Forearm Fractures

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Objectives

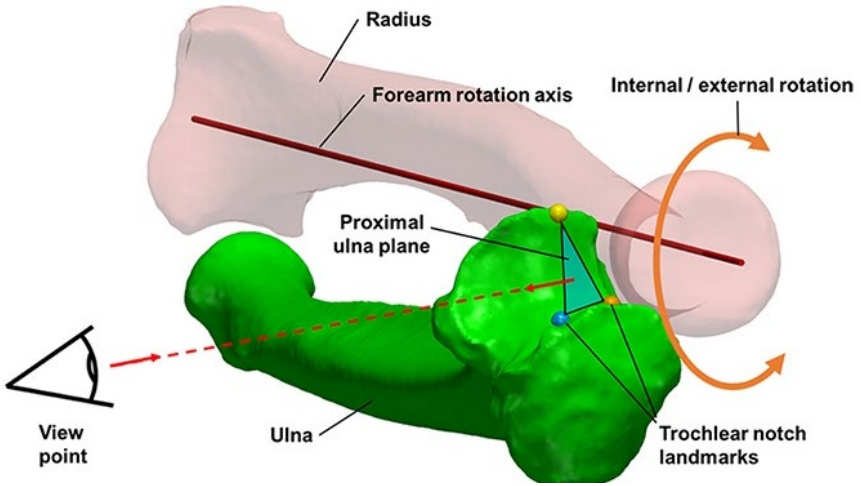
- **Understand rationale for surgery for forearm fractures**
- **Understand which segment is unstable based on injury pattern**
- **Identify goals of surgery based on injury pattern**
- **Review surgical techniques**

Introduction: Forearm Fractures

- Young patients
  - Typically high energy injuries
- Geriatric/osteopenic patients
  - May be low energy events
- Mechanism
  - Fall on outstretched extremity
  - Direct blunt trauma

Anatomy

- Two bones that function as a forearm joint to allow rotation
  - Radius
    - Radial bow in coronal plane
  - Ulna
    - Proximal dorsal angulation in sagittal plane
    - Not a straight bone
    - Distinct bow in coronal plane (see next slides)
  - Proximal radioulnar joint (PRUJ)
    - Articulation of radial head with proximal ulna
  - Distal radioulnar joint
    - Articulation of ulnar head with distal radius
  - Interosseous membrane



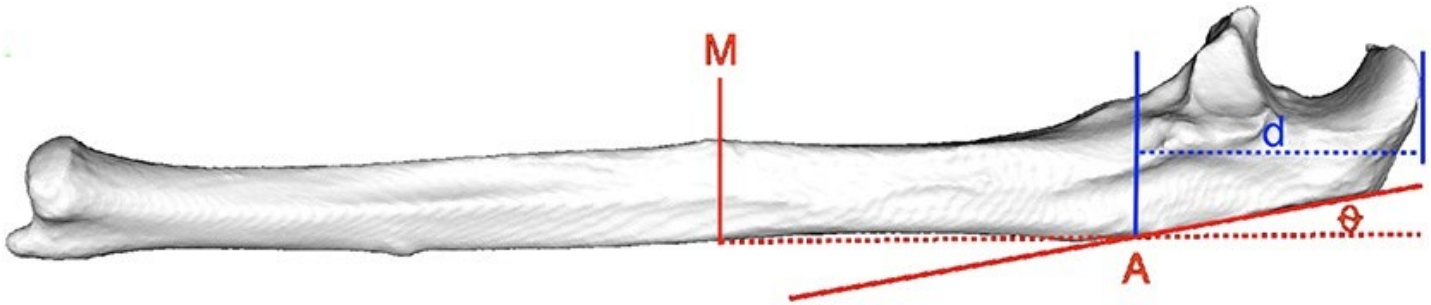
Hreha J+, Snow B+
Image from: Jarvie, Geoff C. MD, MHSc, FRCSC*; Kilb, Brett MD, MSc, BS*,†; Willing, Ryan PhD, BEng‡; King, Graham J. MD, MSc, FRCSC‡; Daneshvar, Parham MD, BS* Apparent Proximal Ulna Dorsal Angulation Variation Due to Ulnar Rotation, Journal of Orthopaedic Trauma: April 2019 - Volume 33 - Issue 4 - p e120-e123 doi: 10.1097/BOT.0000000000001408

