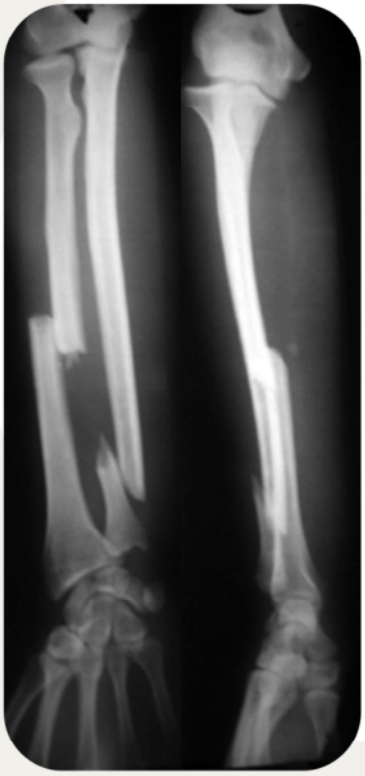
AO TRAUMA

Forearm shaft fractures

Volker Braunstein



Learning outcomes

At the end of this lecture you will be able to:

- Outline the anatomy and physiology of the forearm
- Outline indications for nonoperative and operative treatment
- Discuss principles of surgical treatment

Editors:

- Chris Colton
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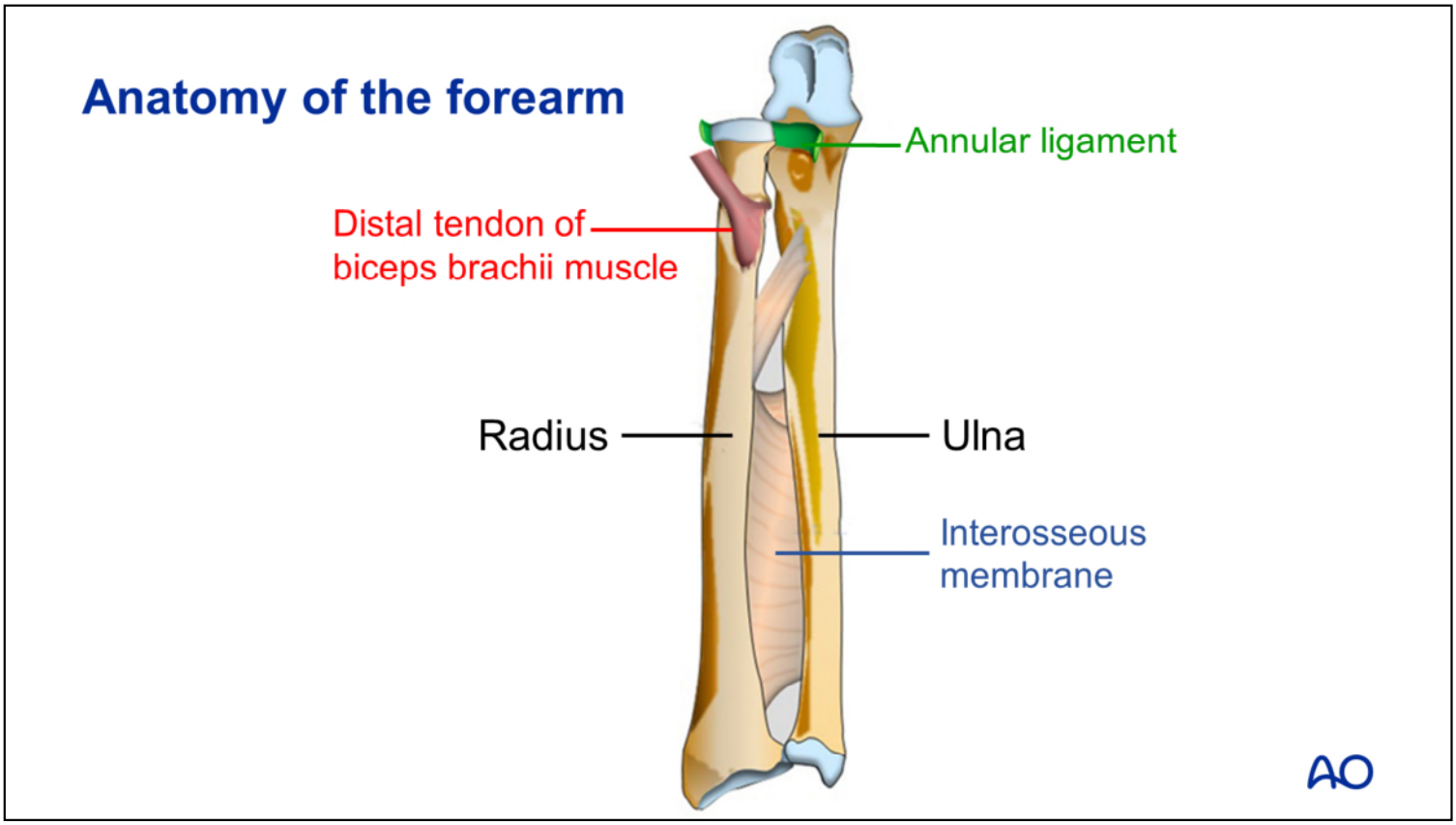
