

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

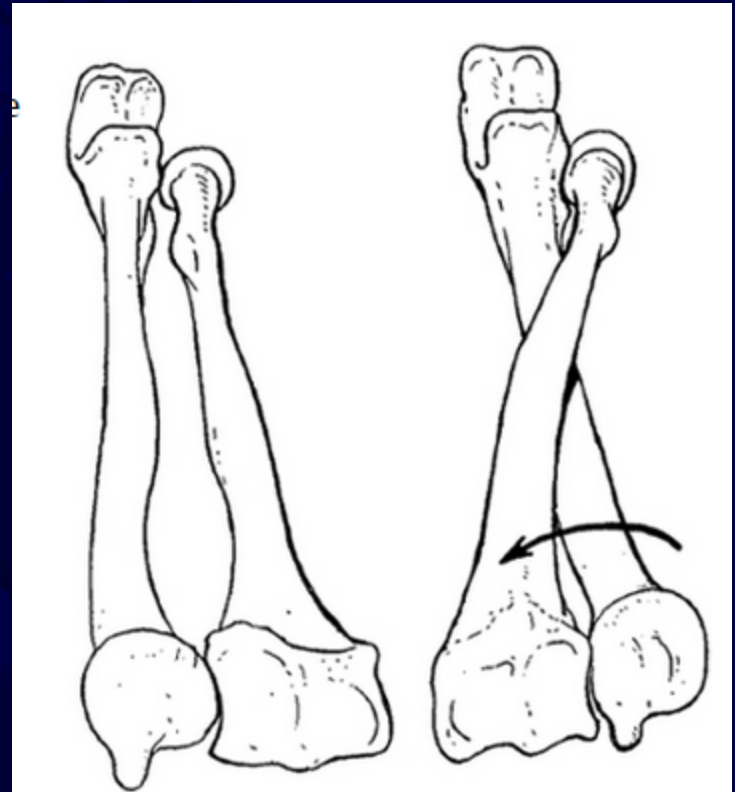

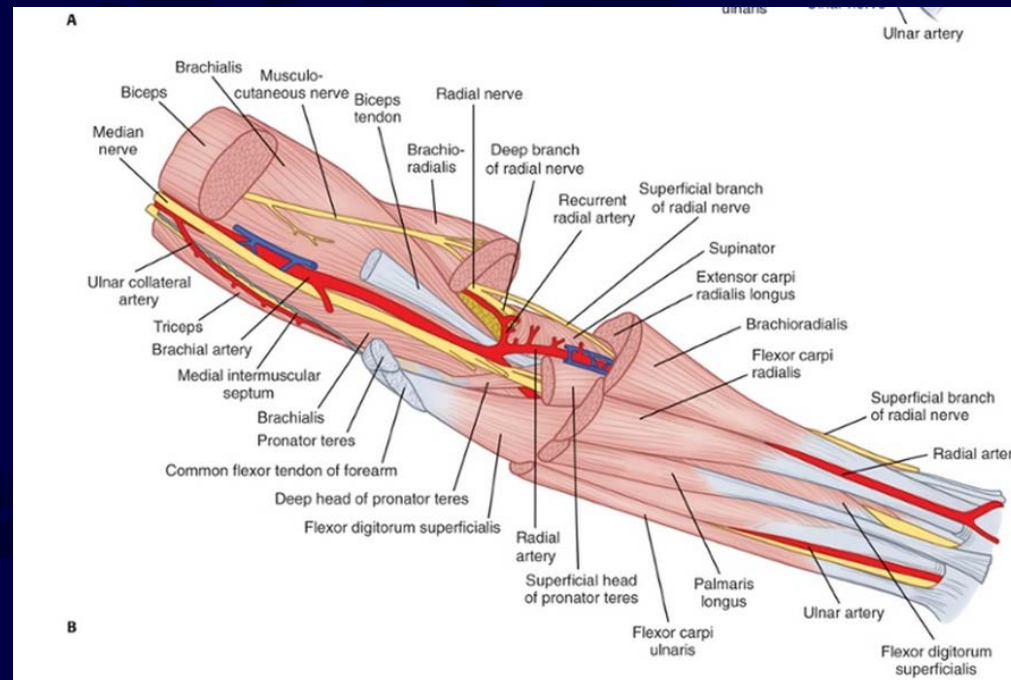


Figure 33-14  During pronosupination, the radius rotates about the ulna (*arrow*). The complex ...

