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

Image from: Jarvie, Geoff C. MD, MHS, 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
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*
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 $\rightarrow$ ORIF
  - Then clinically and radiographically examine DRUJ after ORIF
- If DRUJ remains unstable $\rightarrow$ 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

<table>
<thead>
<tr>
<th>Bado Type</th>
<th>Radial Head Dislocation</th>
<th>Ulnar Fracture</th>
<th>Radial Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Anterior</td>
<td>Diaphysis with anterior angulation</td>
<td>—</td>
</tr>
<tr>
<td>II</td>
<td>Posterior or posterolateral</td>
<td>Diaphysis with posterior angulation</td>
<td>—</td>
</tr>
<tr>
<td>III</td>
<td>Lateral or anterolateral</td>
<td>Metaphysis</td>
<td>—</td>
</tr>
<tr>
<td>IV</td>
<td>Anterior</td>
<td>Same level as radial fracture</td>
<td>Proximal one-third</td>
</tr>
</tbody>
</table>

#### Jupiter Modification of Bado Type II

<table>
<thead>
<tr>
<th>Modification</th>
<th>Location of Ulnar Fracture</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIA</td>
<td>Distal aspect of olecranon and coronoid process</td>
</tr>
<tr>
<td>IIB</td>
<td>Metadiaphyseal fracture not involving coronoid</td>
</tr>
<tr>
<td>IIC</td>
<td>Diaphyseal fractures</td>
</tr>
<tr>
<td>IID</td>
<td>Proximal one-third of ulna involving coronoid and olecranon with dislocation</td>
</tr>
</tbody>
</table>
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*
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
References


- Snow, Brian J. MD*, ‡; Javidan, Pooya MD*; Itamura, John M. MD‡; Lee, Thay Q. PhD*, ‡ The Effects of Varus or Valgus Malalignment of Proximal Ulnar Fractures on Forearm Rotation, Journal of Orthopaedic Trauma: March 2014 - Volume 28 - Issue 3 - p 143-147. doi: 10.1097/BOT.0b013e31829f5ebc


- Jarvie, Geoff C. MD, MHS*; Selvaggi, Robert MD*; 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