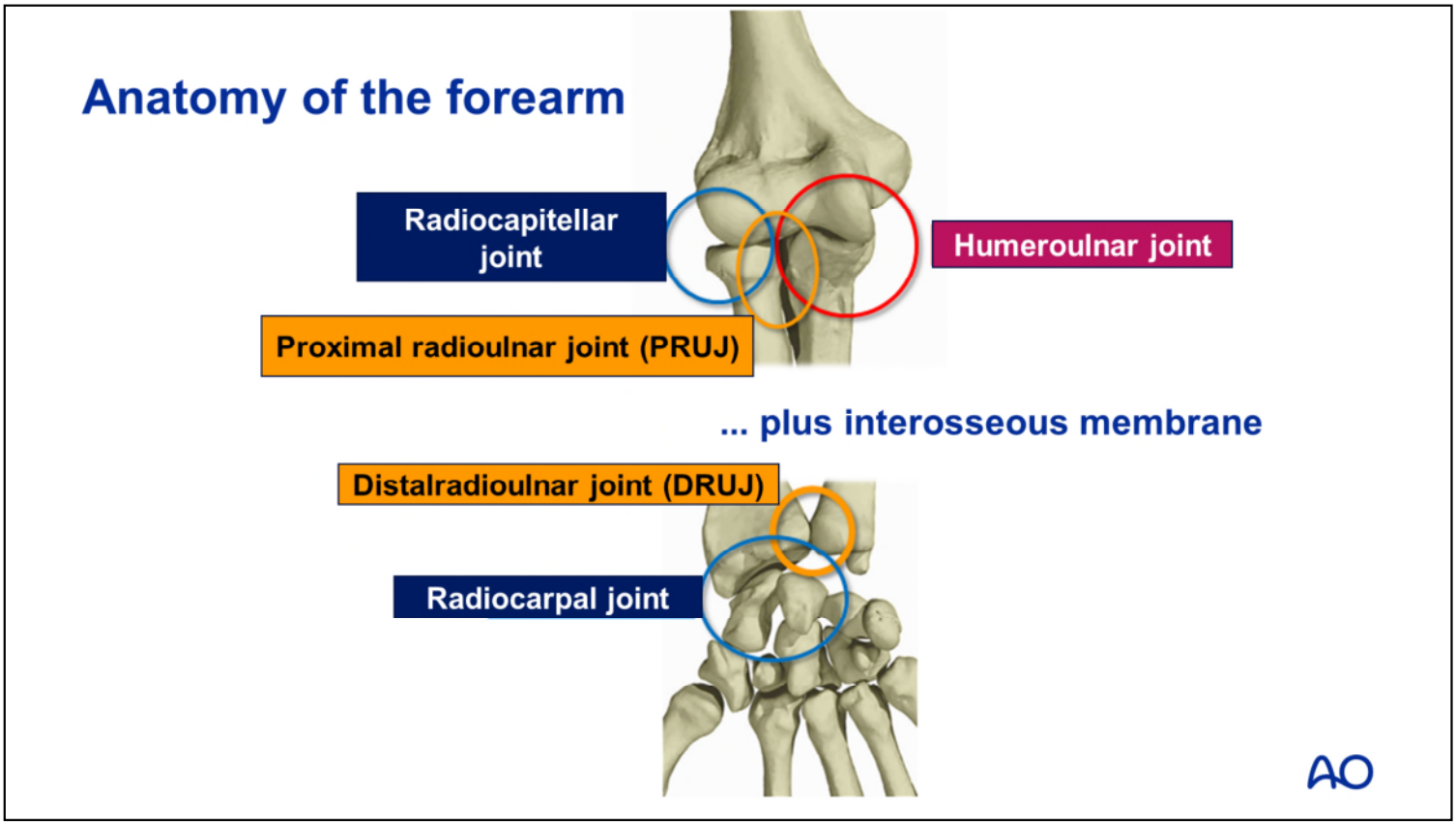
- Isabel Van Rie Richards



The interosseous membrane of the forearm is a fibrous sheet, spanning the interval between the radius and the ulna, that divides the forearm into anterior and posterior compartments. It serves as a site of origin of muscles of the forearm, and transfers forces from the radius to the ulna.