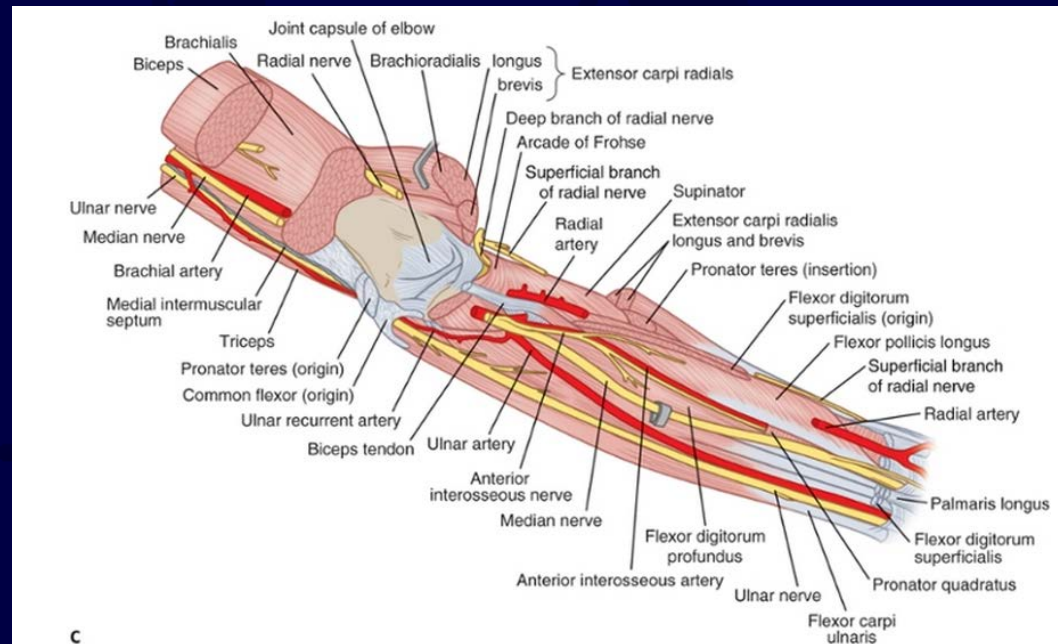
Radial Nerve

- PIN
 - Proximal Radial Neck
- Superficial Branch Distal

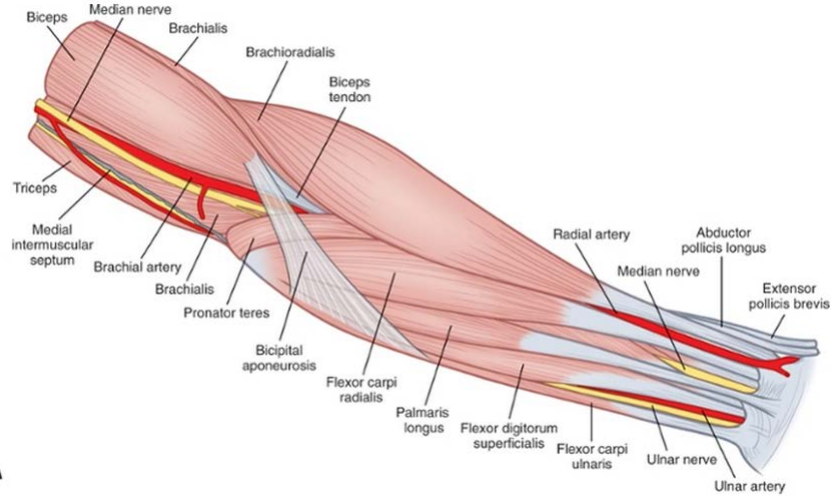


Radial Artery

- Posterior to Brachioradialis



Median Nerve



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

Mechanism

- Low Energy
 - Direct blow (i.e. Nightstick fx)
 - Indirect
 - Galeazzi
 - Monteggia
- High Energy
 - Associated injuries
 - open