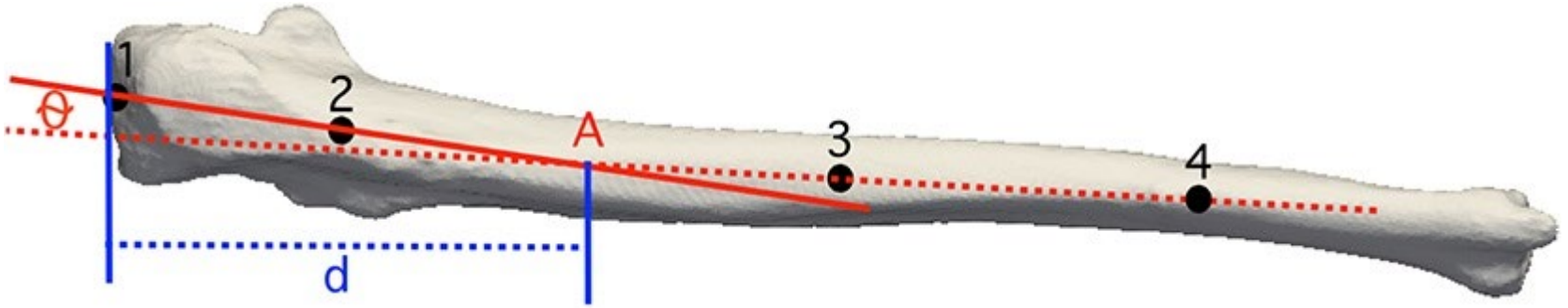
Anatomy

- Radial bow allows for pronosupination
  - Must be restored surgically when compromised
  - Multiple methods for assessment of radial bow
    - Comparison to contralateral images
    - Direct anatomic reduction of simple fractures
    - Biceps tuberosity 180 degrees of radial styloid
- Note opposite apex medial bow of ulna
  - Not a straight bone

Image from: Rockwood and Green, 9e, fig 41-9

Anatomy





- Depiction of ulnar shape, noting proximal ulnar dorsal angulation (PUDA) in the top image, and varus angulation in the bottom image

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Initial Presentation

- Antibiotics for open fractures
- Careful attention to neurovascular status
- Physical and radiographic exam of wrist and elbow joints
- Temporizing splint immobilization above the elbow
- High risk for compartment syndrome
  - Especially high energy mechanisms
  - Be familiar with technique for forearm compartment release: OTA video library

Surgical Indications

- Most fractures are operative in adults
  - Both bone fractures- inherently unstable
  - Loss of radial bow interferes with pronosupination
  - Single bone diaphyseal injuries
    - Often result in
      - PRUJ instability (Monteggia)
      - DRUJ instability (Galeazzi)

- Exceptions
  - Some nondisplaced single bone injuries (i.e. nightstick fracture of ulna)
    - With intact PRUJ/DRUJ
- Outcomes
  - In general good
  - Moderate decrease in perceived strength*

* Droll+

Essex-Lopresti Injuries

- Radial head or neck fracture with DRUJ injury, and intraosseous membrane (IOM) injury
- Wrist exam and imaging mandatory for elbow fractures
- Some authors have described MRI exam of IOM
  - Not required to meet standard of care
- Treatment- surgical fixation or radial head arthroplasty
  - DRUJ stabilization as needed
  - Avoid radial head excision – proximal migration of radius and ulnar positivity at the wrist
  - IOM reconstruction has been described, usually as salvage for chronic injury +
- Outcomes
  - Good, when injury detected and treated *

Surgical Goals for All Forearm Fractures

- Restoration of forearm anatomy
  - Length/alignment/rotation (L/A/R) + correct bow
- Stable and congruent elbow and wrist joints
  - Address fracture of sigmoid notch or radial head
- Robust fixation to allow early motion
  - Avoid thin/tubular plates
- Intelligent fixation based on fracture pattern
  - Simple patterns- anatomic reduction and compression
  - Comminuted patterns- restoration of L/A/R/bow with bridge plating

Surgical Toolbox: Diaphyseal Both Bone

Positioning

- Supine, radiolucent hand table
  - Preferred: Most diaphyseal and distal fractures
  - Disadvantage: must flex (and hold flexed) elbow to approach ulna
  - Addressing radius first typically easier in this position
    - Gives stability to forearm for treatment of ulna in the elbow-flexed position

- Lateral with elbow flexed 90 degrees
  - Advantage: Complex proximal ulna fracture; transolecranon fracture-dislocation
  - Disadvantage: unfamiliar positioning for radius- may require repositioning
  - Indications:
    - Difficult/segmental proximal ulna fracture
    - Ipsilateral humerus fracture to be addressed with same anesthetic

Surgical Toolbox: Diaphyseal Both Bone

Exposure

- Separate approach for each bone
- Radius Exposure
  - Volar Henry:
    - Brachioradialis/FCR interval
    - Radial artery is mobilized to ulnar side
    - Extensile distally and proximally
    - Trans-FCR approach: OTA video link
  - Dorsal/Thompson approach: OTA video link
    - Splits extensors to access radius
    - PIN at risk proximally
    - Extensile to radial head
- Ulnar exposure
  - ECU/FCU split: OTA video library example

Surgical Toolbox: Diaphyseal Both Bone

Clinical photos demonstrating the volar approach to the radius.