The annular ligament encircles approximately 80% of the head of the radial head and retains it in its anatomical relationship at the proximal radioulnar joint.

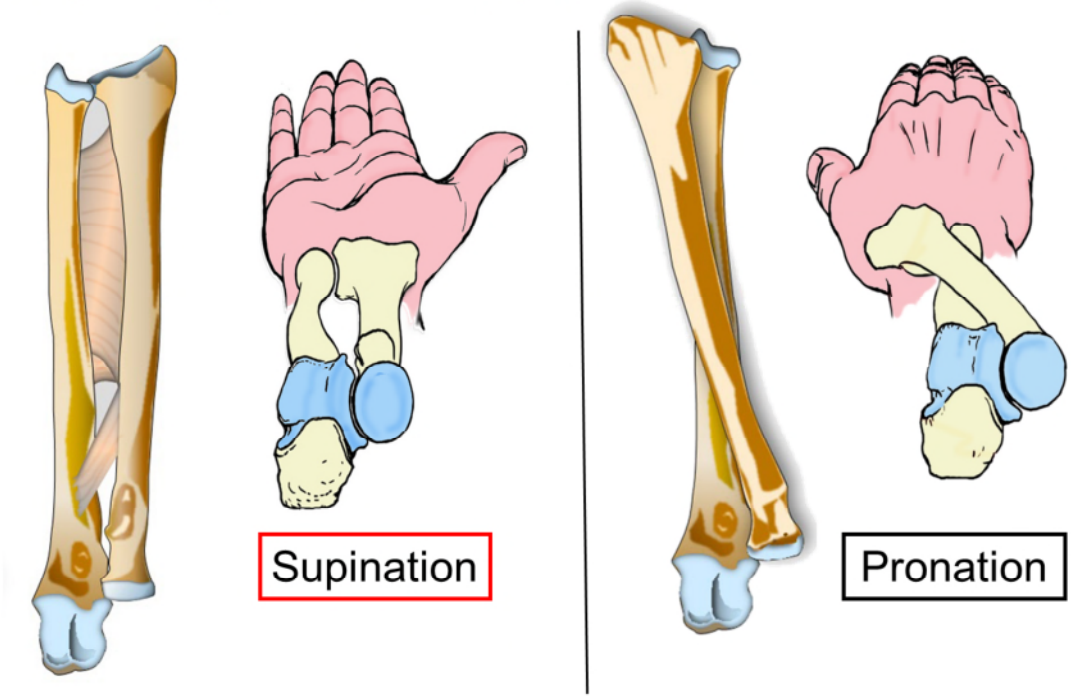


The forearm bones articulate with the humerus at the humeroulnar and radiocapitellar joints. It is at these joints that flexion and extension of the elbow occur.

The articulations between the radius and ulna permit pronation and supination. These comprise the proximal and distal radioulnar joints.

The radiocarpal articulation allows wrist flexion, extension, and both radial and ulnar deviation.

