Supracondylar Humerus

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STUPIDITY

Quitters Never Win, Winners Never Quit,
But Those Who Never Win AND Never Quit Are Idiots.
Functional Anatomy

hinged joint with single axis of rotation (trochlear axis)
trochlea in center with lateral and medial columns
Functional Anatomy

distal humerus angles forward
lateral decubitus during ORIF facilitates reconstruction of this angle
Surgical Anatomy

trochlear axis compared to longitudinal axis = 95 ° in valgus
trochlear axis is 5 ° ER
intramedullary canal ends 2 cm above olecranon fossa
Surgical Anatomy

medial and lateral columns diverge from humeral shaft at 45 ° angle
columns important for support of “distal humeral triangle”
Mechanism of Injury

related to position of elbow flexion when load applied
Evaluation

Physical exam

Soft tissue envelope

Vascular status

Radial and ulnar pulses

Neurologic status

Radial nerve - most commonly injured
14 cm proximal to lateral epicondyle
20 cm proximal to medial epicondyle

Median nerve - rarely injured

Ulnar nerve
Evaluation

XR

AP, lateral 2 obliques
Traction views
  (intra-articular extension and pre-op planning)

CT scan in selected cases
  Comminuted capitellum or trochlea
CT
OTA Classification

AO Long Bone System
Humerus, distal segment given # 13

3 Main Types
A Extra-articular (13-A)
B Partial articular (13-B)
C Complete articular (13-C)

Each broad category further subdivided into 9 specific types
OTA Classification

Humerus, distal segment (13)
Types
Extra-articular (13-A)
Partial articular (13-B)
Complete articular (13-C)
OTA Classification

Humerus, distal segment (13)

Types
- Extra-articular (13-A)
- Partial articular (13-B)
- Complete articular (13-C)
OTA Classification

Humerus, distal segment (13)
Types
  Extra-articular (13-A)
  Partial articular (13-B)
  Complete articular (13-C)
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
SACRIFICE

Your role may be thankless, but if you're willing to give it your all, you just might bring success to those who outlast you.
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

Anatomic *articular* reduction and stable fixation

Restoration of articular axial alignment

Stable internal fixation of articular segment to metaphysis and diaphysis

Early ROM of elbow
Fixation Methods: Group 1

Lag screw fixation

Comminution is supported by small or mini-fragment buttress plate

Bone graft 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 ° to each other
BG considered for comminution and required for bone loss
Treatment: Open Fracture

Tetanus, IV ABx
Emergent I&D
Definitive ORIF
Temporary EF across elbow if definitive ORIF 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 ORIF

Timing

Within 24 hours or at 5-7 days

inflammatory response peaks at 3 days post injury. ORIF during that peak may lead to excessive heterotopic ossification

Empiric antibiotic therapy

? Need for HO prophylaxis
To evaluate the effect of surgical timing on the formation of heterotopic ossification about the elbow, 71 consecutive patients with elbow trauma requiring operative management were evaluated. Fourteen patients were excluded because they suffered from head injury, burns, or severe open injuries requiring surgery on two or more occasions. Sixteen patients were lost to follow-up, leaving a group of 41 patients. The average age of patients was 35 years. The fractures involved the olecranon in 19, distal humerus in 12, and radial head/neck in 10 patients. Six of these fractures were accompanied by a dislocation. Eleven were open injuries; the remaining 30 were closed. Bone grafting was performed in nine patients. The interval between injury and surgical intervention averaged 57 hours. None (0%) of 17 patients treated within 48 hours developed grade II, III, or IV heterotopic ossification, whereas 8 (33%) of 24 patients treated after 48 hours developed grade II, III, or IV heterotopic ossification. There were no significant differences in demographic or injury parameters between these two groups. These findings suggest that fixation of unstable elbow fractures within 48 hours of injury may reduce the formation of ectopic bone.

Prevention of heterotopic ossification at the elbow following trauma using radiation therapy.

The objective of this study was to determine the efficacy of postoperative single dose radiation therapy of 700 centigray on fracture/dislocations of the elbow in the prevention of heterotopic ossification. Eleven patients were reviewed for this study. Each patient sustained high-energy trauma to the extremity causing a fracture/dislocation of the elbow. After open reduction and internal fixation, a postoperative single dose of 700-centigray radiation therapy was administered to the patients within 72 hours of surgery. Primary outcome measurements were clinical physical examination of range of motion and radiographic analysis of heterotopic bone formation at 12 months follow-up. Three of eleven patients (27%) had radiographic evidence of heterotopic ossification formation. Ten of eleven patients (91%) however, were without functional limitations. All fractures healed without complications. There were no complications from the radiation therapy. A single dose of 700-centigray radiation therapy postoperatively within 72 hours may lessen the functional loss from heterotopic ossification formation without effecting healing at the fracture site.