Middle: Elevator is pointing at the superficial branch of the radial nerve.

Right: The fracture has been exposed (elevator at fracture line). The white structure just ulnar to the elevator is the pronator teres tendon. White arrow points to radial artery.

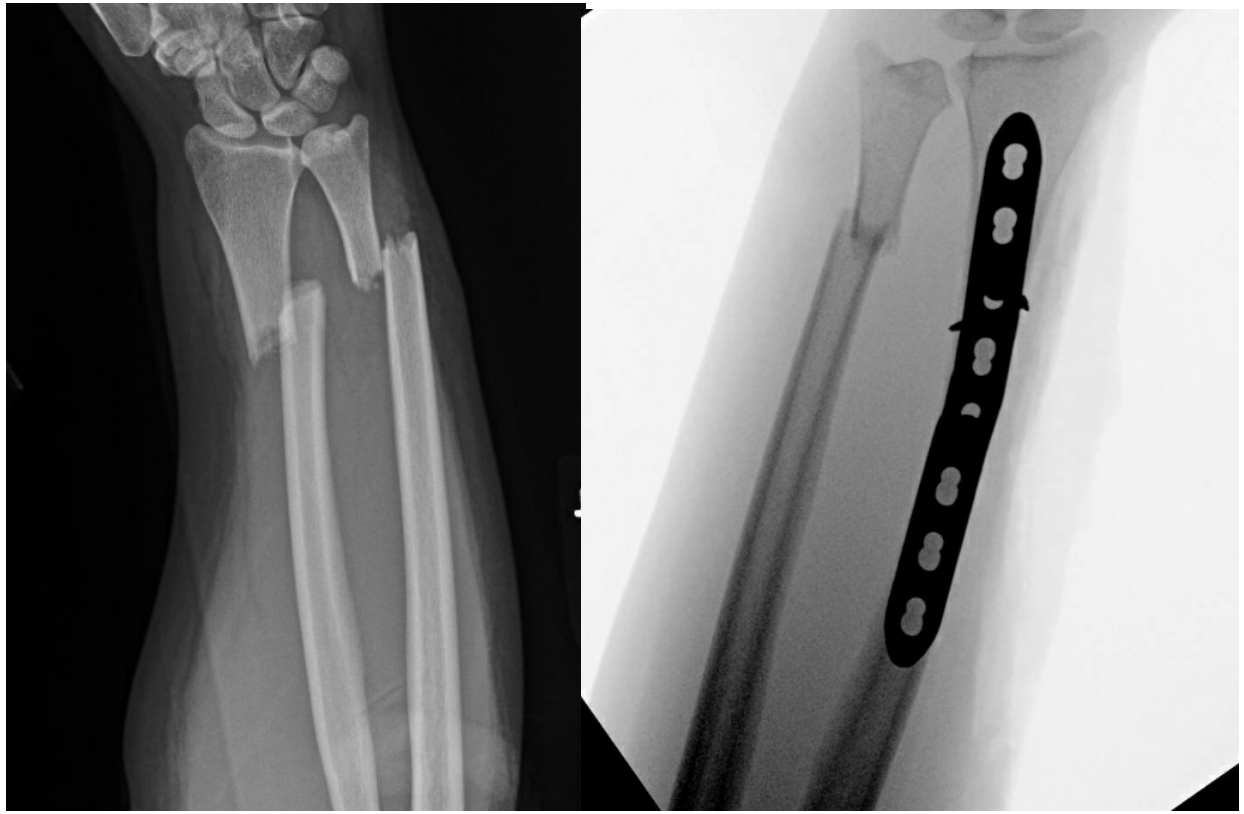
Surgical Toolbox: Diaphyseal Both Bone

Ulnar Exposure

- ECU/FCU split
  - Be aware of ulnar bow
  - Ulna is not truly “subcutaneous” throughout full length
    - ECU/FCU interval may “cross” over border of the bone
    - Utilize correct interval to preserve muscle as possible
  - Extensile proximally into posterior approach to humerus
  - OTA video library example