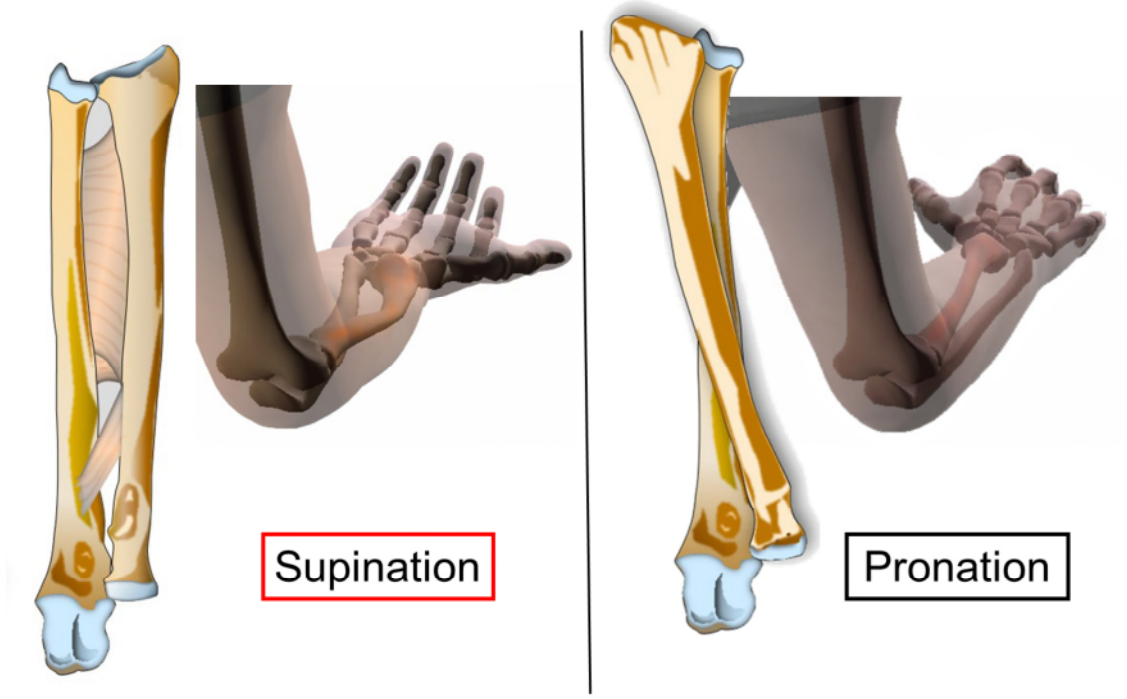
Anatomy—supination and pronation



Supination and pronation is easily confused with medial and lateral rotation but the difference is that pronation and supination can occur only when the forearm in semiflexed.

- Pronation moves the palm of the hand so that it is facing posteriorly *(your forearms are pronated when typing on a keyboard)*.
- Supination moves the palm of the hand so that it is facing anteriorly *(your hands are supinated when holding a bowl of soup)*.

Anatomy—supination and pronation



Supination and pronation is easily confused with medial and lateral rotation but the difference is that pronation and supination can occur only when the forearm in semiflexed.

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Anatomy—supination and pronation

- The forearm bones and their rotational articulations function as a single joint
- For this reason, the objectives of treatment of all joint fractures apply:
  - Anatomical reduction
  - Stable fixation
  - Early functional aftercare

Epidemiology

- 10–14% of all fractures occur in the forearm
- Incidence of forearm shaft fractures does not increase with age

References:

AO Documentation 1980-1996.

Singer BR, McLauchlan GJ, Robinson CM, et al. Epidemiology of fractures in 15,000 adults: the influence of age and gender. *J Bone Joint Surg Br*. 1998 Mar;80(2):243–248.

Fracture mechanism

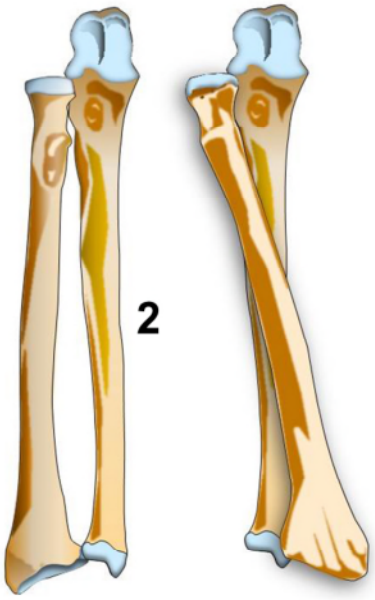
- High-energy trauma, resulting in:
  - Axial compression
  - Bending
  - Rotation
  - Direct trauma

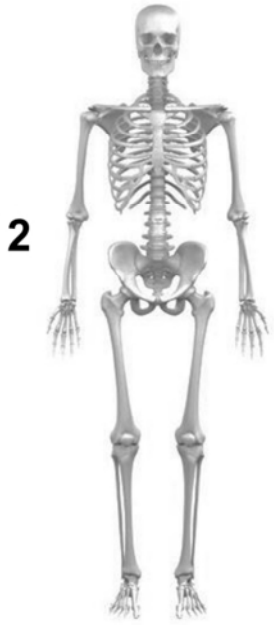
Radiological investigations

- X-ray
  - In two planes (including both radio-ulnar joints)
- CT
  - Rarely indicated
- MRI
  - Occasionally, to identify suspected articular cartilage or ligament damage