Other Options

Hemiarthroplasty (Sorbie prosthesis)

TEA

Comminuted intra-articular fracture in 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
The purpose of this study was to review the cases of patients with a distal humeral fracture that was treated with a noncustom total elbow arthroplasty. We hypothesized that, on the basis of the functional and clinical outcome, total elbow replacement is a reliable option for the treatment of elderly patients with a severe, comminuted fracture of the distal part of the humerus. METHODS: We retrospectively reviewed forty-nine acute distal humeral fractures in forty-eight patients who were treated with total elbow arthroplasty as the primary option. The average age of the patients was sixty-seven years. Forty-three fractures were followed for at least two years. According to the AO classification, five fractures were type A, five were type B, and thirty-three were type C. The average age of the forty-three patients was sixty-nine years and the average duration of follow-up was seven years. Fourteen patients died during the review period. Postoperative clinical function was assessed with use of the Mayo elbow performance score, and anteroposterior and lateral radiographs made at follow-up examinations were reviewed. RESULTS: At the latest follow-up examination, the average flexion arc was 24 degrees (range, 0 degrees to 75 degrees) to 131 degrees (range, 100 degrees to 150 degrees) and the Mayo elbow performance score averaged 93 of a possible 100 points. Heterotopic ossification was present to some extent in seven elbows, with radiographic abutment noted in two. Thirty-two (65%) of the forty-nine elbows had neither a complication nor any further surgery from the time of the index arthroplasty to the most recent follow-up evaluation. Fourteen elbows (29%) had a single complication, and most of them did not require further surgery. Ten additional procedures, including five revision arthroplasties, were required in nine elbows; five were related to soft tissue and five were related to the implant or bone. CONCLUSIONS: Complex distal humeral fractures should be assessed primarily for the reliability with which they can be reconstructed with osteosynthesis. When osteosynthesis is not considered to be feasible, especially in patients who are physiologically older and place lower demands on the joint, total elbow arthroplasty can be considered. This retrospective review supports a recommendation for total elbow arthroplasty for the treatment of an acute distal humeral fracture when strict inclusion criteria are observed.

Operative treatment of distal humeral fractures in the elderly

49 patients (75-90 yrs)
41/49 Type C

Conclusions
No increase in failure of fixation, nonunion, nor ulnar nerve palsy
Age not a contra-indication for ORIF

John, H, Rosso R, Neff U, Bodoky A, Regazzoni P, Harder F:.
Total elbow arthroplasty as primary treatment for distal humeral fractures in elderly patients.

20 patients (avg age 72 yrs)

TEA for distal humeral fracture

Conclusion

TEA is viable treatment option in elderly patient with distal humeral Fracture

Hemiarthroplasty

unsalvageable trochlea fractures
intact epicondyles (loosening)
transolecranon approach (preserves MCL/LCL)
prosthesis must be anatomical and reproduce humeral axis
consider NSAID cover
Mellon and Phalen 1947
Sorbie 1999
Hemiarthroplasty
Biomechanical evaluation of methods of internal fixation of the distal humerus.

2 different plate designs in 5 different configurations
Distal humeral osteotomy with and without bone contact
Conclusions:

stable fixation - plates placed on separate columns
but not necessary 90 ° to each other

J Orthop Trauma 8: 468-475, 1994 Schemitsch EH, Tencer AF, Henley MB:
Comparison of distal humerus fracture fixation: A biomechanical study

Tested five constructs
All stiffer in coronal than sagittal plane

Strongest construct
medial Recon with posterolateral DCP

Surgical Treatment: Group I

Supine with arm on arm board
Sterile tourniquet if possible
Midline incision - medial or lateral to olecranon tip
Ulnar nerve transposition if required or implants in groove (medial fractures)
As complexity of fracture increases more extensile exposure considered
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 or mini-fragment 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?
Surgical Exposures

Triceps splitting

- exposure of shaft to olecranon fossa
- indicated for high extra-articular Group II fractures

