Forearm Fractures

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Problem

- Fractures of adult forearm are inherently unstable
- According to the AO documentation center, forearm fractures accounted for 10-14% of all fractures between 1980 and 1996
- Mistreatment can lead to malunions and nonunions
  - Cosmetically unappealing
  - Functionally impeding
Anatomy

• Radial Bow
  – Critical for rotation

• Interosseous Membrane
  – Tethers Distal Ulna to Proximal Radius
Radial Nerve

- PIN
  - Proximal Radial Neck
- Superficial Branch Distal
Radial Artery

- Posterior to Brachioradialis
Median Nerve

- Midline
- At risk with Carpal Tunnel
- AIN along IOM
Mechanism

- Low Energy
  - Direct blow (i.e. Nightstick fx)
  - Indirect
    - Galleazzi
    - Monteggia

- High Energy
  - Associated injuries
  - open
Clinical Findings

• PE
  – Floppy, Swelling, Pain
  – Assess Elbow and Wrist
  – Neurovascular Examination
    • AIN, PIN, radial/ulna arteries
  – Soft Tissue
    • Open Wounds
    • Compartments
Compartments

- Dorsal: Extensors
- Volar: Flexors
  - Superficial
  - Deep
- Mobile Wad
  - BR
  - ECRB
  - ECRL
Compartment Syndrome

• Pain
  – Passive Extension
• High energy injury
• Tx
  – Dorsal Approach
  – Volar Approach
  – Carpal Tunnel
Work-up

- X-rays in 2 planes (AP and lateral)
  - Be sure to image joint above and below
    - Wrist and elbow
- CT and MRI
  - Typically unnecessary
  - Add little clinical information
Classification

- AO/OTA
  - 22
  - Fracture type
    - A=simple
    - B=Wedge
    - C=complex
  - Involved bones
    - 1=ulna
    - 2=radius
    - 3=both bones
Type A

- Simple Fracture
  - Ulna alone, Radius intact
  - Radius alone, Ulna intact
  - Both Bones broken

- Ex: Transverse radius fracture
Type B

- **Wedge Fractures**
  - Ulna alone
  - Radius alone
  - Both bones

- **Ex: Both Bones**
Type C

- Complex Fractures
  - Ulna alone
  - Radius alone
  - Both bones

- Ex: both bones
Non-Operative Treatment

- Non-operative
  - Poor
  - Nonunion
  - Malunion

- Non-operative
  - Functional Brace / Cast
  - Ulna
    - Stable
    - Closed
    - Distal 1/3
    - < 10 Degrees
  - Radius
    - Nondisplaced
    - Radial bow maintained
Operative Treatment

- Operative
  - Functional
  - Anatomic
- All Unstable
- All Open
- Non-operative treatment rare
Treatment

• Early surgical intervention (within the first 6-8 hours) is optimal to avoid radioulnar synostosis

• Goals
  – Anatomic reduction
  – Rigid fixation
  – Stable construct
  – Restoration of radial bow
Timing of Surgery

• Early Surgery is Desirable but not Essential
  – Easier reduction especially if shortening
  – Avoids pre-op immobilization

• Delayed Surgery
  – If poor soft tissues
  – If other injuries or medical problems prevent
Open Fractures

- Antibiotics
- Tetanus
- Debridement
- Irrigation
- Surgical Tx
  - ORIF: Type I, II, IIIA
  - Ex-Fix: Type IIIB, IIIC
Treatment

• Fixation options include
  – IM nailing
  – External fixation
  – plate fixation
Treatment

- IM Fixation
  - Not routinely used
  - Soft tissue injury
  - Pathologic Fracture
Treatment

• External Fixation
  – open type IIIb
  – open type IIIc
Treatment

• **Plate Fixation**
  – provides stable strong anatomic fixation
  – eliminates need for external casting
  – allows early functional motion with union rates over 95%.

• **Obtain anatomic reduction**

• **Restore ulna & radial length**
  – Prevents subluxation of either proximal or distal radioulnar joints

• **Restore rotational alignment**

• **Restore radial bow**
  – Essential for rotational function of forearm
Approaches

• Ulna
  – exposed along the subcutaneous border between the flexor and extensor carpi ulnaris
  – dorsal cutaneous branch of the ulnar nerve
    • ≈5 cm proximal to the wrist joint
    • identify and protect
Approaches

• Radius
  – Two approaches
    • Henry
      – Volar
      – Good for middle to distal third fractures
    • Thompson
      – Dorsal
      – Good for proximal to middle third fractures
Approaches-Henry (volar)