AO/OTA Fracture Classification

Bone code: 2

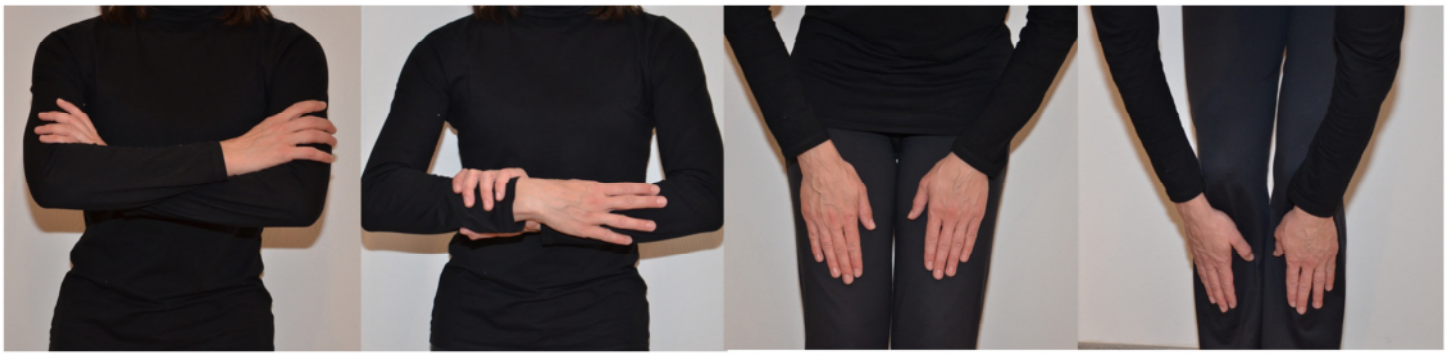




Exercise to remember the numbers of the bones, see next slide.

This exercise can be done with the participants.

Picture demonstrating exercise in order to memorize number of bones for the AO classification

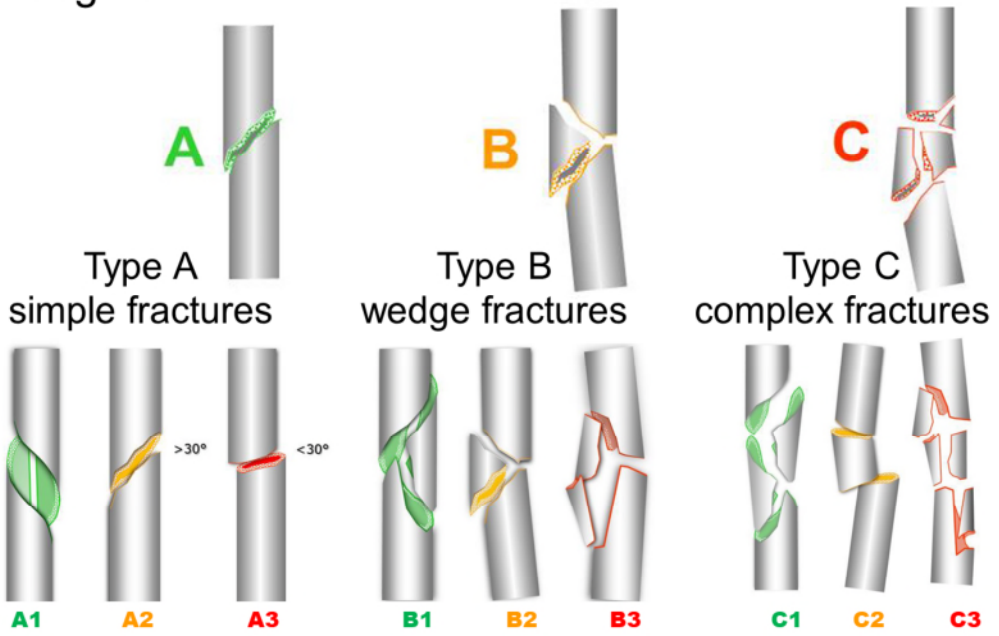


Exercise to remember the numbers of the bones:

- Let the participants stand up.
- They cross the arms, pronounce loudly together number and touch
    1. Upper arms
    2. Forearms
    3. Femurs
    4. Tibias

AO/OTA Fracture Classification

- Segment: 2



Which group?

A. Simple fractures
   1. Spiral
   2. Oblique (+30°)
   3. Oblique (-30°)

B. Wedge fractures
   1. Spiral
   2. Bending
   3. Fragmented

C. Complex fractures
   1. Spiral
   2. Segmental
   3. Irregular

Conservative treatment—indications

- Fractures without displacement and without associated dislocation
- Patients in poor general condition
  - Resulting in high surgical risks

Conservative treatment—indications

Cast for minimum 4 weeks

- Including adjacent joints

Fractures in proximal forearm

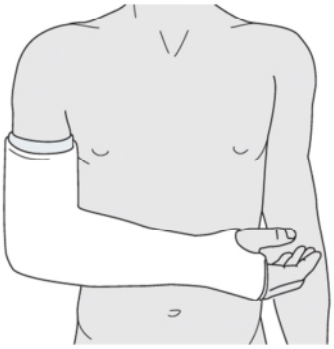
- Cast in supination

Fractures in middle or distal part

- Cast in neutral rotation

X-ray controls

- Frequently—ideally weekly to show fracture position



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Fractures in proximal forearm:

- Cast in supination position to reduce the displacing forces of supinator and biceps brachii muscles

Conservative treatment—risks

Delayed union—nonunion

- Up to 30 %

Limited range of motion (ROM) after immobilization

- Pronation, supination
- Contracture of interosseous membrane

References:

Friedl HP, Trentz O. Unterarmschaft. In: Rüter A, Trentz O, Wagner M, eds. *Unfallchirurgie.* München: Urban & Schwarzenberg; 1995:521–531.