Surgical Toolbox: Reduction of Diaphyseal BBFF

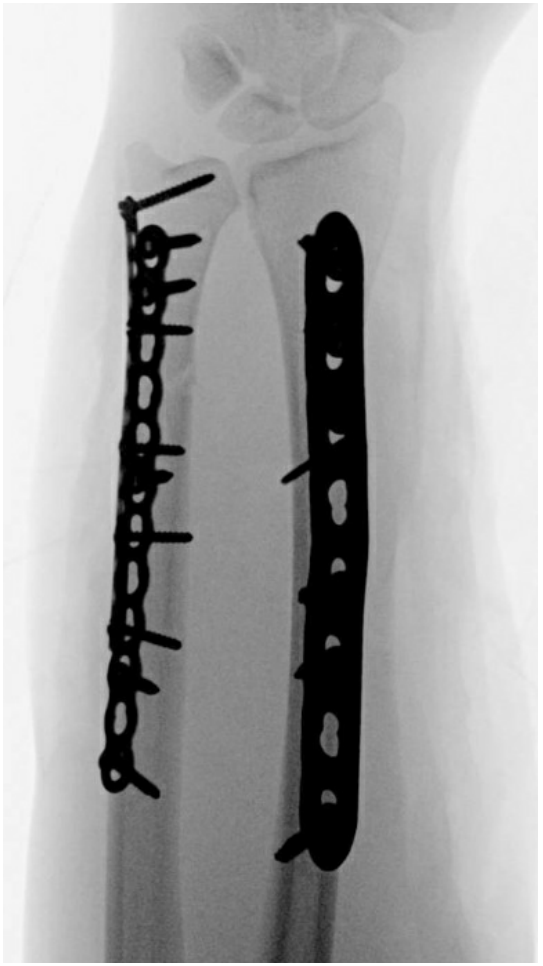
- Simple fractures
  - Traction via reduction forceps proximally and distally to restore length
  - Pointed reduction clamps for oblique fracture
  - Modified “straight-straight” clamps for transverse fractures
  - Most transverse fractures will be inherently stable once length restored
  - Lag simple fragments to simplify fracture
    - Ensures correct restoration of length and radial bow
- Complex fractures with comminution/bone loss
  - Contour straight plate for bowed bone; option precontoured (“anatomical”) plate
  - Clamp to reduce bone to plate
  - Focus on L/A/R/Bow



Above, a 22 year old woman who fell from a skateboard with a closed injury

Surgical toolbox: Fixation of Diaphyseal BBFF

- Simple fractures
  - Lag screw/neutralization plating for obliquity fracture
    - Countersink volar 2.4mm lag screws if under plate
  - Dynamic compression plating for transverse fracture
    - Mini-fragment plate can be used for provisional reduction
  - Plate selection
    - 3.5mm LCDCP or similar on radius and ulna
      - 2.7 DCP in smaller patients on ulna
      - Avoid tubular or flexible plates
    - Slight prebend needed if compression plating
  - Comminuted/Segmental bone loss fractures
    - Long contoured plates with well balanced screw spread preferred
  - Full length films (flat plates) can be useful for assessing radial bow
    - Consider comparison views of contralateral side



Case Example: Both Bone Forearm Fracture





- Bridge plating due to comminution
- Eccentric straight plate highlights restored radial bow

Galeazzi Fracture

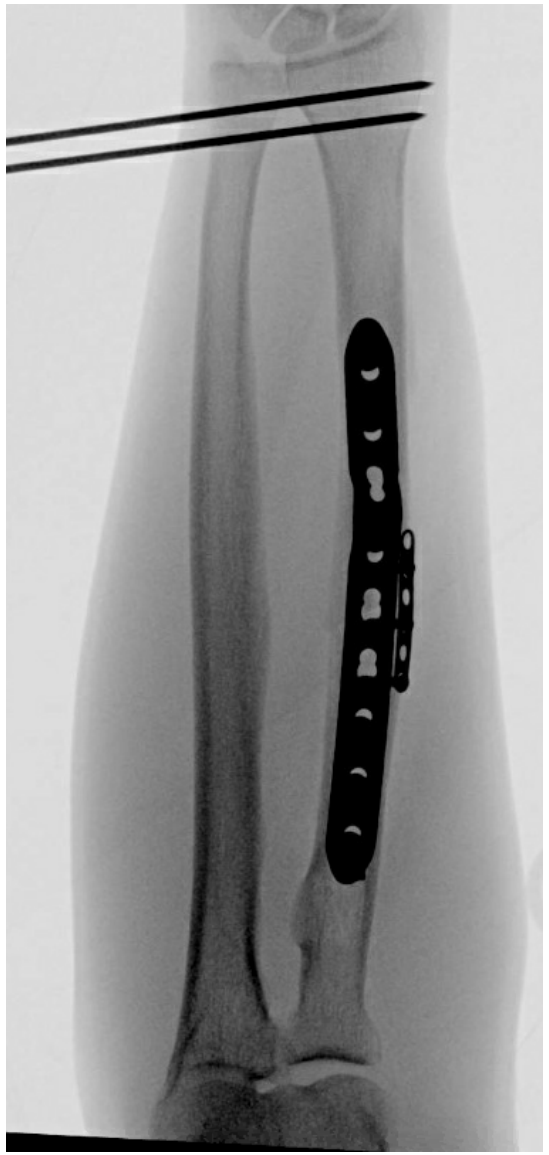
- Distal 1/3 radial shaft fracture with potential DRUJ instability
- Requires surgery to restore forearm stability
  - Radius→ ORIF
  - Then clinically and radiographically examine DRUJ after ORIF
- If DRUJ remains unstable→ address

