Fractures in Shaft and Distal End of the Humerus

계명의대 정형외과학교실

조 철 현

Humerus shaft fracture

- 5% of all fractures
- bimodal distribution

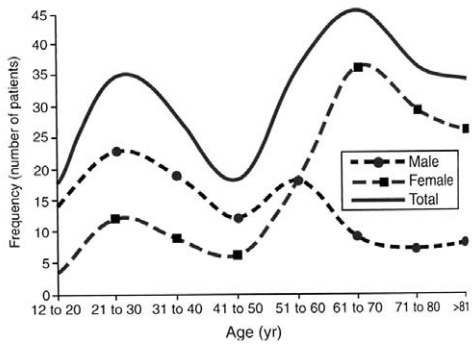

Fig. 1.

Mechanism

: bending force produces transverse fracture of the shaft
: torsion force will result in a spiral fracture
: combination of bending and torsion produce oblique fracture with or without a butterfly fragment
: compression forces will result in fracture either proximal or distal ends of humerus

Classification

: AO/ASIF and OTA classification

Surgical approach

Anterior approach
Anterolateral approach - middle or proximal third

Anteromedial approach
Lateral approach
Posterior approach - distal third

Conservative treatment

: well enveloped in muscle
: has a robust blood supply
: does not bear weight
: easy splinted
→ easiest of the major long bones to treat by conservative treatement

* Acceptable Reduction
Axial malalignment
: will accommodate 10~20 degree of anterior angulation & 10-30 degree of varus
: this amount of angulation would be considered acceptable for patients with low to moderate functional demands
Overriding fracture
: bayonet position with upto 1 inch of shortening is acceptable

1. Hanging arm casts
: may produce fracture distraction & may increase risk of nonunion
2. Sugar tong or coaptation splint
3. Skeletal traction
4. Functional brace

- Although rate of union is generally high with non operative treatment, incidence of mild malunion is high
- In the study by A. Sarmiento MD et al (JBJS, 2000)
: 620 patients with humeral shaft fractures that were treated with cast bracing
: 465 (75 %) of the fractures were closed, and 155 (25 percent) were open
: 9 patients (6 %) who had an open fracture and 7 patients (less than 2 %) who had a closed fracture had a nonunion after bracing
: In 87 % of the 565 patients, the fracture healed in less than 16 deg of varus angulation and in 81 % of the 546 patients, it healed in less than 16 deg of anterior angulation
: At the time of brace removal, 98 % of the patients had limitation of shoulder motion of 25 degrees or less
: functional bracing is associated with a high union rate, particularly when used for closed fractures

Operative treatment

Box 54-1 • Indications for Primary Operative Treatment of Humeral Shaft Fractures

Fracture Indications
Failure to obtain and maintain adequate closed reduction
  Shortening >3 cm
  Rotation >30 degrees
  Angulation >20 degrees
Segmental fracture
Pathological fracture
Intraarticular extension
  Shoulder joint
  Elbow joint

Associated Injuries
Open wound
Vascular injury
Brachial plexus injury
Ipsilateral forearm fracture
Ipsilateral shoulder or elbow fracture
Bilateral humeral fractures
Lower extremity fracture requiring upper extremity weight bearing
Burns
High-velocity gunshot injury
Chronic associated joint stiffness of elbow or shoulder

Patient Indications
Multiple injuries, polytrauma
Head injury (Glasgow Coma Scale score = 8)
Chest trauma
Poor patient tolerance, compliance
Unfavorable body habitus
  Morbid obesity
  Large breasts

1) Plate osteosynthesis
- Use an anterolateral approach for midshaft or proximal fractures, and a posterior approach for distal fractures
- Use a broad 4.5 mm compression plate in most patients, with a minimum of three (and preferably four) screws proximal and distal
- A 4.5 mm narrow plate is acceptable for small individuals
- Insert a lag screw between major fracture fragment, if possible
- Check the distal corner of the plate for radial nerve entrapment prior to closure following the anterolateral approach
- The intraoperative goal is to obtain sufficient stability to allow immediate postoperative shoulder and elbow motion

2) Intramedullary nailing

* Indications
  - segmental fractures
  - pathologic fractures
  - fracture in patients with morbid obesity
  - fractures with poor soft tissue over the fracture

* Avoid IM nailing
  - preexisting shoulder pathology
  - narrow humeral canal(<9mm)
  - permanent upper extremity weight-bearers
  - recognized radial nerve palsies