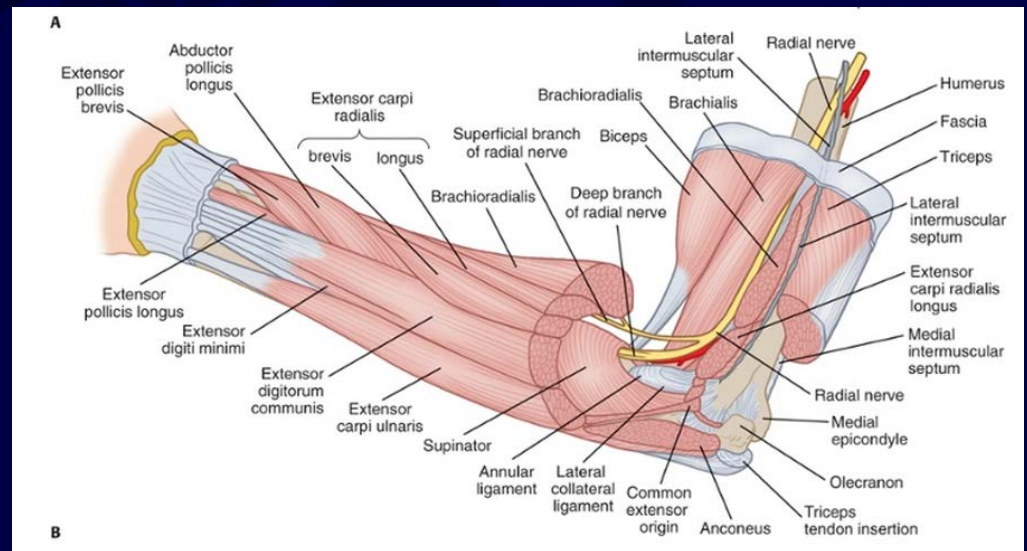
Clinical Findings

- 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



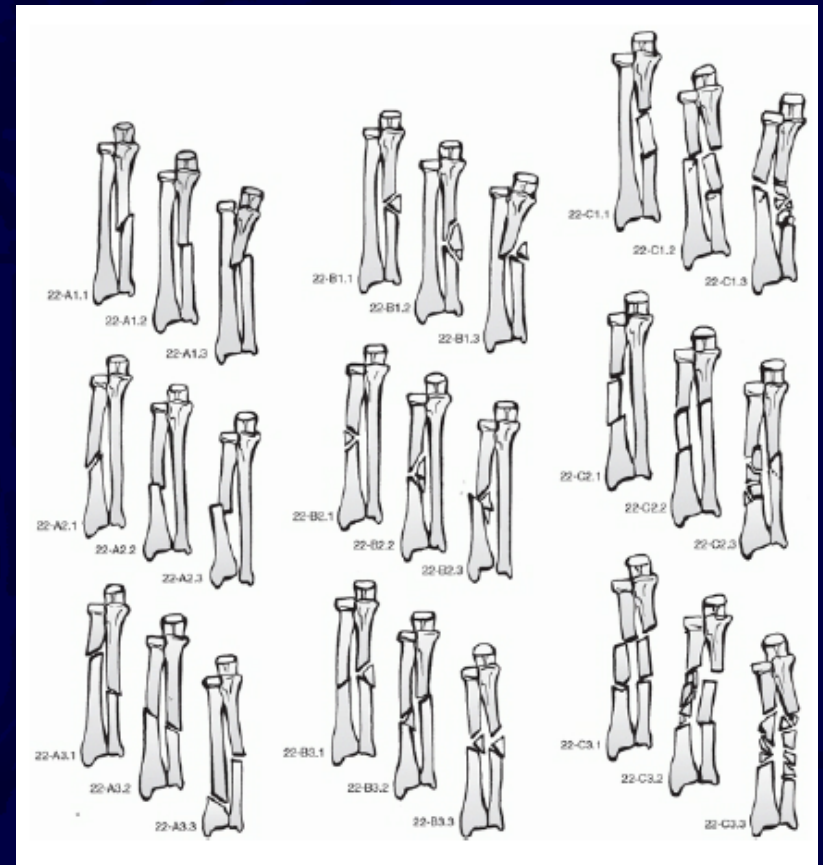
Work-up

- 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

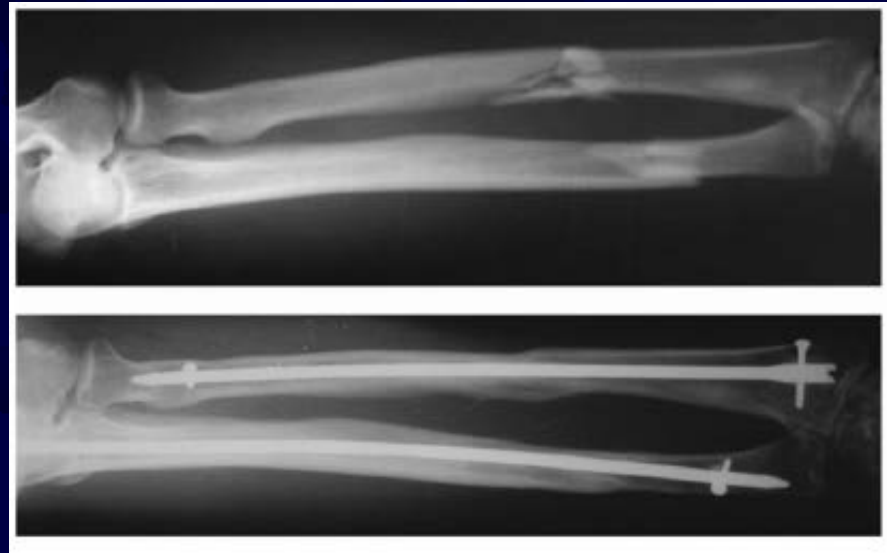


Treatment

- Fixation options include
 - IM nailing
 - External fixation
 - plate fixation

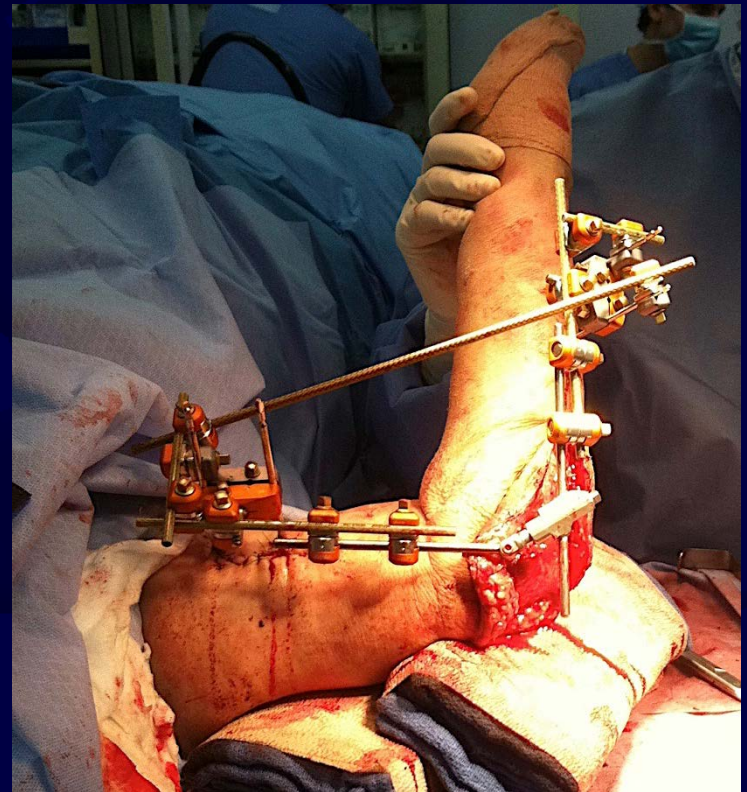
