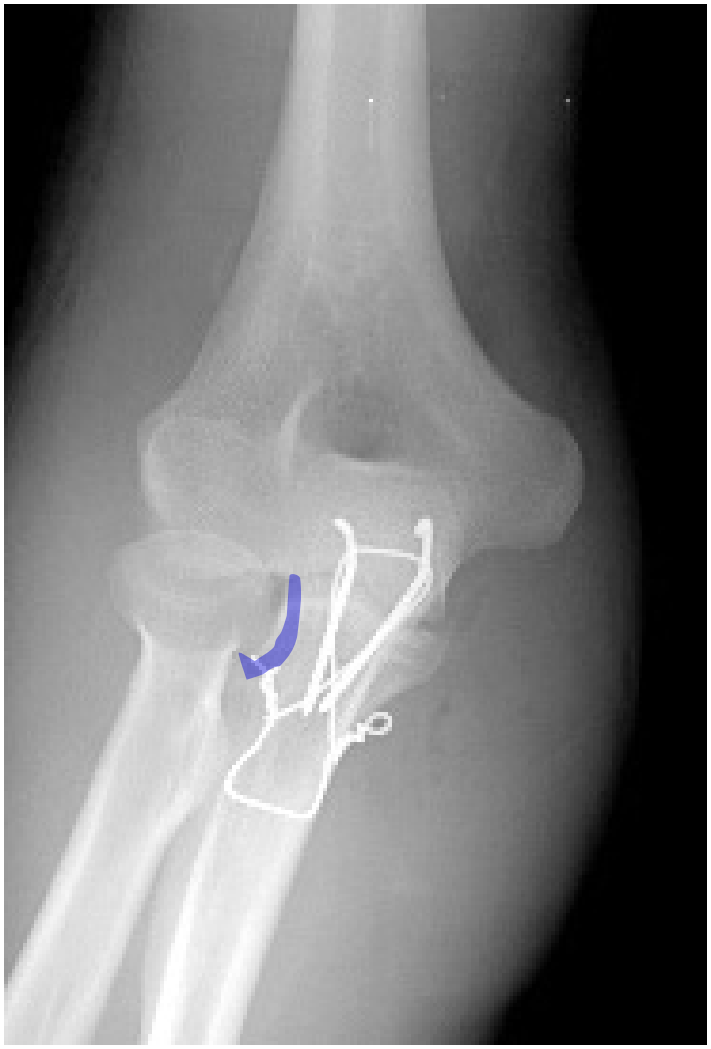
Case Example

Simple Transverse Fracture Pattern



- History: 25 year old falls off bicycle and can not extend elbow

- What is the fracture orientation?
- Amenable to Tension Band Wiring



Engage anterior cortex

Pins are directed “ulnarly” away from PRUJ

Potential Complications…

- K wires project though anterior cortex too far… irritate AIN
  - Solution, withdraw wire 5 mm prior to bending wires over olecranon tip
- K wires project to far radial… interfere with proximal radio-ulnar joint
  - Solution, start wires more radial and aim more ulnarly

Intramedullary Screw ?

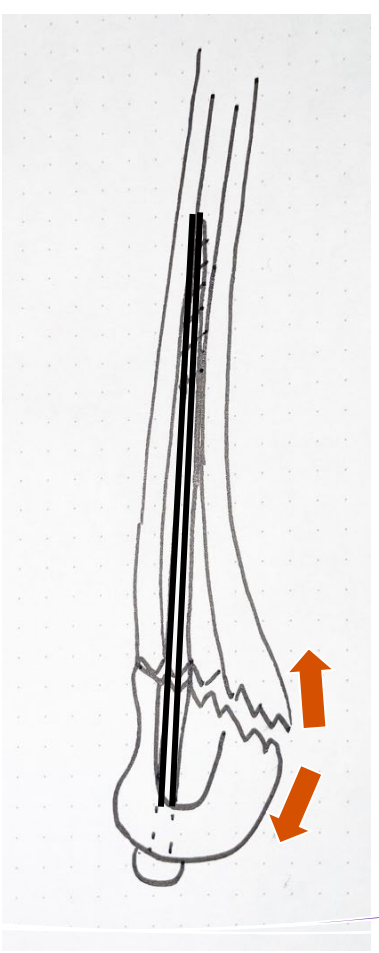
- Need to add tension band wire
- Long/large screw required
  - 6.5mm cancellous
  - 85-110 mm long
- Risk of shortening… osteopaenic bone, oblique fracture and comminution

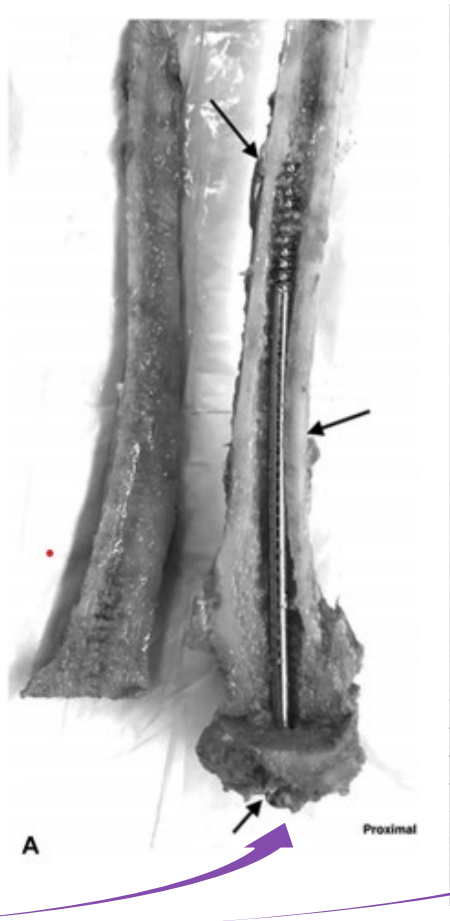
Mal-reduction

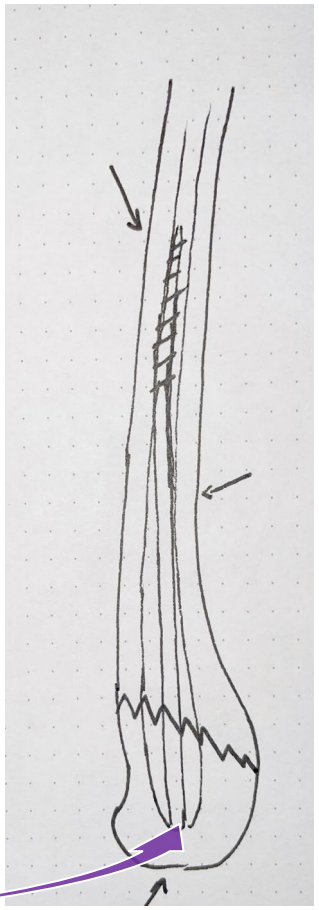
Anatomy of the Proximal Ulna

- Beware of the varus bow of the proximal ulna, which may cause a medial shift of the tip of the olecranon if a long screw is used.