Triceps-sparing postero-medial approach (Byran-Morrey)

- 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
Surgical Exposures

Triceps Reflecting Anconeus Pedicle
alternative to mobilizing insertion of triceps off olecranon
anconeus and triceps in continuity with forearm fascia in an extra-articular osteotomy of olecranon elevated from lateral to medial (osteooanconeus flap)
anterior transposition of ulnar nerve
triceps re-attached with suture through bone

Orthop Clin North Am. 2000 Jan;31(1):91-101, O'Driscoll,
TRAP
Surgical Exposures

Intra-articular olecranon osteotomy

- Transverse
  - technically easier to do
  - higher incidence of nonunion
    - Gainor, et al, 1995
- Chevron
  - technically more challenging
  - more stable fixation

Olecranon hardware removal in 80% of cases

If I was a broken elbow, the last thing I would want to have is another broken bone - R.R. Richards
Osteotomy Fixation

TBW

K-wires
  easier to place, less stable than screw

6.5 mm screw plus washer
  difficult to place (must be down canal to avoid translation of fragment, more stable)

Plates and screws
  olecranon plates
    (Accumed, Zimmer periarticular)
  most stable
  lower incidence of h/w removal, non-union
Osteotomy Fixation

TB

Wire

dual twist technique
palpable necessitating removal

Braided cable

small crimp less palpable but still be prominent
UNDERACHIEVEMENT

The Tallest Blade of Grass
is the First to be Cut by the Lawnmower.
Olecranon osteotomy for exposure of fractures and nonunions of the distal humerus.

Although olecranon osteotomy provides excellent exposure of the distal humerus, enthusiasm for this approach has been limited by reports suggesting numerous complications. It has been suggested that specific techniques for creating and repairing an olecranon osteotomy may help limit complications. This paper describes a technique for olecranon osteotomy using an apex, distal, chevron-shaped osteotomy. Kirschner wires directed out the anterior ulnar cortex distal to the coronoid process and bent 180 degrees and impacted into the olecranon proximally, and two 22-gauge, figure-of-eight, stainless steel tension wires. A single surgeon used this technique for exposure of a fracture (16 patients) or nonunion (29 patients) of the distal humerus in 45 consecutive patients. One patient returned to activity too soon, had loosening of the wire fixation, and required a second operation for plate fixation of the ulna. The remaining 44 osteotomies (98%) healed with good alignment within 6 months. There were no broken or migrated wires prior to healing. Twelve patients (27%) had removal of the wires used to repair the olecranon: in 6 patients, this was for symptoms related to the wires (13%); 1 for septic olecranon bursitis, and 5 at the time of another procedure (elbow capsular release in 4 patients and submuscular ulnar nerve transposition in 1). Olecranon osteotomy can be used for exposure of the distal humerus with a low rate of complications when specific techniques are used.

Cyclic loading of olecranon fracture fixation constructs.

BACKGROUND: Despite the good results that are usually reported after fixation at the sites of olecranon fractures and osteotomies, problems such as loss of fixation, nonunion, and the need for revision surgery are still encountered. Various types of fixation have been recommended, but few have been evaluated with use of clinically relevant cyclic load testing at appropriate levels of stress. The purpose of the present study was to test multiple olecranon fixation techniques under physiologic cyclic loads.

METHODS: We studied ten cadaveric elbows with use of cyclic loading that simulated (1) active range of motion and (2) pushing up from a chair. Each specimen underwent fixation of a simulated 50% transverse olecranon fracture with use of intramedullary and cortically fixed tension band constructs (in randomized order) followed by fixture with a 7.3-mm-diameter cancellous screw with and without a tension band. Displacement transducers were placed posteriorly on the tension side and anteriorly near the articular surface.

RESULTS: Both configurations involving the 7.3-mm-diameter cancellous screw provided the most stable fixation—nearly five times better than that provided by the Kirschner-wire techniques. Use of the tension band in conjunction with the intramedullary screw improved the stability of fixation. In none of the constructs did the AO tension band result in compression across the osteotomy gap.

CONCLUSIONS AND CLINICAL RELEVANCE: The use of a 7.3-mm screw in conjunction with a tension band provided better fixation of simulated displaced transverse fractures than did the use of Kirschner wires in conjunction with a tension band or the use of a screw only. The AO principle of converting posterior tensile forces to articular compressive forces was not demonstrated in this study. We therefore question the validity of the tension band concept in olecranon fracture fixation and recommend passive rather than active range of motion in the immediate postoperative period to limit fracture distraction.