3) External fixator

: External fixation of the humerus is a suboptimal form of fixation with a significant complication rate and has traditionally been used as a temporizing method for fractures with contraindications to plate or nail fixation
- extensively contaminated
- frankly infected fractures
- fractures with poor soft tissues
- rapid stabilization with minimal physiologic perturbation

Radial Nerve Palsy with humerus shaft fracture

- 1.8~18% of humeral shaft fractures
- more common in middle and distal third fracture & transverse or spinal pattern than oblique or comminuted type
- Usually the radial nerve injury is a neurapraxia
- Recovery rates of about 100% in low-energy injuries and 33% in high-energy injuries
- Usual nonoperative manner, support the wrist and fingers with dynamic splint
  : consider nerve exploration, when function has not returned in 3 to 4 months
- Early exploration and repair of a severed nerve have not been proved to produce any better results than repair at a later date
- Early radial nerve exploration
  : open fracture
  : associated ipsilateral injury (floating elbow)
  : Holstein-Lewis syndrome

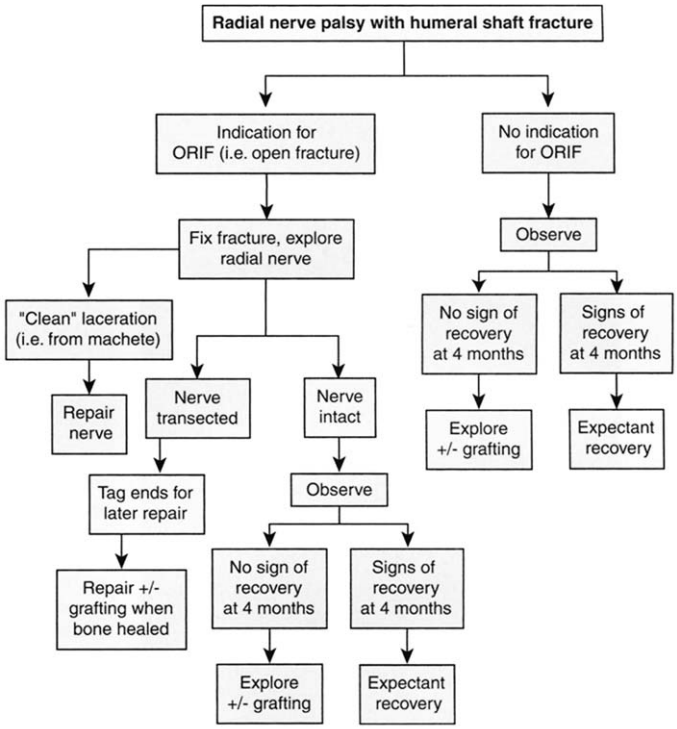

Fig. 2.

Complication

Complication after intramedullary nailing

: insertion site morbidity

: distraction

: fractures at the end of the nail

Nonunion

Risk factor

- open fracture
- segmental, transverse, or highly comminuted fracture
- bone loss
- wide displacement of the fracture fragments(〉100% of the shaft diameter)
- preexisting shoulder or elbow stiffness
- intervening local infection

: inadequate plate size

: fracture site distraction

: inadequate screw purchase

: mechanical failure from osteopenic bone

Infection

Distal humerus fracture

- remain a challenging problem despite advances in technique and implants
- often involve articular comminution, and many occur in older patient with osteoporosis

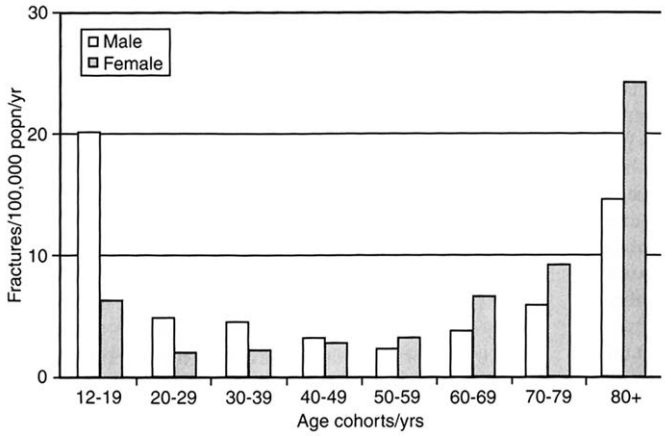

Fig. 3.