- Incision begins 1 cm lateral to the biceps insertion
- Extends distally to the radial styloid
- Interval between brachioradialis and FCR
- Identify radial artery and superficial radial n.
- Protect PIN proximally
Approaches-Thompson (dorsal)

- Incision begins just anterior to the lateral epicondyle
- Extends distally towards the ulnar side of Lister’s tubercle
- Interval is developed between the ECRB and the EDC, exposing the supinator muscle
- Identify PIN
  - 1cm proximal to its distal edge of supinator
Intra-op Tips

- Supine w/ hand table
- Tourniquet
- Approach simpler fx 1st
- Reduce and provisionally fix
- Approach other fx
- Reduce and plate with LCDC or LCP in compression mode
- Goal of 6 cortices above and below with 3 screws over 4 or more holes on each side
- Check and modify reduction of other bone
- Plate with LCDC or LCP in compression mode
- Goal of 6 cortices above and below with 3 screws over 4 holes on each side
- Confirm reduction with c-arm
- Irrigate and close ulna wound first
- Irrigate and close radial wound
- If unable to close, VAC and return in 3-5 days to close vs STSG
The Role of Bone Grafting

• Bone Graft if there is Severe Bone Loss or the patient has an Open Fracture Severely Compromising Local Biology
  – If >1/3 cortical circumference is lost, consider bone grafting because interfragmentary compression becomes impossible
  • But the standard teaching that >30% comminution “requires” grafting has been challenged where newer biologic techniques are used.
Technical Tips for Plate Fixation of Forearm Fractures

• Use Indirect Reduction Techniques Preserving Soft Tissue Attachments
  – Periosteal stripping must be minimized
  – Narrow retractors placed to avoid penetration of interosseous membrane

• Close or Skin Graft Open Wounds within 3-5 days
Post-op

- Sterile dressing and sugartong splint
- Closely monitor compartments
- Low threshold to split dressing
- POD#1
  - Initiate digital ROM
- Delay Wrist/Elbow ROM 3-5 days
  - Prevents hematoma formation
Follow-up

• Forearm rotation is initiated as the patient's comfort allows
  – Usually 1\textsuperscript{st} or 2\textsuperscript{nd} week post-op
• RTC @ 2 weeks, 6 weeks, 12 weeks, and 4-6 months postoperatively
  – AP/lat X-rays each visit
• Activity modification to ADL’s only until fracture healed
  – 8-12 weeks
• progressively return to a normal lifestyle.
Complications

• Refracture after plate removal
• Symptomatic hardware
• Nonunion
• Malunion
• Infection
• Neurologic injury
• Compartment syndrome
• Radioulnar synostosis
Pain & Hardware Removal

- **Two Years**
  - Bone Density Does Not Normalize for 21 months
  - 4 to 20% Refracture Risk
    - Usually through original fracture or screw hole
    - Large plate (4.5 mm DCP)
    - Nonunion
    - Infection & Nerve Injury
    - Pain may persist after plate removal

- **Post-removal**
  - 67% Residual Symptoms
  - 9% Worse
  - Weather
  - Exercise
  - Skin or Tendon Irritation
Malunion

- Loss of motion with >10° of angulation
- 5° loss of radial row = 15° loss of sup/pro
- Decreased grip strength occurs with loss of the radial bow
  - Schemitsch, EH & Richards RR JBJS 1992:74A:1068-78
- Tx: Osteotomy and Repair
Nonunion

- Poor biomechanics
- Poor Technique
  - Stable construct
    - Too few screws
    - Improper compression
  - Soft tissue management
- Initial Fracture
  - Open Injury
  - Comminuted fracture

- Tx
  - Revision Fixation
  - Bone Grafting
  - Segmental bone loss
    - Iliac crest <3.5cm
    - Consider vascularized fibular graft >3.5cm
Neurologic Injury

• Closed Fracture
  – Usually iatrogenic
  – PIN: Proximal approach
  – AIN: Vigorous Radial Reduction
  – Radial Sensory Branch: Anterior dorsal exposure

• Open Fracture
  – AIN Most Common
Synostosis

- Incidence 1-8%
- Risks
  - BBFFx at same level
  - TBI
  - Surgical delay (> 2 wks)
  - Single incision
  - IOM Penetration
- Tx
  - Early resection
Outcomes

• Closed Fractures
  – 98% Union, 3% infection, 92% good function
  – 96% Union, >85% good function

