Fractures of the Distal Humerus
Functional Anatomy

- Hinged joint with single axis of rotation (trochlear axis)
- Trochlea is center point with a lateral and medial column
Functional Anatomy

- The distal humerus angles forward
- Lateral positioning during ORIF facilitates reconstruction of this angle
Surgical Anatomy

• The trochlear axis compared to longitudinal axis is 94-98 degrees in valgus
• The trochlear axis is 3-8 degrees externally rotated
• The intramedullary canal ends 2-3 cm above the olecranon fossa
Surgical Anatomy

- Medial and lateral columns diverge from humeral shaft at 45 degree angle
- The columns are the important structures for support of the “distal humeral triangle”
Mechanism of Injury

• The fracture is related to the position of elbow flexion when the load is applied
Evaluation

• Physical exam
  – Soft tissue envelope
  – Vascular status
    • Radial and ulnar pulses
  – Neurologic status
    • Radial nerve - most commonly injured
      – 14 cm proximal to the lateral epicondyle
      – 20 cm proximal to the medial epicondyle
    • Median nerve - rarely injured
    • Ulnar nerve
Evaluation

• Radiographic exam
  – Anterior-posterior and lateral radiographs
  – Traction views are necessary to evaluate intra-articular extension and for pre-operative planning (“ligamentotaxis”)
    – Traction removes overlap
  – CT scan helpful in selected cases
    • Comminuted capitellum or trochlea
OTA Classification

• Follows AO Long Bone System
• Humerus, distal segment given # 13
• 3 Main Types
  • Extra-articular fracture (13-A)
  • Partial articular fracture (13-B)
  • Complete articular fracture (13-C)
• Each broad category further subdivided into 9 specific fracture types
OTA Classification

• Humerus, distal segment (13)
  – Types
    • Extra-articular fracture (13-A)
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Summary - Classifications

• Classifications are useful for research!
• Classification data may not be reproducible between different surgeons!
• Classification data may not be reproduced by the same surgeon at different times!
Summary - Classifications

• Meaningful patterns
  – Extra-articular distal humerus
    • Medial epicondyle
    • Lateral epicondyle
    • Distal metaphyseal humerus
  – Partial articular distal humerus
    • Capitellum
    • Trochlea
  – Complete articular distal humerus
Simplicity

• Group 1
  – Lateral epicondyle
  – Medial epicondyle
  – Capitellum
  – Trochlea

• Group 2
  – Distal humerus
    • Extra-articular
    • Intra-articular

Note: Fixation tactics & implants are based on groups
Treatment Principles

1. Anatomic articular reduction
2. Stable internal fixation of the articular surface
3. Restoration of articular axial alignment
4. Stable internal fixation of the articular segment to the metaphysis and diaphysis
5. Early range of motion of the elbow
Treatment: Open Fracture

- Emergent I&D
- Definitive reduction and internal fixation
- Temporary external fixation across elbow if definitive fixation not possible
  - Definitive fixation at repeat evaluation
- Empiric antibiotic therapy
- Repeat evaluation in OR until soft tissue closure (2-5 days)
Treatment: Closed Fracture

• Definitive reduction and internal fixation
  – Timing
    • Within 24 hours or at 5-7 days
      – The inflammatory response peaks at 3 days post injury. ORIF during that peak may lead to excessive heterotopic ossification

• Empiric antibiotic therapy
Fixation Methods: Group 1

- Lag screw fixation
- Comminution is supported by small or mini-fragment buttress plate
- Bone graft is considered for comminution and required for bone loss
Fixation Methods: Group 2

- Lag screw fixation if possible
- Two column plate fixation
  - Not necessarily at 90 degrees to each other
- Bone graft is considered for comminution and required for bone loss
- Role of locked plating?
Literature: Schemitsch, et al, 1994

- Tested 2 different plate designs in 5 different configurations
- Distal humeral osteotomy with and without bone contact
- Conclusions:
  - For stable fixation the plates should be placed on the separate columns but not necessary 90 degrees to each other

- Tested five constructs
- All were stiffer in the coronal plane than compared to the sagittal plane
- Strongest construct
  - medial reconstruction plate with posterolateral dynamic compression plate
Literature: Korner, et al, 2004

• Biomechanically compared double-plate osteosynthesis using conventional reconstruction plates and locking compression plates

• Conclusions
  – Biomechanical behavior depends more on plate configuration than plate type. Advantages of locking plates were only significant if compared with dorsal plate application techniques (not 90/90)
Other Potential Surgical Options

• Total elbow arthroplasty
  – Comminuted intra-articular fracture in the elderly
  – Promotes immediate ROM
  – Usually limited by poor remaining bone stock

• “Bag of bones” technique
  – Rarely indicated if at all

• Cast or cast / brace
  – Indicated for completely non-displaced, stable fractures
Literature: John, et al, 1994

- 49 patients (75-90 yrs)
- 41/49 Type C
- Conclusions
  - No increase in failure of fixation, nonunion, nor ulnar nerve palsy
  - Age not a contraindication for ORIF