Funtional anatomy

: restitution of the mechanical stability of the fractured distal humerus is dependent upon re-creating this triangle of stability

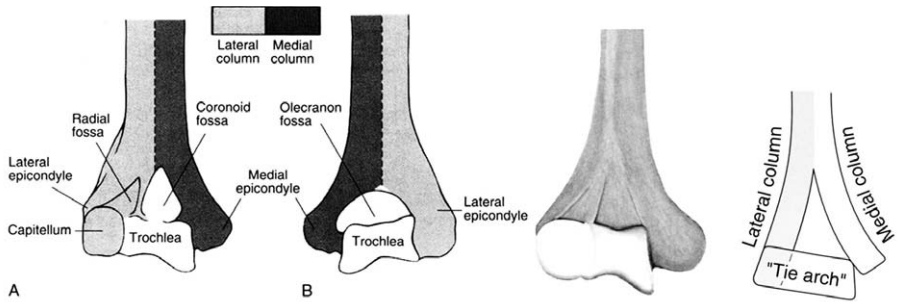

Fig. 4.

Surgical anatomy & approaches

Table 54-1 • Surgical Approaches Used for Treatment of Fractures of the Distal Humerus

	Surgical Approach	Indications	Contraindications	Advantages	Disadvantages
Posterior	Olecranon osteotomy	ORIF for fractures involving columns and articular surface	TER	Good access to posterior articular surfaces for reconstruction	Nonunion and failure of fixation of osteotomy Poor anterior access to capitellum
	Triceps-splitting	ORIF/TER for fractures involving columns and articular surface	Previous olecranon osteotomy approach Patients at increased risk for healing problems	Avoids complications associated with olecranon osteotomy	Poor access to articular surface for internal fixation Risk of triceps detachment
	Triceps-reflecting	Fractures requiring TER	ORIF Previous olecranon osteotomy approach Patients at risk for healing problems	Avoids complications associated with olecranon osteotomy	Risk of triceps detachment
	Triceps-detaching	ORIF/TER for fractures involving columns and articular surface	Previous olecranon osteotomy approach Patients at risk for healing problems	Avoids complications associated with olecranon osteotomy	Poor access to articular surfaces for internal fixation Risk of triceps detachment
Medial		Medial epicondylar fractures Medial column fractures			Lateral column inaccessible
	Kocher	Lateral column fractures Lateral epicondylar fractures Capitellar fractures	Suspected more complex articular surface fracture	Radial nerve protected	Medial column inaccessible
Lateral	Koeber				Risk of injury to radial nerve Medial column inaccessible
	Jupiter	Complex articular surface fractures	Significant involvement of the columns		Medial column inaccessible
Anterior	Henry	Vascular injury	Requirement for plate fixation of columns or articular surface reconstruction	Good access to brachial artery	Limited access to columns

Classification

* AO classification (27 main fracture types)
  Type A: extra-articular
  Type B: partially articular
  Type C: completely articular

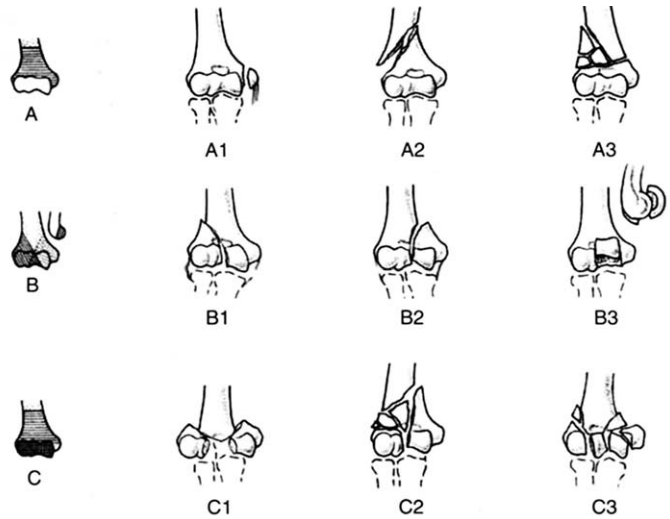

Fig. 5.