Pearl: ideal is center – center start point on tip of olecranon







the IM screw and associated 3 aspects of fixation (arrows) with the cortex, varus bend, and thread endosteal engagement.

How to decide Plate versus Tension Band Wire

- Evaluate comminution of **dorsal cortex**
  - If intact: tension band wire appropriate
  - If comminuted, plate appropriate
- Evaluate **orientation of fracture line**
  - Transverse: tension band wire
  - If Oblique Or Complex Then plate

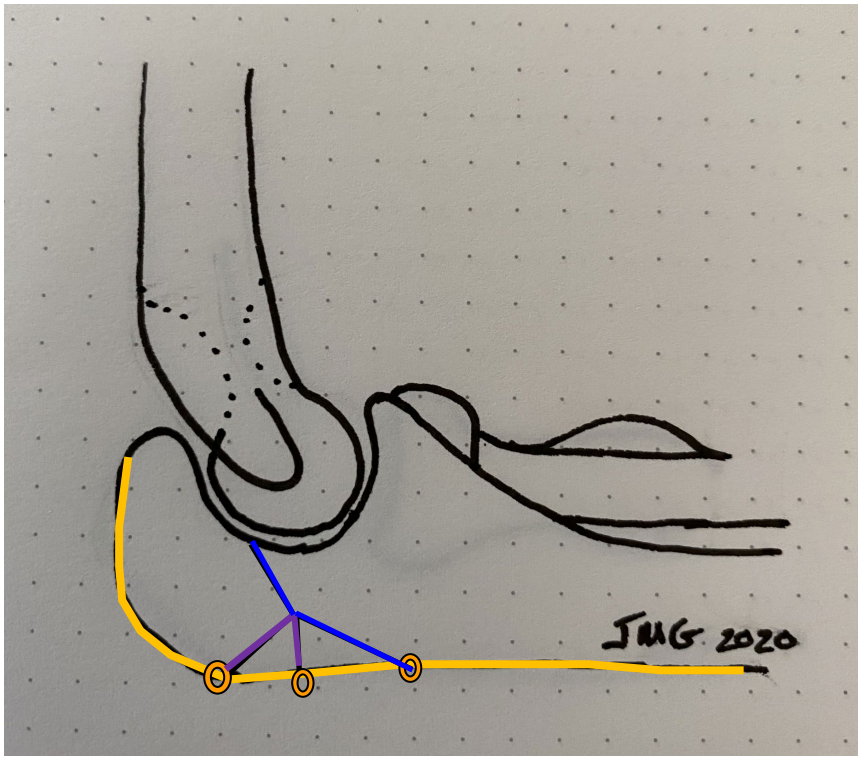


Plate Fixation

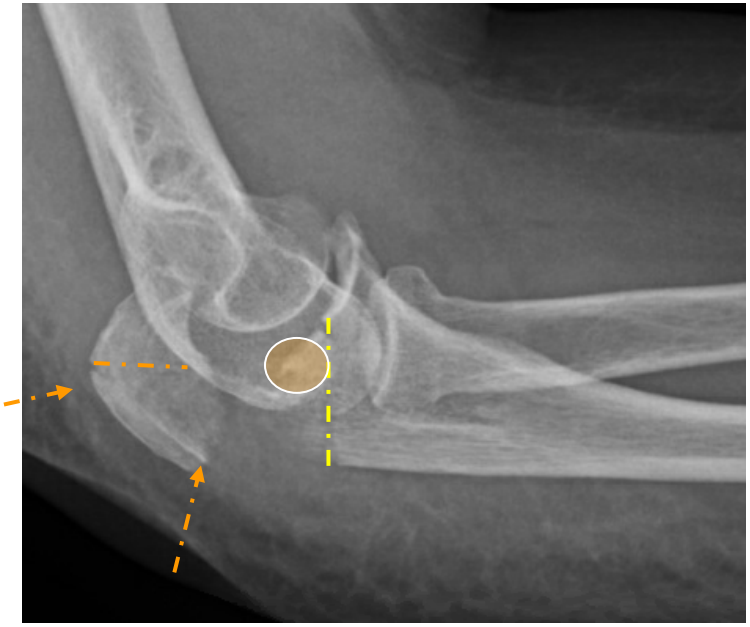
- Indications:
  - comminuted fractures
  - fractures with shaft extension
  - oblique fracture line

- Plate choice…
  - Traditional…
    - LCDCP, recon, 1/3 tubular
    - Before locked plates
  - Anatomic, locking
    - Plates designed for proximal Ulna

- Screw placement crucial for stability

Case Example…

59 year old woman, right hand dominant, lives alone, falls, unable to extend elbow…