Operative treatment—indications

- Displaced fractures of both radius and ulna
- Displaced, isolated fracture of either bone
  - Rotated or angulated > 10°
- Fractures combined with radioulnar dislocations
  - Monteggia injury (ulnar fracture and dislocation of radiocapitellar joint)
  - Galeazzi injury (distal radius and dislocation of distal radioulnar joint)
- Open fractures

Operative treatment—indications

- Monteggia injury

Operative treatment—indications

- Galeazzi injury

Goals of treatment

- Anatomical reduction
- Restoration of length (ulna and radius)
- Restoration of axial and rotational alignment
- Restoration and stabilization of joints
- Repair of soft-tissue injuries

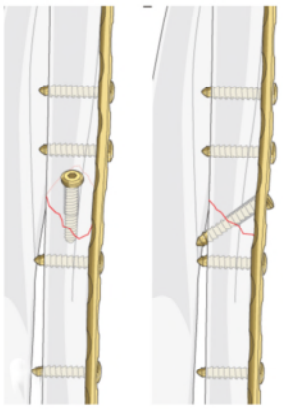
➢ Stable fixation allows immediate postoperative movement

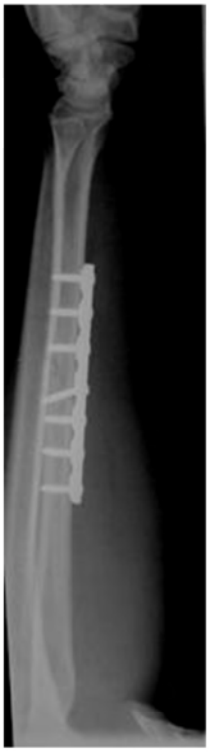
Preoperative planning

- Technique
  - Absolute or relative stability
- Implant
  - Plates, external fixator, or nail
- Strategy and approach
  - Which bone should be fixed first

Surgical technique

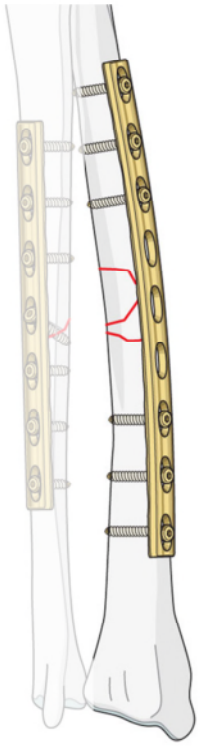
- Type A (simple) and type B (wedge) fractures
  - Absolute stability technique:
    - Interfragmentary lag screw (if possible)
    - Compression plate





Surgical technique

- Type C (complex) fractures
  - Absolute stability technique not often achievable
  - Relative stability by bridge plating common



Surgical technique

- Type C (complex) fractures:
  - Absolute stability technique not often achievable
  - Relative stability by bridge plating common

➢ Check pronation and supination intraoperatively after reduction and fixation

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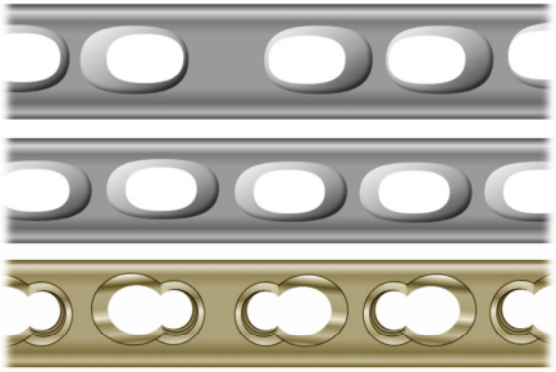
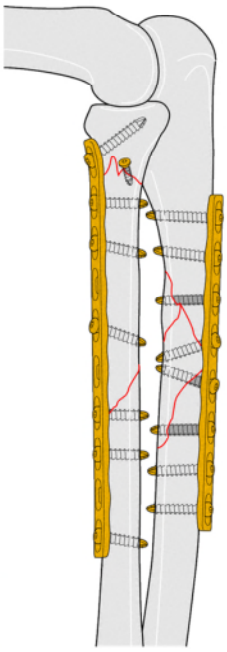
Choice of implants

- 3.5 mm plate
  - Gold standard
  - 7–8 holes
  - DCP, LC-DCP, or LCP





Choice of implants

- Elastic stable intramedullary nails (ESIN)
  - Controversial in adults
  - Excellent results in pediatric forearm fractures