Treatment

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



Treatment

- External Fixation
 - open type IIIb
 - open type IIIc

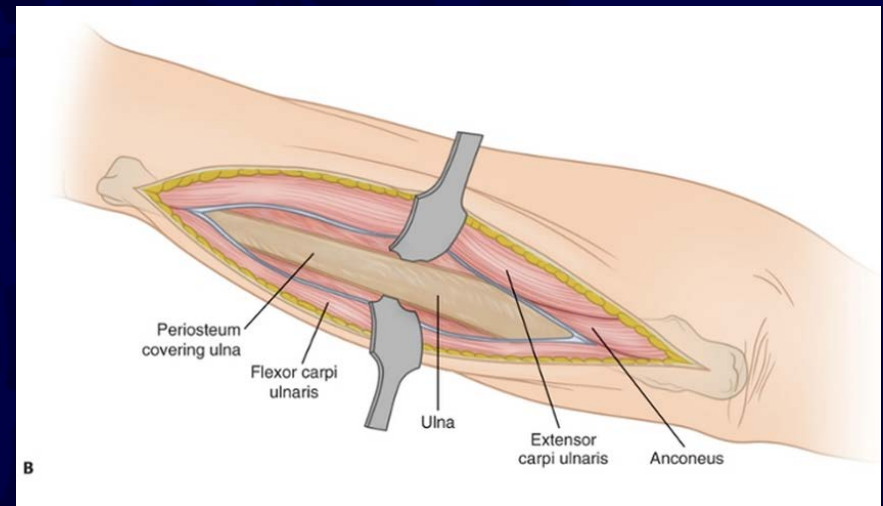


Treatment

- 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

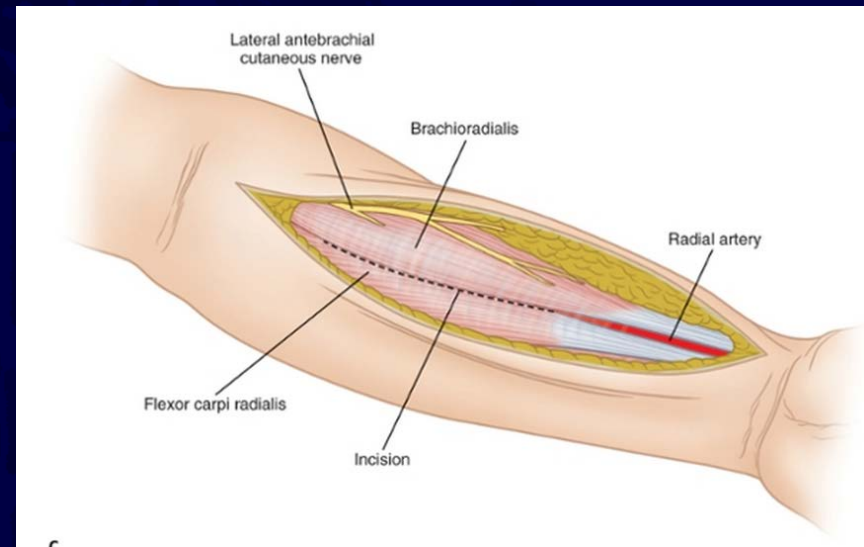


Approaches

- Radius
 - Two approaches
 - Henry
 - Volar
 - Good for middle to distal third fractures