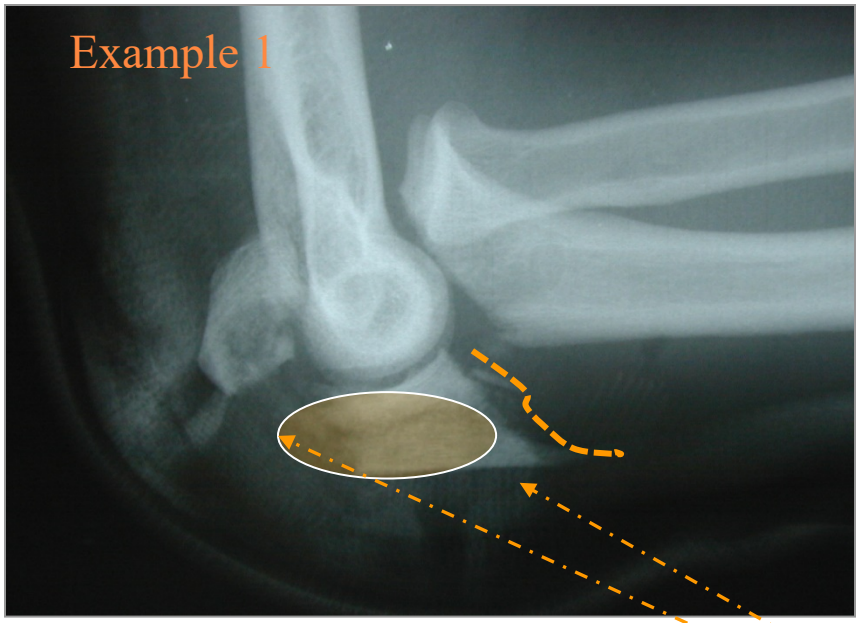
What is the fracture pattern

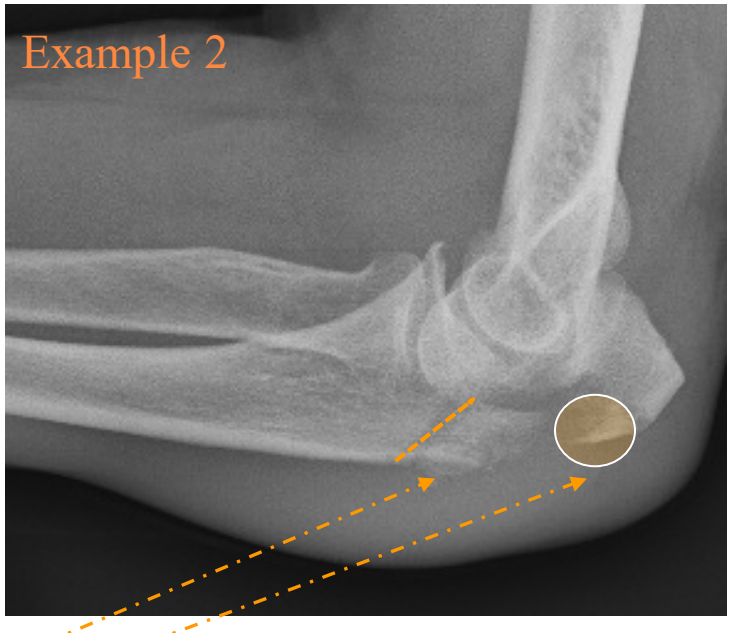
Is this a simple or oblique fracture pattern? Simple?

Is the dorsal cortex broken in more than one place Yes and there is comminution

- So consider anatomic locked plate….

What plate: anatomic locking or traditional?





Fracture Pattern? Oblique, Segmental, Comminuted

Plate Fixation

Traditional plate…

- Screw placement critical

Anatomic Locked plating

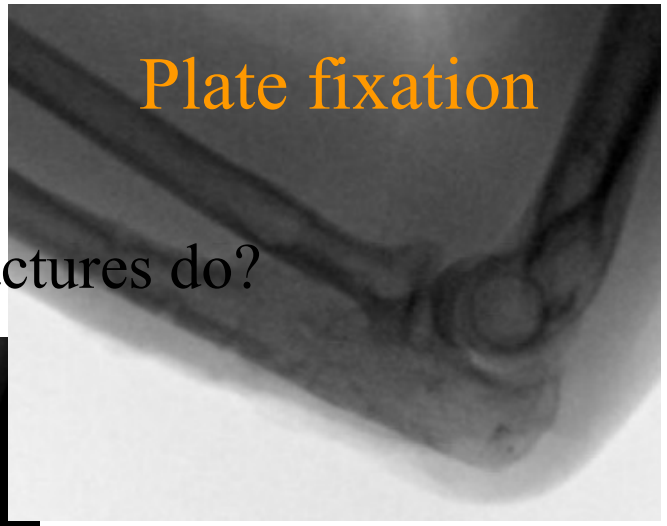
- Again screw placement critical

Pearl: As fracture becomes more distal and oblique *stabilization more amenable to plate fixation*

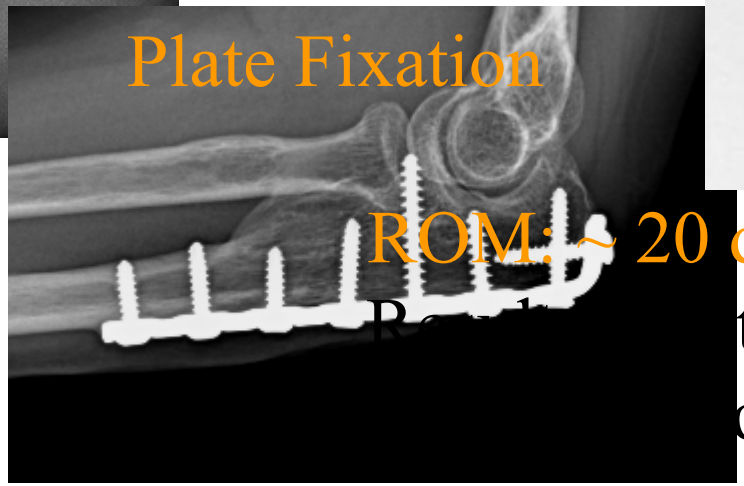
Case Example…

- History: 63 year old woman falls on outstretched hand. Otherwise Healthy. Unable to extend elbow. What is the fracture pattern? Oblique and Distal

What fixation is appropriate?



How do these fractures do?



ROM: ~ 20 degrees -Full

toration of Function,

on may be prominent

Locked plating

- Relative indications
  - Comminution
  - Osteoporotic bone
- Removal of hardware…
  - 18-53%; probably irrespective of locking or non locking implant
    - Chen, M.J. et.al. *Surgical and Nonoperative management of Olecranon fractures in the Elderly: A Systematic Review and Meta-Analysis* J Ortho Trauma 2021;35 (1) 10-16
    - Bailey, C.S. et. al. "*Outcome of Plate Fixation of Olecranon Fractures"* J. Ortho Trauma 2001: 15 (8) 542-548
    - Snoddy, MC, et. al. "*Olecranon Fractures: factors influencing re-operation"* Int Orthop. 2014:38(8) 1711-1716

Locked Anatomic Plates

Advantages

- Simplify plate fixation
  May accommodate
  - Slight varus proximal angulation
  - Slight tilt of bottom proximal subcutaneous border
- Often allow for locked configurations
- Very proximal extended plate options
  - requires extensive triceps split
  - may improve proximal fixation