* Jupiter classification (25 type)
  : is based on the 'two-column' and "tie-arch" concepts of elbow stability

Treatment

General consideration

Patient characteristics

: diabetes mellitus, dementia, Parkinson' s disease, alcohol abuse, smoking, Fracture type

Surgical expertise

Plating technique

90-90° plating

: standard plating technique

Medial-lateral parallel plating

: lock the two columns of the distal humerus together and provide the feature and stability of an arch

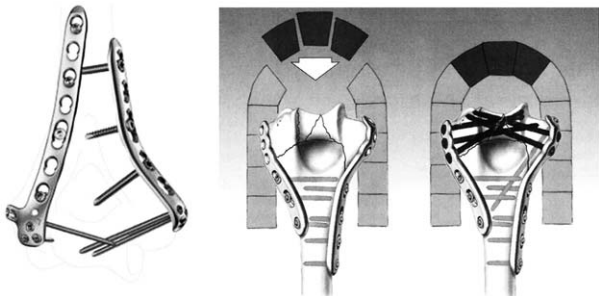

Fig. 6.

Box 54-2 • Technical Objectives for Fixation of Distal Humeral Fractures

Every screw should pass through a plate.
Each screw should engage a fragment on the opposite side that is also fixed to a plate.
As many screws as possible should be placed in the distal fragments.
Each screw should be as long as possible.
Each screw should engage as many articular fragments as possible.
Plates should be applied such that compression is achieved at the supracondylar level for both columns.
Plates used must be strong enough and stiff enough to resist breaking or bending before union occurs at the supracondylar level.

■ Treatment of bicolumn fractures (AO/OTA type C fractures)
- Fractures occur in the middle-aged and elderly females during simple falls and in younger individuals during high-energy sports injuries or road traffic accidents.
- The usual protocol is to reconstruct the articular surface tie-arch first, and then reconstruct the two columns.
- Three key concepts for successful internal fixation
  : anatomic and stable reconstruction of artucular surface
  : stable reconstruction of both columns two orthogonal plate
  : early postoperative motion to reduce elbow stiffness
- Reconstruction of the articular surface
  : If there is significant articular communition, it is preferable to use a fully threaded screw, rather than a partially threaded lag screw, to avoid compressing the joint surface in the area of comminution.
  : ulnar nerve identify
- Reconstruction of the columns
  : The use of two orthogonal plates is the most stable method of treating these fractures

Complications

1) Nonunion/fixation failure
   - Risk factors
     : "Low" fracture configurations, particularly associated with extreme porosity
     : inadequate internal fixation, using K-wires or screws to fix the columns
2) Malunion
3) Wound complication and infection
4) Nerve injury
5) Elbow stiffness and heterotrophic ossification

6) Osteoarthritis
7) Instability
8) Olecranon osteotomy complication

REFERENCES

1. Anglen JO, Archdeacon MT, Canada LK, et al: Avoiding complications in the treatment of humerus fractures. Instr Course Lect 2009;58:3-12.
2. Crenshaw AH, Perez EA: Fractures of the shoulder, arm, and forearm. Cambell's operative orthopedics. 11th ed. 2008;3:3371-3460
3. Green A: Open reduction and internal fixation with 90-90 plating of bicolumn distal humerus fractures. Instr Course Lect 2009;58:515-520.
4. Green A: Surgical treatment of bicolumn distal humerus fractures: relevant anatomy amd classification. Instr Course Lect 2009;58:505-508.
5. Green A: Postoperative management after open reduction and internal fixation of distal humerus fractures. Instr Course Lect 2009;58:535-540.
6. Jupiter JB: Complex fractures of the distal part of the humerus and associated complications. Instr Course Lect 1995;44:187-198.
7. McKee MD: Fractures of the shaft of the humerus. Rockwood and Green's fractures in adults. 6th ed. 2006;1:1117-1159.
8. O' Driscoll SW: Parallel plating fixation of Bicolumn distal humerus fractures. Instr Course Lect 2009;58:521-528.
9. Ramsey ML: Surgical exposures for bicolumn distal humerus fractures. Instr Course Lect 2009;58:509-514.
10. Robinson CM: Fractures of the distal humerus. Rockwood and Green's fractures in adults. 6th ed. 2006;1:1051-1116.
11. Sanchez-Soleto J: Distal humerus nonunion. Instr Course Lect 2009;58:541-550.
12. Sarmiento A, Zagorski JB, Zych GA, et al: Fuctional bracing for the treatment of fractures of the humeral diaphysis. J Bone Joint Surg 2000;82:478-486.
13. Yamaguchi K, Stein JA: Elbow arthroplasty for the treatment of bicolumn distal humerus fractures. Instr Course Lect 2009;58:529-534.