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Elastic stable intramedullary nailing (ESIN):

- Remains controversial in adults—no reliable rotation control
- Excellent results in pediatric forearm diaphyseal fractures

References:

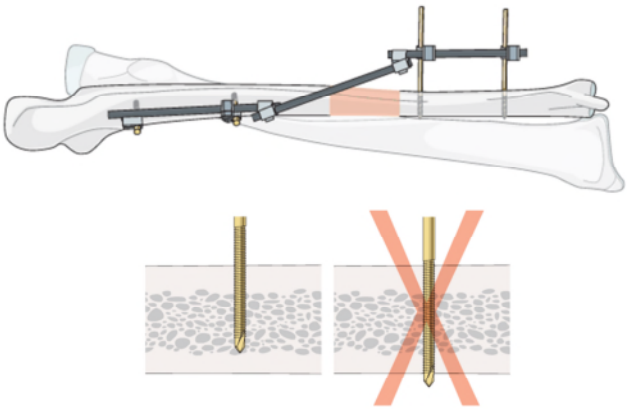
Van der Reis WL, Otsuka NY, Moroz P, et al. Intramedullary nailing versus plate fixation for unstable forearm fractures in children. *J Pediatr Orthop.* 1998 Jan-Feb;18(1):9–13.

Fernandez FF, Egenolf M, Carsten C, et al. Unstable diaphyseal fractures of both bones of the forearm in children: plate fixation versus intramedullary nailing. *Injury.* 2005 Oct;36(10):1210–1216.

Kapoor V, Theruvil B, Edwards SE, et al. Flexible intramedullary nailing of displaced diaphyseal forearm fractures in children. *Injury*. 2005 Oct;36(10):1221–1225.

Choice of implants

- External fixator
  - Open fractures
  - Careful pin insertion



Courtesy: Volker Braunstein

Choice of implants

- External fixation
  - Fracture consolidation
    - Cannot be achieved by external fixation alone
    - Rates of nonunion and malrotation are considerable

➢ Change as soon as plate fixation is safe

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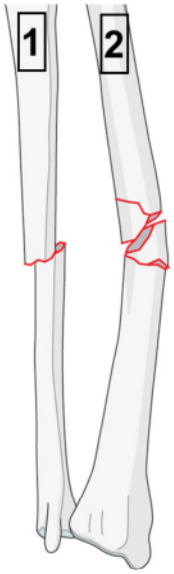
References:

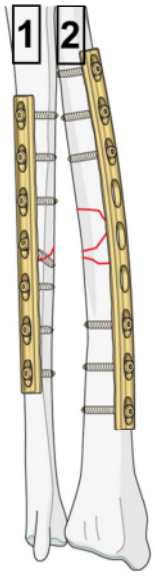
Wild JJ Jr, Hanson GW, Bennett JB, et al. External fixation use in the management of massive upper extremity trauma. *Clin Orthop Relat Res.* 1982 Apr;(164):172–176.

Helber MU, Ulrich C. External fixation in forearm shaft fractures. *Injury.* 2000;31 Suppl 1:45–47.

Strategy



1. Fix simple fracture first
2. Then fix multifragmentary fracture



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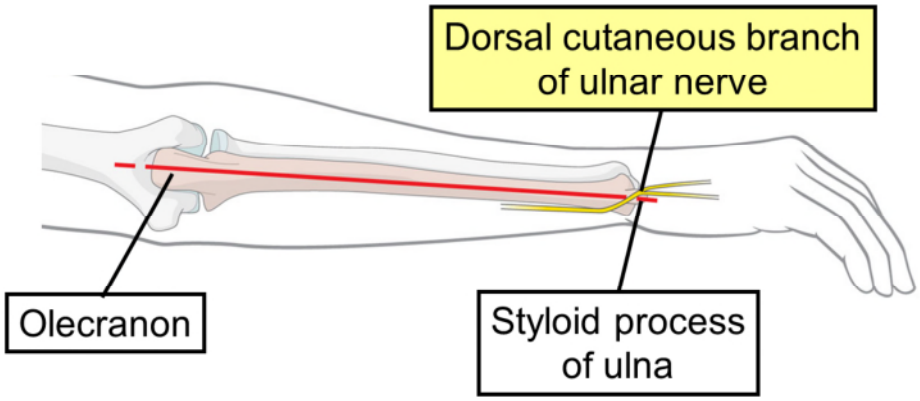
Order of fixation:

- Normally, the simpler of the two fractures will be approached first and preliminary fixation is undertaken.
- If both bones have similar fractures, then the ulna will normally be addressed first.