Result

very good  good  fair/poor
Literature: Cobb & Morrey, 1997

- 20 patients
  - (avg age 72 yrs)
- TEA for distal humeral fracture
- Conclusion
  - TEA is viable treatment option in elderly patient with distal humeral Fracture

![Bar chart showing results](chart.png)
Literature: Frankle et al, 2003

- Comparision of ORIF vs. TEA for intra-articular distal humerus fxs (type C2 or C3) in women >65yo
- Retrospective review of 24 patients
- Outcomes
  - ORIF: 4 excellent, 4 good, 1 fair, 3 poor
  - TEA: 11 excellent, 1 good
- Conclusions: TEA is a viable treatment option for distal intra-articular humerus fxs in women >65yo, particularly true for women with assoc comorbidities such as osteoporosis, RA, and conditions requiring the use of systemic steriods
Surgical Treatment: Group I

- Supine with arm on arm board
- Sterile tourniquet if possible
- Medial or lateral incision
- Ulnar nerve transposition considered only if required implants in groove (medial fractures)
- As complexity of fracture pattern increases a more extensile exposure should be considered (see Exposures: Group II)
Surgical Treatment: Group I

- Fragments are reduced and held with K-wires
- Lag screws replace K-wires
- Intra-articular screws can be buried in cartilage
- Back to front screw direction possible with larger capitellar or trochlear fragments
- Small fragment or modular hand plates used to buttress when fracture is comminuted
Surgical Treatment: Group II

- Lateral decubitus position
- Arm hanging over a post
- Sterile tourniquet if possible
- Midline posterior incision
- Exposure?
Exposures

- Reduction influences outcome in articular fractures
- Exposure affects ability to achieve reduction
- Exposure influences outcome!
- Choose the exposure that fits the fracture pattern
Exposures: Group II

• Triceps splitting
  – Allows exposure of shaft to olecranon fossa
  – Only indicated for high extra-articular Group II fractures

• Extra-articular olecranon osteotomy
  – Allows adequate exposure of the distal humerus but inadequate exposure of the articular surface
  – Indicated for extra-articular Group II fractures
Literature: Voor, et al, 1995

- Recommend extra-articular osteotomy over intra-articular osteotomy in all cases
- Interesting biomechanical study
- Clinical study indicated to justify
Exposures: Group II

• Intra-articular olecranon osteotomy
  – Types
    • Transverse
      – Indicated for intra-articular Group II fractures
      – Technically easier to do
      – Higher incidence of nonunion (Gainor, et al, 1995)
    – Olecranon hardware removal in 80% of cases
Exposures: Group II

- Intra-articular olecranon osteotomy
  - Types
    - Chevron
      - Indicated for intra-articular Group II fractures
      - Technically more difficult
      - More stable
      - Olecranon hardware removal in 80% of cases
Osteotomy Fixation Options

- Tension band technique
- Dorsal plating
Osteotomy Fixation

• Tension band technique
  – Anti-shear component
• K-wires
  – Easier to place
  – Less stable than screw
Osteotomy Fixation

- Tension band technique
  - Anti-shear component
    - 6.5 mm screw plus washer
    - Beware of the bow of the proximal ulna, which may cause a medial shift of the tip of the olecranon if a long screw is used.
      - More stable

From Hak and Golladay, JAAOS, 8:266-75, 2000
Osteotomy Fixation

• Tension band technique
  – Tension band
  • Wire
    – Dual twist technique
    – Often palpable necessitating removal
  • Braided cable
    – Small crimp less palpable but still can be prominent
Tension band screw

Tension band Wire
Osteotomy Fixation

• Dorsal plating
  – Low profile periarticular implants now available allowing antishear screw placement through the plate
  – No clinical or biomechanical studies yet published using these plates
Chevron Osteotomy

- Expose olecranon and mobilize ulnar nerve
- If using screw/TBW fixation, pre-drill and tap for 6.5mm screw placement down the ulna canal
- Small, thin oscillating saw used to cut 95% of the osteotomy
- Osteotome used to crack and complete it
Exposures: Group II

- Triceps-sparing postero-medial approach (Byran-Morrey Approach)
  - Midline incision
  - Ulnar nerve identified and mobilized
  - Medial edge of triceps and distal forearm fascia elevated as single unit off olecranon and reflected laterally
  - Resection of extra-articular tip of olecranon
Bryan-Morrey Approach
Exposures: Group II

- Triceps-sparing postero-medial approach
  - An alternative to mobilizing the insertion of the triceps off the olecranon in continuity with the forearm fascia is an extra-articular osteotomy of the olecranon (osteoanconeus flap)
  - Anterior transposition of ulnar nerve
  - Triceps re-attached with suture through bone
Surgical Treatment: Group II

- Lateral decubitus position
- Arm hanging over a post
- Sterile tourniquet if possible
- Midline posterior incision
- Exposure
- Reduction and K-wire fixation
- Lag screws inserted and K-wires removed
- Bi-column plating
- Reconstruction of triceps insertion per exposure chosen
To transpose or not to transpose?