 - Thompson
 - Dorsal
 - Good for proximal to middle third fractures

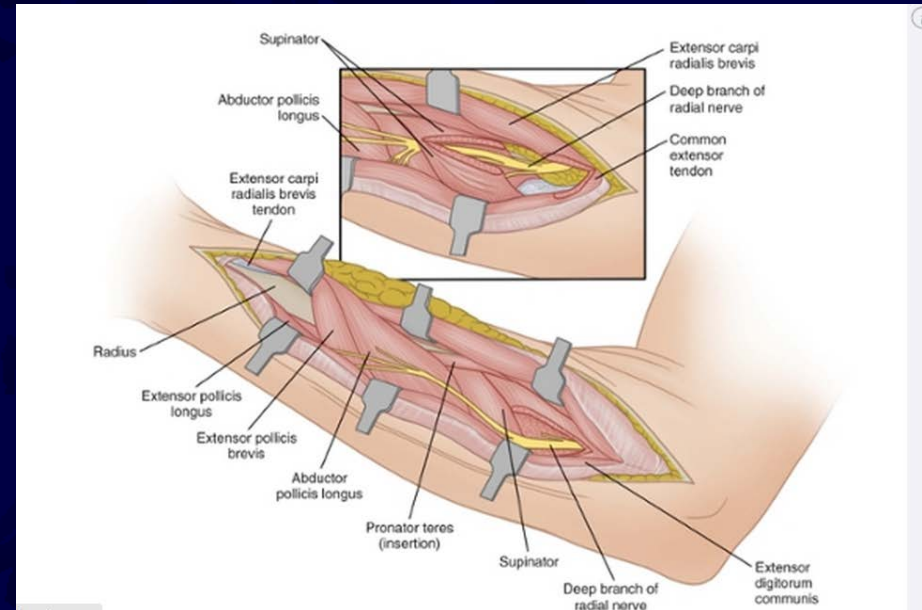
Approaches-Henry (volar)

- 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.
 - Wright, RR, Schmeling, GJ, and Schwab, J.P. The necessity of acute bone grafting in diaphyseal forearm fractures: a retrospective review. J. Orthop Trauma 11:288-94, 1997.