Above, a 61 year old man who had a car tire fall on his arm when his tire jack failed with a closed injury

Surgical Toolbox: Galeazzi

- Preoperative examination of contralateral DRUJ
- Clinical exam after radius fixation to determine next steps
  - Restoration of radius length and bow often restores DRUJ stability
  - if unstable: TFCC repair, splinting in position of reduction/stability, pinning in position of reduction/stability (usually supination)
  - Typically dorsal instability, but volar instability possible
  - Author's protocol for DRUJ
    - If lax compared to contralateral, splint in stable position x2 weeks
    - If dislocating with pronosupination, pin in reduced position x4 weeks
  - In general, good outcomes if anatomy restored*

*Giannoulis+



Monteggia Fracture

- Ulna shaft fracture with radial head dislocation (PRUJ instability)
- Classification system based on direction of dislocation (next slide - diagram of classification)
- Associated injuries:
  - LUCL injury, radial head fracture, coronoid fracture

- Outcomes
  - In general, good
  - Poorer with Bado type II fractures (see next slide), associated radial head and coronoid fractures*

*Sreekumar+

Monteggia Fracture

Classification of Monteggia Fractures

Bado Classification

Bado Type	Radial Head Dislocation	Ulnar Fracture	Radial Fracture
I	Anterior	Diaphysis with anterior angulation	—
II	Posterior or posterolateral	Diaphysis with posterior angulation	—
III	Lateral or anterolateral	Metaphysis	—
IV	Anterior	Same level as radial fracture	Proximal one-third

Jupiter Modification of Bado Type II

Modification	Location of Ulnar Fracture
• IIA	• Distal aspect of olecranon and coronoid process
• IIB	• Metadiaphyseal fracture not involving coronoid
• IIC	• Diaphyseal fractures
• IID	• Proximal one-third of ulna involving coronoid and olecranon with dislocation

Reproduced from Rockwood and Green 9e, chapter 46

Surgical Toolbox: Monteggia

- Restoration of ulnar shape is the goal
  - Mal-reduced ulna = persistent radiocapitellar instability
- Surgical strategy for more complex injuries
  - Careful preoperative assessment of radial head, coronoid
  - Coronoid fragment and radial head fracture can be addressed in lateral position
  - Posterior exposure via fracture line or modified Boyd
    - Alternative separate lateral approach with elevated flaps through same posterior incision

Surgical Toolbox: Monteggia

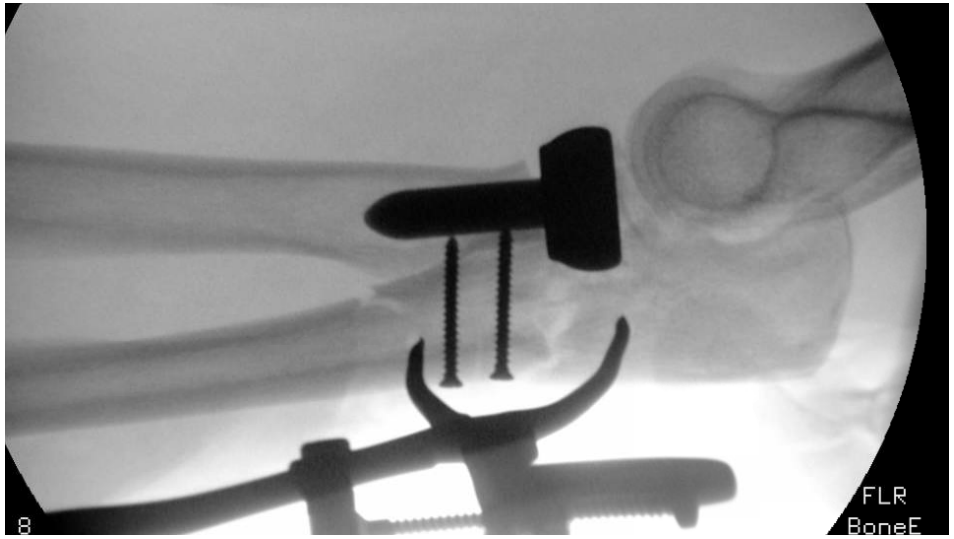
- Sequence: radial head arthroplasty trial → provisional reduction of ulna→ assessment of radial head size → definitive radial head arthroplasty → re-reduction and definitive fixation ulna → assessment of lateral ligament complex (see next case example)