• Open Fractures
  – 93% Union, 4% infection, 85% good function
Outcomes

- Motion
  - Near Normal
- Grip Strength
  - 30% Reduced
- Disability is Pain Related
  - Goldfarb et al JBJS Br 2005 Mar;87(3):374-9
  - Droll et al JBJS Am 2007 Dec;89(12):2619-24
Special Cases

- Fractures Associated with Joint Disruption
  - Galleazzi Fracture
  - Monteggia Fracture
  - Combined Patterns
- Fractures Associated with other Injury
  - Floating Elbow (Ipsilateral Humerus Fracture)
  - Open Fractures
Fractures Associated with Joint Disruption
Galeazzi & Monteggia

• Best Treatment
  – ORIF w. Plate Fixation of Diaphyseal Fracture
  – Joint Usually Reduces Indirectly and is stable
  – If Unstable: require open reduction of joint
  – If irreducible – it is usually because the diaphyseal fracture has been mal-reduced
Galeazzi Fractures

• Classic: Fracture of distal 1/3 radial shaft with Dislocation Distal Radioulnar Joint

• Variants: Fracture can occur anywhere along the radius or associated with fractures of both bones with DRUJ disruption
Galleazzi Fractures

Radiographic Signs of DRUJ Injury:

- Fracture at Base of Ulnar Styloid
- Widened DRUJ on AP x-ray
- Subluxed Ulna on Lateral x-ray
- >5 mm Radial Shortening
- Radius Fracture < 7.5cm from the wrist joint
  - (unstable DRUJ in 55%)
Galleazzi Fractures

- **Always require Plate fixation of the Radius**
  - Distal Medullary canal too wide/funnel shaped for intramedullary fixation
  - Sometimes require temporary pin fixation of DRUJ or repair of the ulnar styloid when fractured

- **Postop:**
  - If DRUJ stable – early motion
  - If DRUJ unstable – immobilize forearm in supination for 4-6 weeks in a long arm splint or cast
  - DRUJ pins are removed at 6-8 weeks
Galeazzi fractures

• May be associated damage to triangular fibrocartilage, which may require early or late repair with open or arthroscopic techniques

  – Can Occur with Low Velocity Gunshots
### Monteggia Fractures

Classic: Fracture of Proximal 1/3 Ulna with Dislocation of Radial Head

<table>
<thead>
<tr>
<th>Type</th>
<th>%</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>60%</td>
<td>Both Anterior: Dislocation Radial Head &amp; Angulation Ulna Fracture: Equivalent: Radial Head or Neck fractured</td>
</tr>
<tr>
<td>II</td>
<td>20%</td>
<td>Both Posterior: Dislocation Radial Head + Angulation Ulna Equivalent: Posterior Elbow Dx.</td>
</tr>
<tr>
<td>III</td>
<td>15%</td>
<td>Lateral Dislocation Radial Head + Any Fracture of Proximal Ulna</td>
</tr>
<tr>
<td>IV</td>
<td>5%</td>
<td>Anterior Dislocation Radial Head + Fractures Proximal Shafts of Both Bones are at the same level</td>
</tr>
</tbody>
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Monteggia Fractures

Radiographic Findings:

Normal:
- Line Drawn through Radial Head & Shaft should always line up with Capitellum
- Supinated Lateral: lines drawn tangential to head anteriorly and posteriorly should enclose the Capitellum

Monteggia Fracture:
These radiographic findings are disrupted
Monteggia Fractures

• After fixation of the ulna, the radial head is usually stable (>90%)  
  – If radial head not reduced recheck ulna length

• If open reduction is required for the radial head, the annular ligament is repaired  
  – Failure of the radial head to reduce with ulnar reduction is usually due to interposed annular ligament or rarely the radial nerve

• Associated Radial Head Fractures may require fixation/replacement
Monteggia Fractures

• Postoperative treatment depends on rigidity of ulnar fixation and stability of the radial head
  – Casting with more than 90 degrees of elbow flexion is rarely needed to maintain the radial head reduction (6 weeks)
Literature

- Falder S, Sinclair JS, Rogers CA, Townsend PL. Long-term behaviour of the free vascularised fibula following reconstruction of large bony defects. Br J Plast Surg. 2003 Sep;56(6):571-84. PMID:12946376 (Link to Abstract)

Level of Evidence 5 and Other Journal Articles (includes Case Reports, Expert Opinions, Personal Observations, and Biomechanic Studies)

Literature

Literature

Conclusion

- Forearm fx's are inherently unstable fx's
- Vast majority require operative fixation
- Goal is anatomic reduction with stable fixation
- Restore ulna length
- Restore radial bow
- Respect the soft tissue
- Don’t miss injury to joint above or below

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