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 1st or 2nd 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**
 - Rossen, JW et al, JBJS 1991:73B:65-7.
- **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
 - Mih, AD et al, CORR 1994:299:256-8

Malunion

- Loss of motion with $>10^\circ$ 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
 - Chapman, M et al: JBJS 1989:71A:159-69
 - 96% Union, >85% good function
 - Anderson, LD et al: JBJS 1975:57A:287-97
- Open Fractures
 - 93% Union, 4% infection, 85% good function
 - Moed, BR et al: JBJS 1986:68A:1008-17

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
 - Lenihan, MR et al J.O.T. 1992:6:32-35.

Monteggia Fractures

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

Type	%	Description
I	60%	Both Anterior: Dislocation Radial Head & Angulation Ulna Fracture: Equivalent: Radial Head or Neck fractured
II	20%	Both Posterior: Dislocation Radial Head + Angulation Ulna Equivalent: Posterior Elbow Dx.
III	15%	Lateral Dislocation Radial Head + Any Fracture of Proximal Ulna
IV	5%	Anterior Dislocation Radial Head + Fractures Proximal Shafts of Both Bones are at the same level



Monteggia Fractures

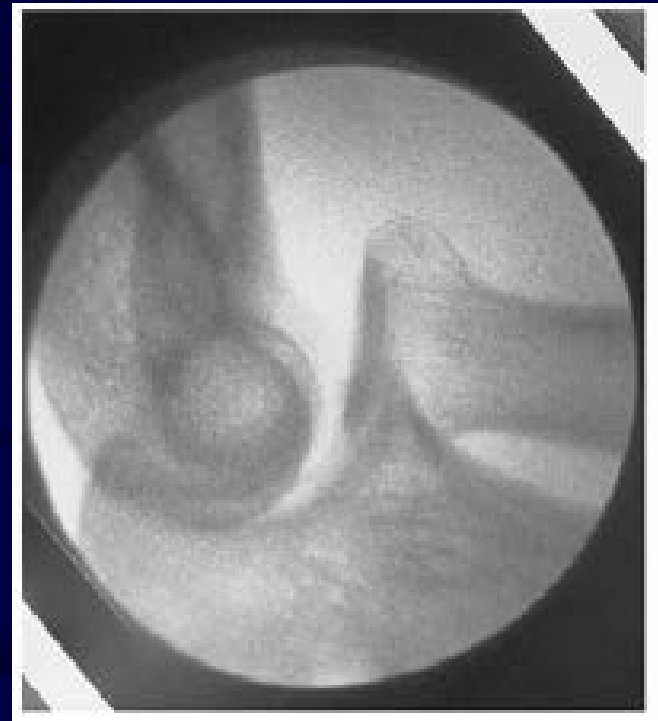
Radiographic Findings:

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

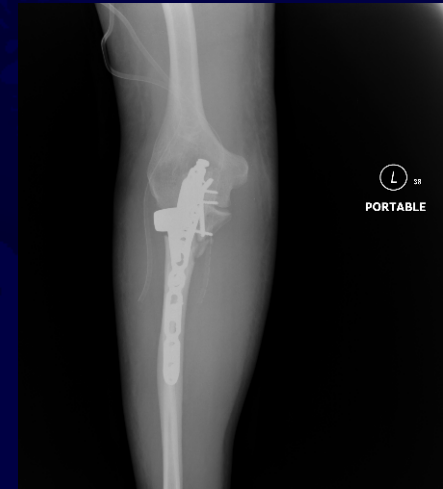
Monteggia Fracture:

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)

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Conclusion

- Forearm fxs are inherently unstable fxs
- 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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