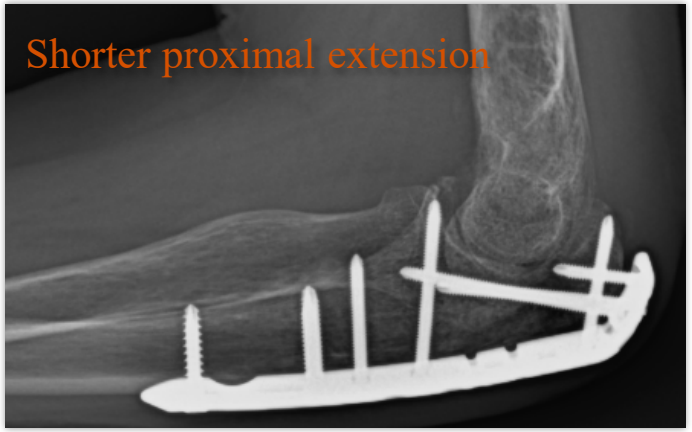
Disadvantages

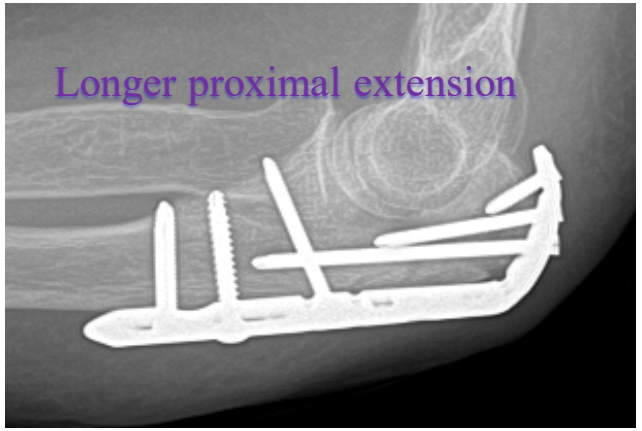
- More difficult to contour anatomically
- Locking configurations do not prevent violation of proximal articulations
- More expensive
- Not necessarily less prominent

Locked Anatomic Plates

Elements…

- "Anatomic" but often does not perfectly accommodate anatomy
  - ~ 4 degrees of proximal varus
  - ~12 degrees proximal dorsal angulation
- Typically, most plates have two proximal lengths…
  - **Shorter**, which does not require as much splitting and elevation of central insertion of triceps, but reduces proximal fixation opportunities
  - **Longer**, which requires more extensive proximal split and elevation of central insertion of triceps, but allow greater fixation opportunities

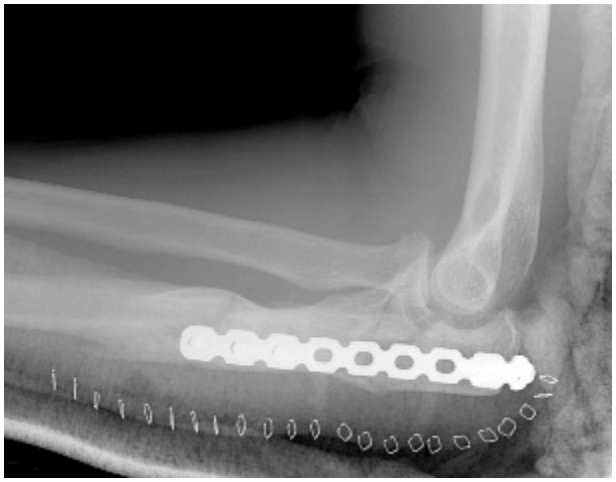




Proximal Ulna with Shaft Extension

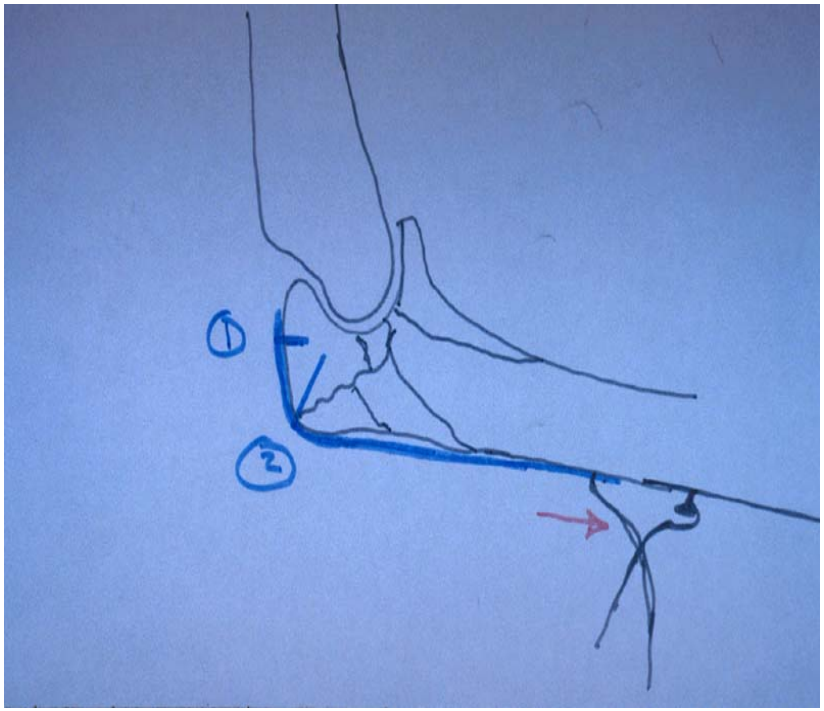
Plate Location

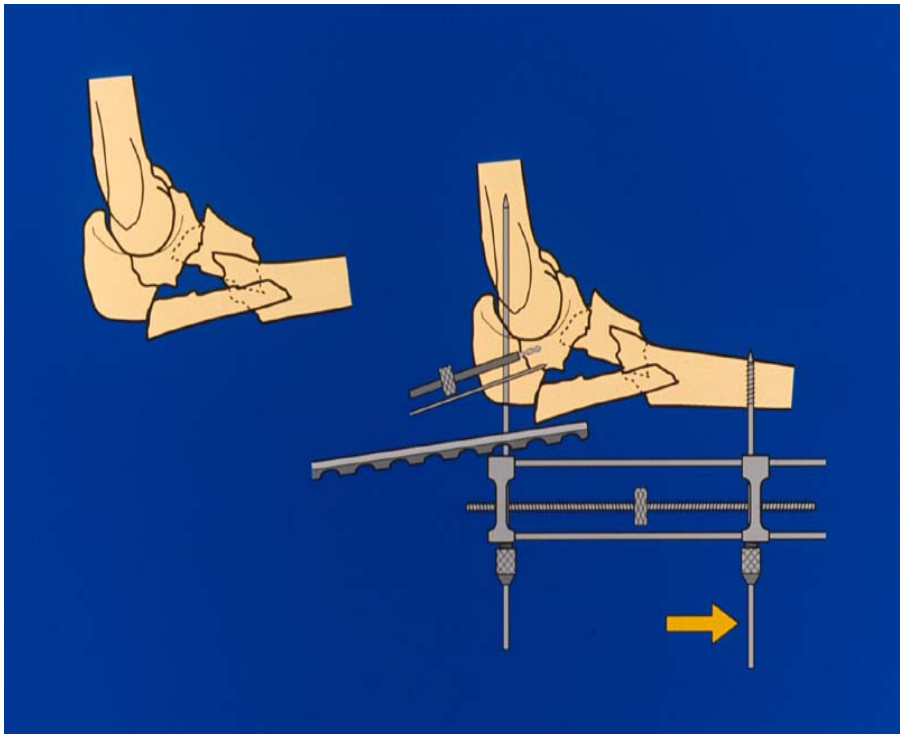
- No mechanical difference between posterior or lateral placement
  (King et al, J Shoulder Elbow Surg 5:437, 1996)
- Less problems with plate prominence when placed laterally and one can get bicortical screw purchase
- Posterior Plate allows more advantageous screw placement
  - Coronoid screw
  - IM screw
  - Olecranon tip screw