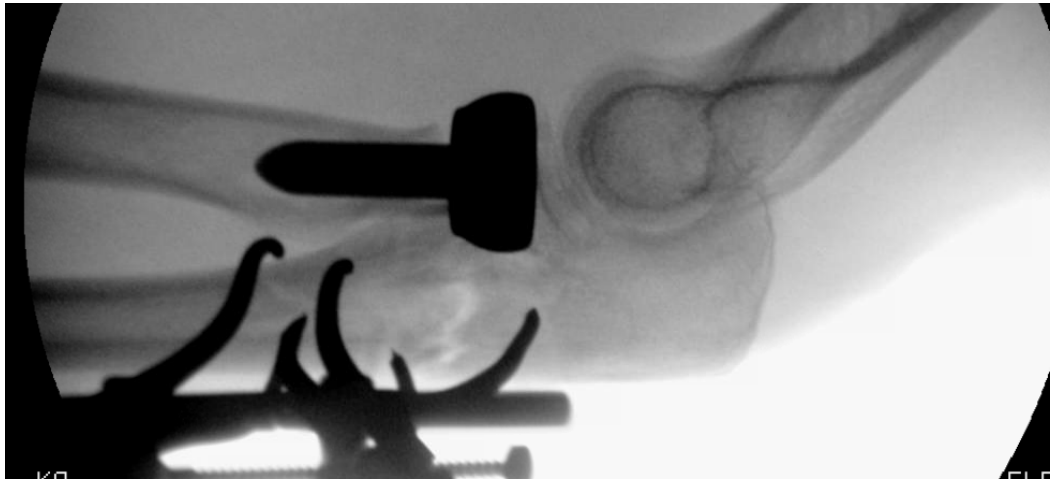
- Postop: typically splint for 1-2 weeks then early motion
  - If ligament repair required, avoid varus stress

Case Example: Monteggia

- Posterior monteggia fracture with posterior radial head dislocation and radial head fracture

Case Example: Monteggia

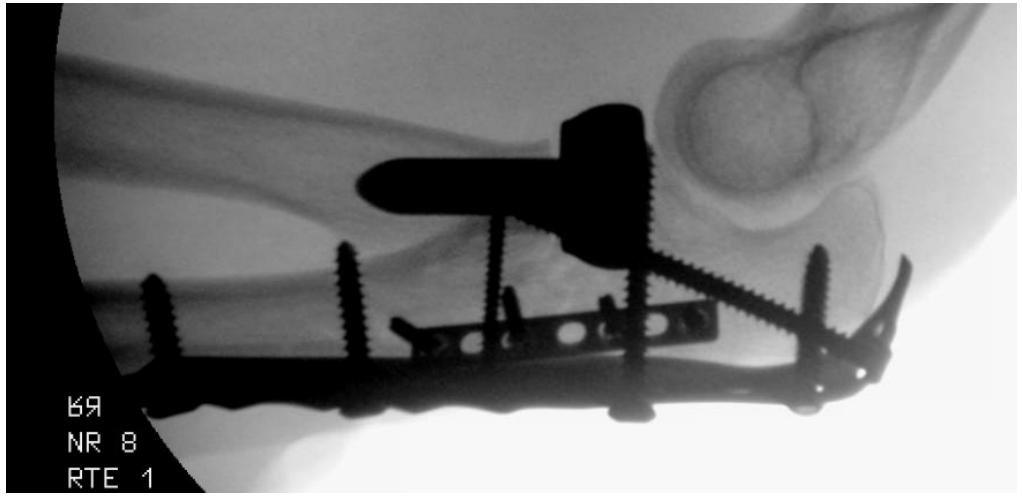




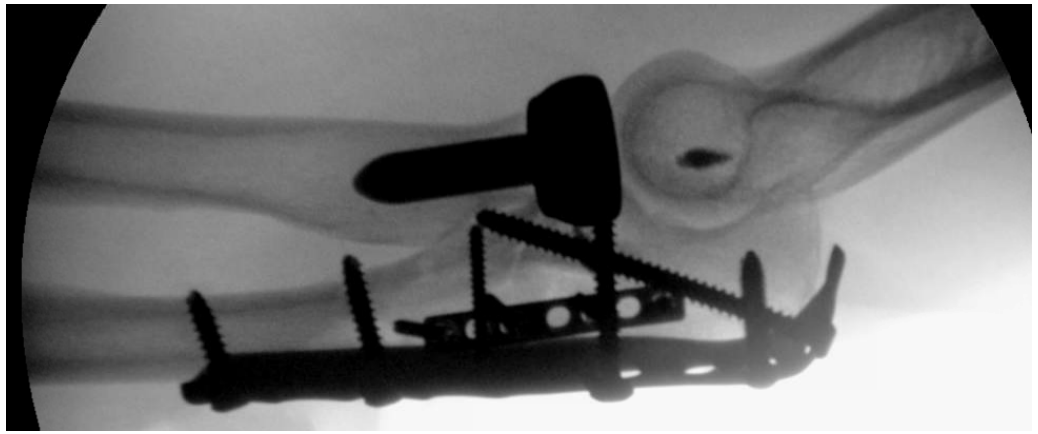
- In the top image, malreduction of the ulna results in persistent radiocapitellar subluxation