Strategy: approach—ulna

- Positioning of arm
  - In pronation

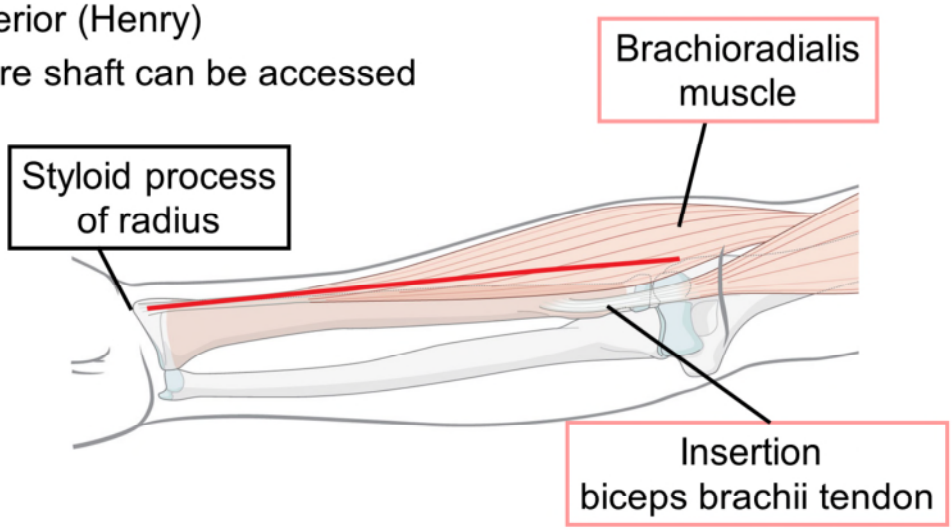


Skin incision:

- The standard ulnar approach offers good exposure along the whole ulnar shaft. The length of the incision depends on the exposure needed.
- The skin incision follows the subcutaneous border of the ulna, along a line drawn between the tip of the olecranon process and the ulnar styloid process.
- Pearl: If the forearm is markedly swollen, it may not be possible to close the skin of the ulnar approach. In these circumstances, it is better to plan the skin incision over the adjacent extensor muscle compartment, so an open incision will have a muscular bed rather than exposing the implant.

Strategy: approach—radius

- Positioning of arm in supination
  - Anterior (Henry)
  - Entire shaft can be accessed



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Introduction

- The anterior (Henry) approach offers good exposure of the whole length of the radius. The length of the incision depends on the extent of exposure needed. The Henry approach in the proximal forearm might result in a more obvious scar.

The landmarks for the skin incision are:

1. Styloid process of the radius
2. Groove between the brachioradialis muscle and the insertion of the biceps brachii tendon

Postoperative treatment

Temporary splintage 10–14 days

- Longer for unreliable patients
- Start functional treatment as soon as possible
- Weight bearing, 6–8 weeks postoperatively
- High risk of stiffness if delayed

X-ray control

- 1, 6, and 12 weeks postoperatively

Removal of implants is rarely indicated

- High risk of neurovascular injury and refracture

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Temporary immobilization with a well-padded, bulky splint for 10–14 days is advised to allow adequate soft-tissue healing. During this period, elevation, gentle finger motion, active and passive, together with elbow flexion/extension and shoulder motion, can be started. The splint is then removed and active assisted range of motion exercises, including gentle forearm rotation, begin.

Results and complications

- Excellent to satisfactory 80% to 92%
- Synostosis 2.6% to 6.6%
  - Posttraumatic radioulnar cross union
- Nonunion 3.7% to 10.3%
  - Anatomical reduction and absolute stability crucial
- Refracture after implant removal up to 25%
  - Implant removal is not generally recommended

Questions

Classify this forearm fracture.

1. Type A fracture (simple)
2. Type B fracture (wedge)
3. Type C fracture (complex)

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Optional
Insert questions to check learning.

Classify this forearm fracture

1. Type A fracture (simple) ✓

2. Type B fracture (wedge)

3. Type C fracture (complex)

Optional
Insert questions to check learning.

Which technique should be applied?

1. Relative stability
2. Absolute stability
3. Adequate stability

Optional
Insert questions to check learning.

Which technique should be applied?

1. Relative stability

2. Absolute stability ✓

3. Adequate stability

Optional
Insert questions to check learning.

What is the choice of implant?

1. ESIN (Elastic intramedullary nail)

2. Two lag screws

3. Lag screw and protection plate

Optional
Insert questions to check learning.

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Optional
Insert questions to check learning.

Conclusion

You should now be able to:

- Outline the anatomy and physiology of the forearm
- Outline indications for nonoperative and operative treatment
- Discuss principles of surgical treatment