Indirect Reduction

-sometimes useful



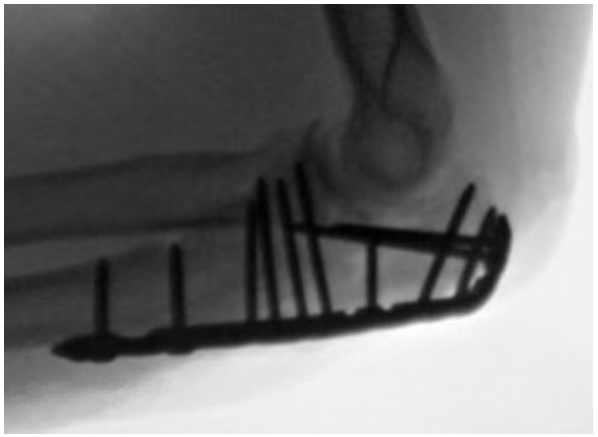


ex fix/distractor - push-pull;
fix plate proximally first

Case Example

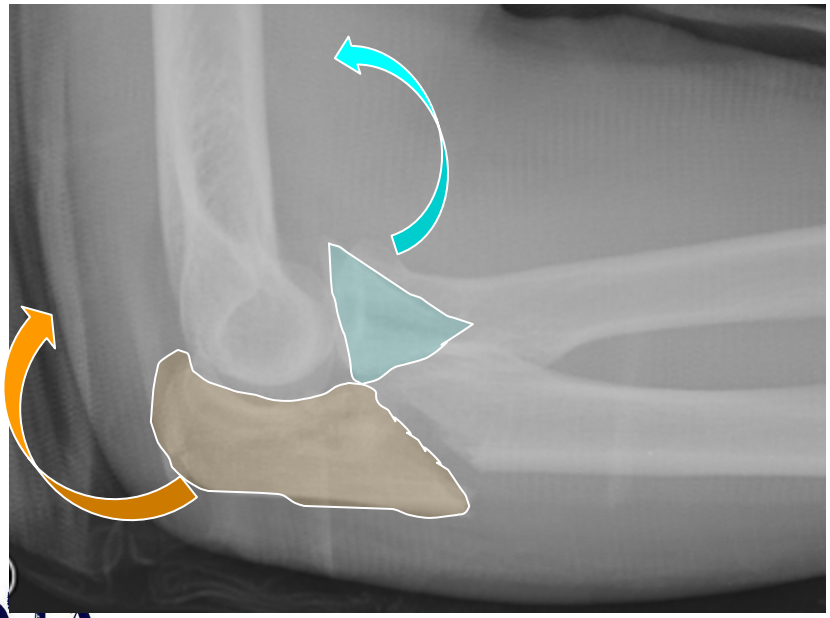
- Hx: 73 yo women fell down stairs landing on her elbow with immediate pain and inability to move elbow…

What is the fracture pattern?
Olecranon and Coronoid fractures…
Transolecranon fracture
Operative plan? Simplify fracture and lag through the plate

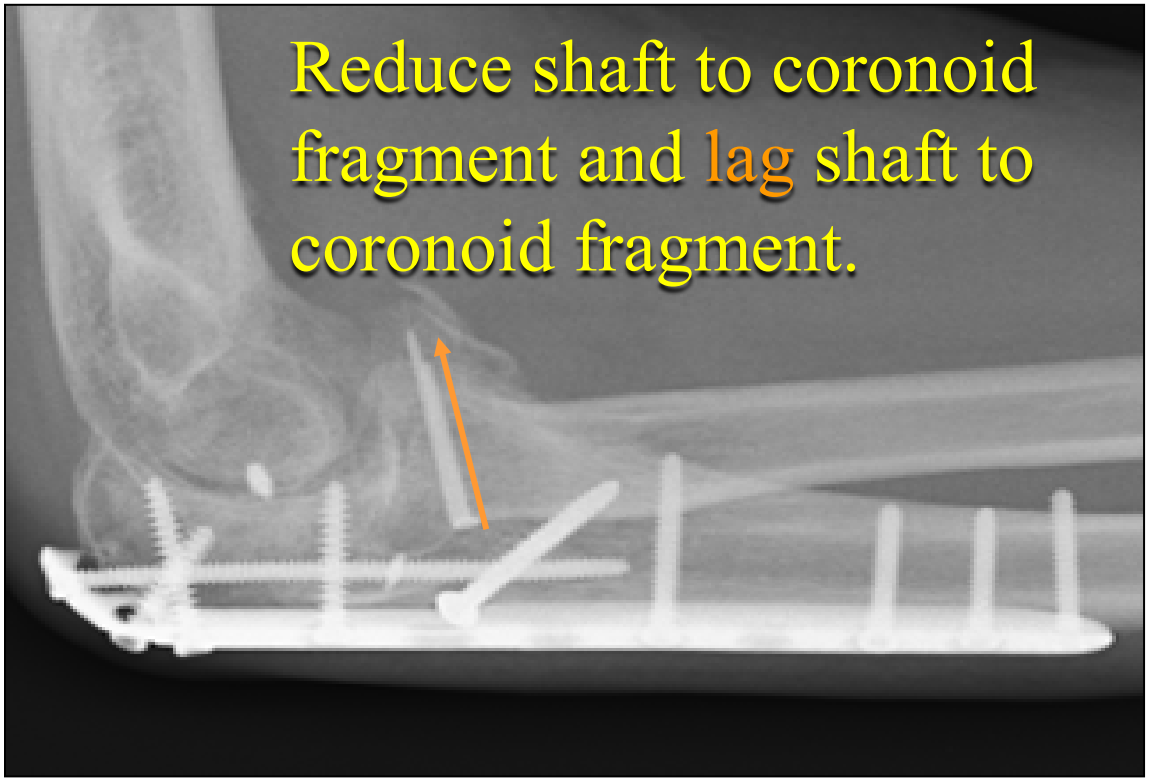


Another example- Concurrent Coronoid and Olecranon fractures

- Hx: 55 year man falls from step ladder, sustaining olecranon and coronoid fractures
- To reduce fractures, it helps to understand the forces displacing fragments