- Identification and mobilization of the ulnar nerve is required for Group II and medial Group I fractures.
- Ulnar nerve palsy may be related to injury, surgical exposure and mobilization, compression by implant, or scar formation.
To transpose or not to transpose?

- Wang, et al, in a consecutive series of distal humeral fractures treated with ORIF and anterior ulnar nerve transposition had no post-operative ulnar nerve compression syndrome. Overall results: E/G 75%, F 10%, and P 15%. They conclude that routine anterior transposition indicated.
To transpose or not to transpose?

- Transposition required if fixation requires implant placement in the ulnar groove
- Consider transposition of the ulnar nerve if extensive dissection in the ulnar groove required to achieve reduction
To transpose or not to transpose?

• My preferred method
  – Anterior sub-cutaneous technique
  – Fascial sling (off flexor mass) attached to skin to prevent reduction of transposition
Post-operative care

- Bulky splint applied intra-op
- Elbow position
  - 90 degrees of flexion or extension?
  - Authors support either and proponents strongly argue that their position is the best
    - Extension is harder to recover than flexion
    - Final arc of motion recovered is more functional if centered on 90 degrees of flexion
    - Use what works in your hands and rehab protocol
Post-operative care

- Range-of-motion begun 2-3 days
  - Tailored to the fixation and soft tissue envelope
- AROM / AAROM
- PROM rarely used and may promote heterotopic ossification
- Anti-inflammatory for 6 weeks if at high risk for heterotopic ossification
Outcomes

• Most daily activities can be accomplished:
  – 30 – 130 degrees extension-flexion
  – 50 – 50 degrees pronation-supination

• Outcomes based on pain and function

• Good functional outcome
  – 15-140 degrees of motion
Outcomes

• Flexion is the first to return usually
  – Within the first two months
• Extension comes more slowly
  – Usually returns 4-6 months
• Supination/pronation usually unaffected
• Pain- 25 % of patients describe exertional pain
Outcomes

• What I tell patients to expect:
  – Loose 10-25 degs of flexion and extension
  – Maintain full supination and pronation
  – Decrease in muscle strength
  – Overall:
    • Good/excellent 75%
  – Factors most likely to affect outcome
    • Severity of injury
    • Occurrence of a complication
Complications

• Failure of fixation
  – Associated with stability of operative fixation
  – K-wires fixation alone is inadequate
  – If diagnosed early, revision fixation indicated
  – Late fixation failure must be tailored to radiographic healing and patient symptoms
Complications

• Nonunion of distal humerus
  – Uncommon
  – Usually a failure of fixation
  – Symptomatic treatment
  – Bone graft with revision plating
Complications

• Non-union of olecranon osteotomy
  – Rates as high as 5% or more
  – Chevron osteotomy has a lower rate
  – Treated with bone graft and revision tension band technique
  – Excision of proximal fragment is salvage
    • 50% of olecranon must remain for joint stability
Complications

• Infection
  – Range 0-6%
  – Highest for open fractures
  – No style of fixation has a higher rate than any other
Complications

• Ulnar nerve palsy
  – 8-20% incidence
  – Reasons: operative manipulation, hardware prominence, inadequate release
  – Results of neurolysis (McKee, et al)
    • 1 excellent result
    • 17 good results
    • 2 poor results (secondary to failure of reconstruction)
  – Prevention best treatment
Complications

• Painful retained hardware
  – The most common complaint
  – Common location
    • Olecranon
    • Medial hardware
  – Hardware removal
    • After fracture union
    • One plate at a time in bicolumn fractures
      – Removal of both plates with a single surgery is a fracture risk
Summary

- ORIF indicated for most displaced patterns
- Total elbow arthroplasty excellent alternative in patient with osteopenia
- Preferred intra-articular osteotomy: Chevron
- Search a long time for a reason to NOT transpose ulnar nerve
Case Examples

• Lateral column fracture
• Medial column fracture
• Intra-articular distal humeral fracture
• Extra-articular distal humeral fracture
• Fixation failure olecranon osteotomy
• Fixation failure distal humeral fracture
Case 1: 18 y/o s/p fall
Lateral epicondyle and capitellum Fx’s
Lateral approach
Capitellum: Post to Ant lag screws
Epicondyle: Screw + buttress plate
Healed
Loss of 20 degs ext
Case 2:
43 y/o female fell from horse
• Chevron intra-articular approach
• Tension band screw
• ORIF medial column Fx
• Extensile exposure required intra-op
Antegrade IM nail for humeral Fx

Healed
Lacks 10 degs elbow extension
Full shoulder motion
Olecranon hardware tender
Case 3: 20 y/o male MCA
Distal, two column Fx
NV intact
Transverse intra-articular approach
Lag screw and bi-column plating
Tension band wire with cable
Healed
Lacks 20 degs flex & ext.
Osteotomy healed without complications
References


References

• Cobb TK, Morrey BF: Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients. JBJS 79A: 826-832, 1997

References


References


References