- In the bottom image, the reduction has been corrected and the radiocapitellar joint is reduced

Case Example: Monteggia



- In this case, there was persistent elbow instability which prompted an evaluation of the LUCL complex



- The LUCL was found to be injured
- Once repaired with a suture anchor, elbow stability was restored
- Patient was splinted x10 days, then started on a rehab protocol including early motion with varus elbow precautions to protect the LUCL repair

Trans-olecranon Fracture-dislocation

- Distinct from monteggia fracture- PRUJ is intact
- Distal humerus drives through proximal ulnar articular surface
- Often significant articular injury of the greater sigmoid notch

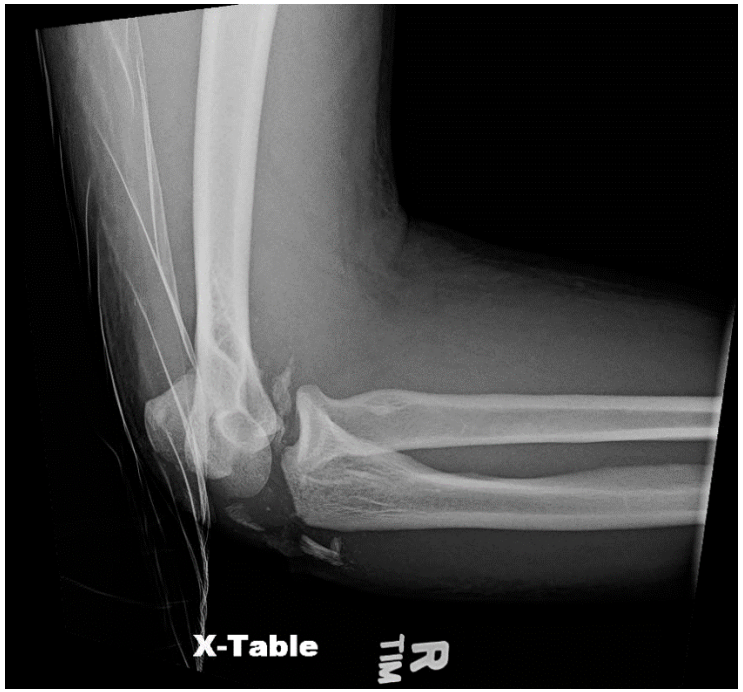
- Outcomes:
  - In general excellent
  - Poorer with radial head, coronoid fractures, and ligamentous injuries*

*Haller+

Case Example: Trans-olecranon Fx-dislocation

- Case example of young patient with a high energy, open trans-olecranon fracture

- There is articular injury, bone loss, and concern for ligamentous injury

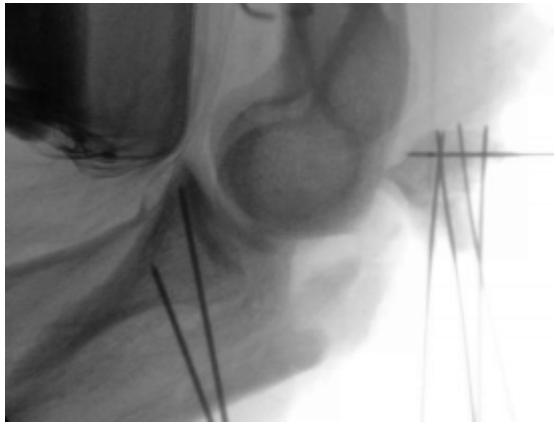


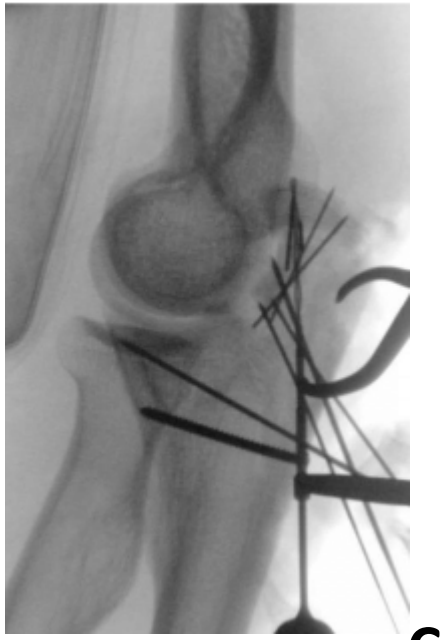
Case Example: Trans-olecranon Fx-dislocation

- The articular surface is reduced directly
- Multiple plates are used to “cage in” the comminution
- Nonlocking screws are used in a stout plate to anchor the unstable distal segment
- The lateral ligamentous complex is repaired
- This particular patient had a head injury and was unable to follow a typically rehab protocol
  - Typically, the patient is placed in a splint for 10-14 days, following which early motion with varus elbow precautions is prescribed