Operative Plan

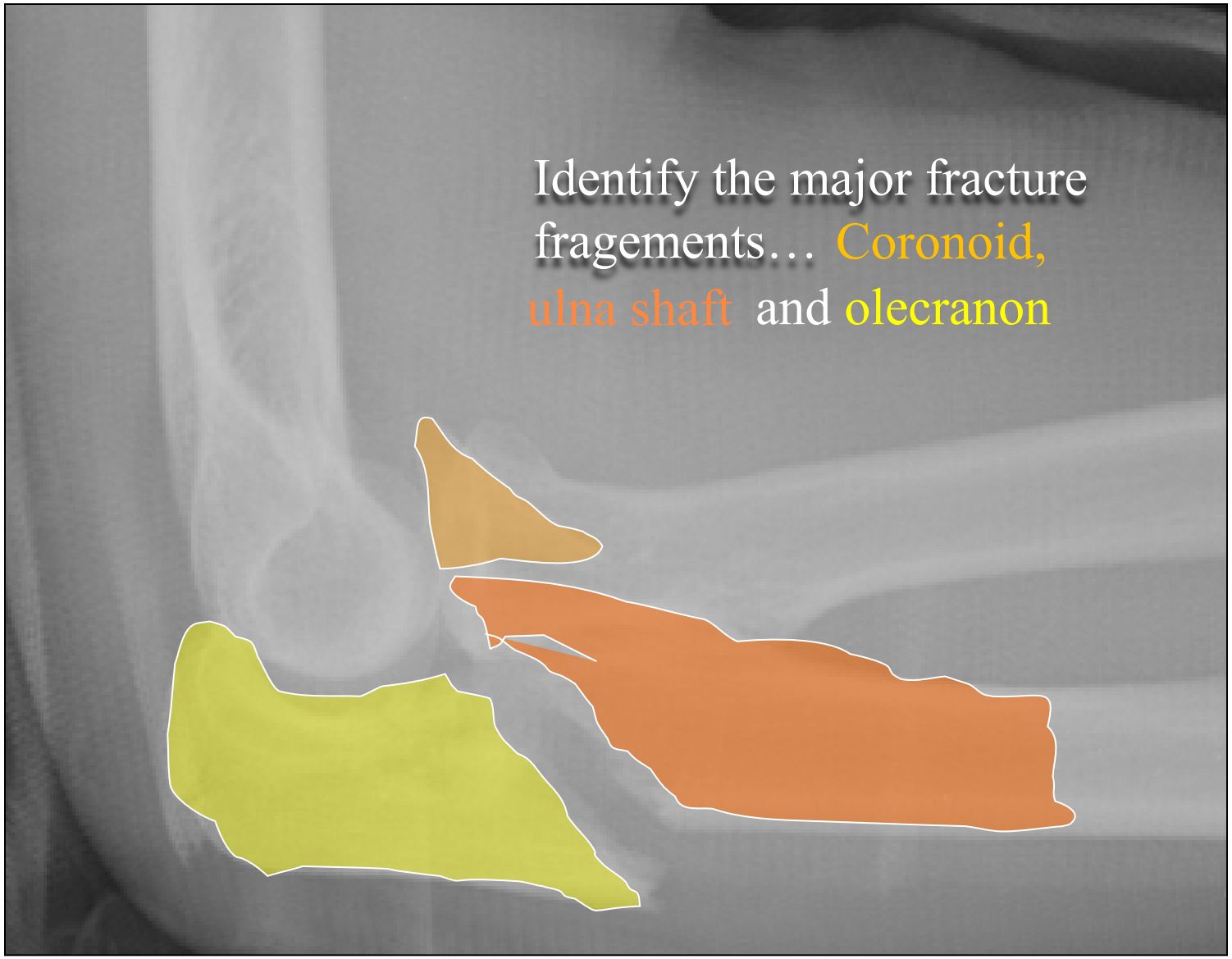


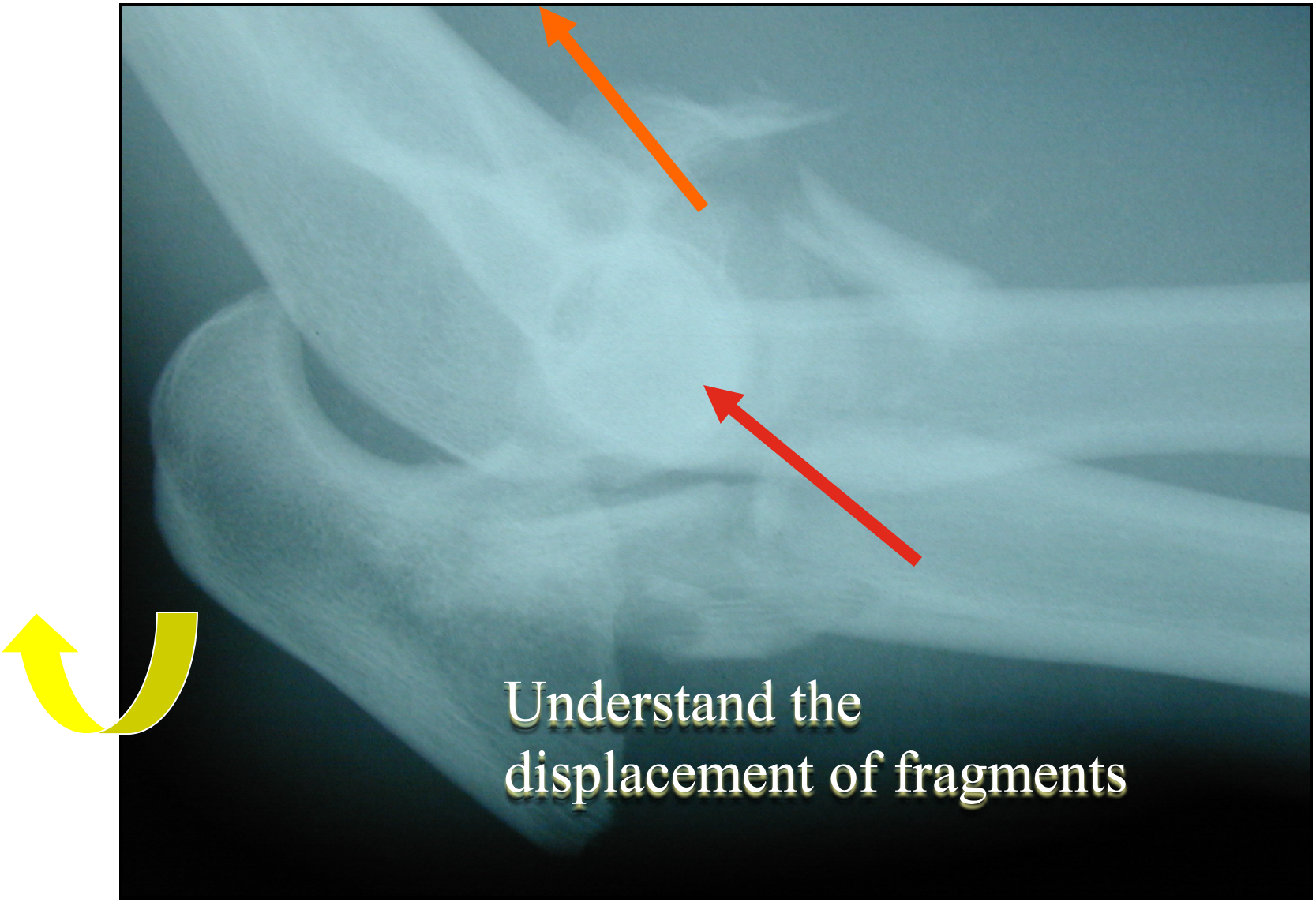
Then reduce and stabilize olecranon fracture

Pearl: Shown is pre-contoured "anatomic plate," ie plate designed for proximal ulna, which can help simplify stabilization

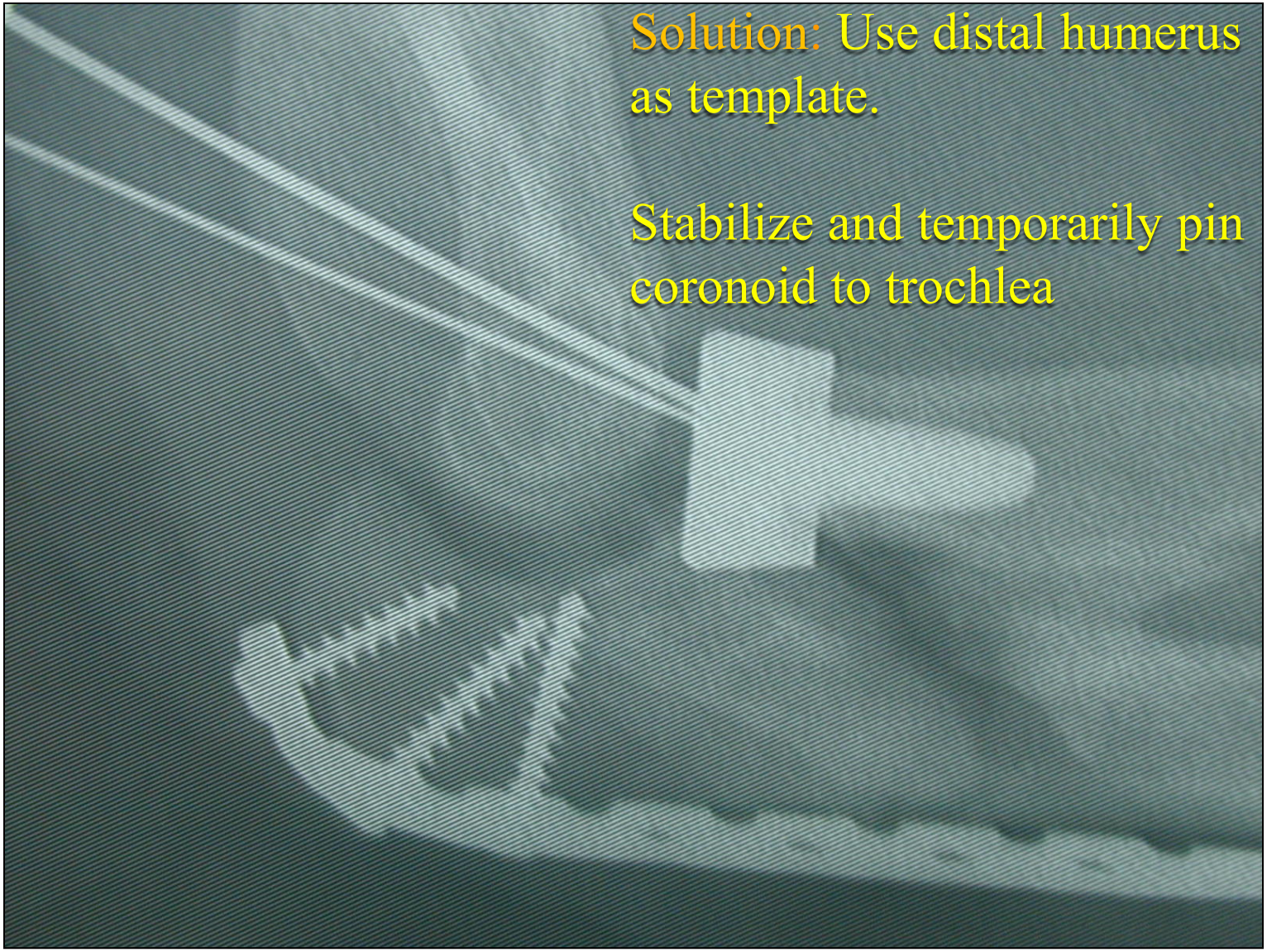
Let's look at that idea again… Another Complex Proximal Ulna Fractures

- Complex fracture pattern
  - olecranon
  - ulna shaft
  - coronoid
- Requires stepwise repair


Identify the major fracture fragements… Coronoid, ulna shaft and olecranon


Understand the
displacement of fragments


With all the comminution: how to hold reduction and repair coronoid fragment?


Solution: Use distal humerus as template.
Stabilize and temporarily pin coronoid to trochlea

Outcomes

- Does Implant Matter...
  - Limited prospective data, myriad retrospective
  - Functional ROM; loss of terminal extension common
  - Chen, M. et. al. Metaanalysis J Ortho Trauma 2021
    - Union rates 94% TBW and plate
    - Reoperation rates TBW ~ 40%; plate ~ 33%
    - Adverse events…

      deep infection 9% plate, no TBW

      superficial infection 5% TBW, no plate

      wound problems 12% plate; 7 % TBW

Chen, M.J. et. al. *Surgical and Nonoperative Management of Olecranon Fractures in the Elderly: A Systematic Review and Meta-Analysis* J Ortho Trauma 2021;35 (1) 10-16

Complications

Potential Surgical Complications

- Hardware symptoms in 3 - 80%
- 34-66% require hardware removal
- Nonunion/malunion rates < 5%; essentially all in TBW
- Infection 0-9%
- Pin migration up to ~ 44%; ~ 5-15% when anterior cortex engaged.
- Ulnar neuritis/AIN injury 2-5%
- Heterotopic ossification up to 33% with delayed unstable elbow

-Hak, D.J.; Golladay, GJ Olecranon fractures: treatment options JAAOS 2000:8 (4) 266-275 a
-Chen, M.J. et. al. *Surgical and Nonoperative management of Olecranon fractures in the Elderly: A Systematic Review and Meta-Analysis* J Ortho Trauma 2021;35 (1) 10-16
-Sabine, C. et. al *K-wire position in tension band wiring techniques affects stability of wires and long term outcomes in surgical treatment of olecranon fractures.* J Shoulder and Elbow Surg. 2012; 21(3):405-411

Hardware Problems…

K-Wire/Tension Band Wire fixation…

- Macko & Szabo JBJS 1985 retrospective review
  - 16/20 Prominent K- Wires
  - 4 skin breakdown; 1 infection
  - 2 loss off reduction

- Romero, Miran & Jensen J Ortho Sci 2000 retrospective review
  - 55 patients, 71.7% reoperation rate
  - 61.3% complain of hardware prominence

Outcome

Plate fixation…

- Giacomo, et.al. Injury, 2016. Multicenter Cohort study
  - 37% symptomatic hardware
    - Painful
    - Restricts motion (39% of all had 10 degree or more loss of extension)
  - 15% elective removal of hardware

Outcomes

Plate (P) versus Tension Band Wire (TBW)

- Duckworth, et.al. JBJS 2017, Vol 99:1261-73 Prospective Randomized Trial
  - TBW vs P – similar DASH and ROM
  - TBW higher rate of symptomatic hardware
  - P higher rate major complications of infection and revision

Take Home Principle…

- Treatment of olecranon fractures, requires an understanding of the fracture pattern and the patient's functional demands.

- So When addressing Olecranon fractures Understand:
  - Who is the patient/what are his or her demands?
  - What is the fracture pattern and is it associated with other injuries?
  - If operative intervention indicated, run the check list to develop the most effective and cost-conscious treatment for the the fracture

Final Pearl

- Olecranon fractures may be associated with elbow instability…
- Be aware of associated radial head/neck and coronoid fractures.

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

Return to Upper Extremity Index

Return to index

Selective Bibliography

- Oldie but Goodie Reviews…
  - Hak, David J. MD; Golladay, Gregory J. MD *Olecranon Fractures: Treatment Options;* Journal of the American Academy of Orthopaedic Surgeons: July 2000 - Volume 8 - Issue 4 - p 266-275
  - Rouleau, D.M.; Sandman, E.; Riet, RV *Management of Fractures of Proximal Ulna* JAAOS vol 21 (2013) issue 3:149-160
  - Stein, S.P. *Coronoid Process Fractures* JAAOS vol 16 (2008) issue 9:519-529

Selective Bibliography

- A few classics
  - Gartsman GM, Sculco TP, Otis JC. Operative treatment of olecranon fractures. Excision or open reduction with internal fixation. The Journal of Bone and Joint surgery. American Volume. 1981 Jun;63(5):718-721.
  - Doornberg J, Ring D, Jupiter JB. Effective treatment of fracture-dislocations of the olecranon requires a stable trochlear notch. Clin Orthop Relat Res. 2004 Dec;(429):292-300.
  - Villanueva P, Osorio F, Commessatti M, Sanchez-Sotelo J. Tension-band wiring for olecranon fractures: analysis of risk factors for failure. J Shoulder Elbow Surg. 2006 May-Jun;15(3):351-6.
  - Prayson MJ, Iossi MF, Buchalter D, Vogt M, Towers J (2008) Safe zone for anterior cortical perforation of the ulna during tension-band wire fixation: a magnetic resonance imaging analysis. J Shoulder Elbow Surg 17(1):121–125

Selective Bibliography

- A few key recent references…

  - Duckworth, AD, Clement, ND; Aitken, SA; Court-Brown, CM; The epidemiology of fractures of the proximal ulna. Injury 43(2012) 343-346

  - Duckworth, AD, Clement, ND; Mc Eachen, JE; White, TO; Court-Brown, C; McQueen, M M Nonoperative Management of Displaced Olecranon fractures in Low Demand Elderly J Bone Joint Surg Am (2014) 96; 67-72

  - De Giacomo, A. F. ; Tornetta, P; Sinicrope, B.J.; Cronin, P. K.; Althausen, P L.; Bray, T. J. ; Kain, M.S.; Marcantonio, A; Sagi, C; James, CR. Outcomes after plating of olecranon fractures: A multicenter evaluation, Injury, 47 (2016) Is7: 1466-1471,

  - Duckworth, AD, Clement, ND; White, TO; Court-Brown, C; McQueen, M M Plate versus Tension Band Wire Fixation of Olecranon Fractures: A prospective randomized trial J Bone Joint Surg Am (2017) 99; 1261-12-73

Selective Bibliography

- A few key recent references (continued)…
  - Chen, M.J. et.al. *Surgical and Nonoperative management of Olecranon fractures in the Elderly: A Systematic Review and Meta-Analysis* J Ortho Trauma 2021;35 (1) 10-16
  - Githens, T.C, et. al. *Understanding the Radiographic Anatomy of the proximal Ulna and Avoiding Inadvertent Intra-articular Screw Placement*. J. Ortho Trauma 2020: 34 (2) 102-107