Surgical Toolbox: Trans-olecranon Fracture

- Reduce and work distal to proximal
- Anatomic reduction of articular injury
    - Free articular fragments provisionally wired
    - Dis-impaction of articular surface on intact segments may be required
        - Anticipate need for allograft/void filler
    - Retained threaded wires, mini-fragment implants can be useful
    - “Pilon of the elbow”
- Assess elbow radiographically at conclusion
    - Occasionally LUCL injury needs to be repaired





Peri-implant Fractures

- Can occur adjacent to existing implants
  - Often fracture is through peripheral existing screw hole

- Remove old implants
- Reduction can be challenging- be aware potential for pre-existing non-anatomic union
  - If fracture is through screw hole- restoration of screw hole shape, compared to adjacent, can be helpful
- Use a long implant spanning entire old zone of injury

Bone Loss

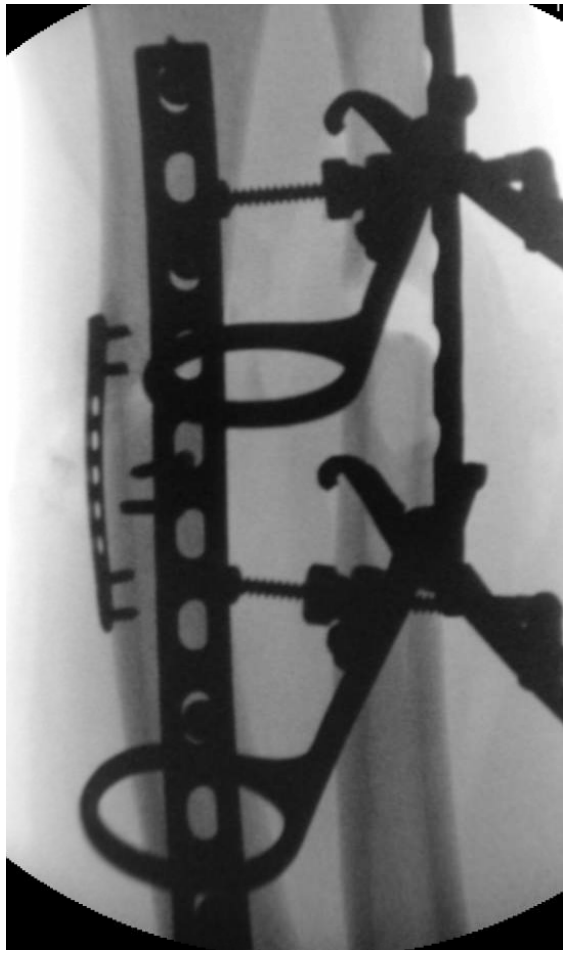
- May occur in conjunction with high energy open fractures, ballistic fractures
- If in radius- anticipate need for bending plate on the flat, or consider a precontoured plate as a reduction aid
- PMMA spacer and induced membrane technique - viable option
- Consider stiff implant or two plates to last through duration of healing

- Bone transport- described, potentially useful depending on patient compliance and surgeon skillset

Case Example: Bone Loss

- This patient with a high energy open both bone fracture had both radial and ulnar bone loss

Case Example: Bone Loss



- Far left image demonstrates the degree of bone loss
- The ulna in particular is missing a segment after length is restored

Case Example: Bone Loss

- In this case PMMA cement was used to fill the void, with the intent to come back and bone graft the defect later

Case Example: Bone Loss

- Two plates were used on the ulna to strengthen the construct in anticipation of a long period prior to healing
- Again, note the eccentric plate placement on the radius- one sign that radial bow has been restored

Postop-protocols

- Variable depending on injury severity, soft tissue injury, and fracture pattern
- In general (author preference)
  - Diaphyseal fractures, DRUJ/PRUJ unaffected: immediate range of motion
  - Radius fx with DRUJ instability
    - After fixation, if DRUJ lax compared to contralateral, splint in stable position x2 weeks
    - If dislocating with pronosupination, pin in reduced position x4 weeks
  - Ulna fx with PRUJ instability
    - If elbow stable after fixing bony injury- immediate ROM
    - If lateral ligament repair required- splint x10 days, then varus elbow precautions and supine gravity assisted flexion/extension x6 weeks
  - If severe soft tissue injury
    - Consider splint x2 weeks for soft tissue rest

Summary: Forearm Fractures

- **Typically operative injuries**
  - **“Fractures of necessity”**
- **May be associated with sequelae of high energy trauma**
  - **Compartment syndrome, open fractures, bone loss**
- **Restoration of length, alignment, rotation and correct shape is critical to forearm function**
- **Proximal fractures may have articular injuries to address**
- **Ensure the wrist and elbow joints are stable**
- **Different fracture patterns have different unstable segments**
  - **Anticipate the predicted failure mechanism and plan fixation to prevent it**

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