Posterior olecranon plating: biomechanical and clinical evaluation of a new operative technique.

The purpose of this investigation was to compare the biomechanical analysis of a new plating technique for olecranon fractures to tension band wiring, and review early clinical results. Six matched pairs of cadaveric ulnae were used for the biomechanical analysis. A transverse osteotomy of the mid part of the olecranon was made. One ulna of each pair was stabilized using a tension band and the other with a posterior hook plate. The ulnae were mounted and loaded, and displacement at the osteotomy site recorded. Twenty patients treated with this new technique (14 fractures and 6 osteotomies) were reviewed at one year (range: 8 to 18 months) for infection, union rate, hardware related complaints, and removal. Statistical analysis showed significantly less displacement occurred at the osteotomy site in the plating group. Clinically, all patients had fracture union, and there were no hardware related problems. Posterior plating with this technique achieves greater stability compared to tension band wiring. Early clinical results indicate a low level of hardware related complications.

Chevron Osteotomy

expose olecranon (watch crista laterally for LCL, and sublime medially for MCL)
mobilize ulnar nerve (N190)
pre-drill and tap for plate along ulna (split triceps proximally to tip of olecranon – repair at end)
Microsaggital oscillating saw (small thin blade) used to cut 95% of osteotomy
Hoke osteotome to crack and complete it (allows subsequent interdigitation)
Surgical Positioning

lateral decubitus position
forearm hanging over a post
sterile tourniquet
midline posterior incision
desired surgical exposure?
reduction and provisional K-wire fixation through plate
(Accumed Mayo Elbow plating system)
lag screws inserted through plate
bi-column plating
reconstruction of triceps insertion (via chosen method)
To Transpose or Not to Transpose?

Identification and mobilization of UN is required in supracondylar fractures.

UN palsy may be related to injury, surgical exposure and mobilization, compression by implant, or scar formation.
Intercondylar fractures of the distal humerus: routine anterior subcutaneous transposition of the ulnar nerve in a posterior operative approach.

Intercondylar fractures of the distal humerus in adults are rare and notoriously difficult to treat. The goals of open reduction are to preserve the articular surface and restore elbow function. We treated 20 patients by open reduction with dual-plate internal fixation and routine anterior subcutaneous transposition of the ulnar nerve. The follow-up period ranged from 15 to 35 months. The fractures were classified according to Muller's system. The results were evaluated using the Cassebaum rating system and subjective functional status. Excellent or good results were achieved in 15 elbows (75%), two had a fair result, and three, poor. A clearer understanding of fracture patterns, rigid dual-plate internal fixation, and early rehabilitation are needed to improve the results from this vexing injury. We recommended routine ulnar nerve anterior subcutaneous transposition using a posterior approach. Compared with published reports, our preliminary results demonstrated no postoperative ulnar nerve compression syndrome at follow-up. Routine anterior subcutaneous transposition of the ulnar nerve to avoid the postoperative ulnar nerve compression syndrome is required.

To Transpose or Not to Transpose?

Transposition required if fixation requires implant placement in ulnar groove
Consider transposition of UN if extensive dissection in ulnar groove required to achieve reduction
To Transpose or Not to Transpose?

preferred method (Terry Axelrod)

- 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 - controversial
  extension harder to recover than flexion
ROM on POD # 2
  tailored to fixation, soft tissue envelope and stability
AROM / AAROM
PROM rarely used and may promote heterotopic ossification
NSAID for 4/52 for heterotopic ossification prophylaxis
Outcomes

Most daily activities can be accomplished:

- 30 – 130 ° extension-flexion
- 50 – 50 ° pronation-supination

Outcomes based on pain and function

Good functional outcome

- 15-140 ° of motion
Outcomes

Flexion first to return
within 1 – 2 /12 post-op

Extension comes more slowly
within 4-6 /12

Supination/pronation usually unaffected

Pain - 25 % describe exertional pain
Patient Education

Expect:

to lose 10-25° of flexion and extension
maintain full supination and pronation
decreased 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 (< 3/52)
- 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 osteotomy

~ 5% or more
Chevron lower rate
Rx with BG and revision plating
excision of proximal fragment is salvage
50% of olecranon must remain for joint stability
Complications

Infection

0-6%

highest for open fractures

not related to fixation methods
Complications

UN palsy
8-20%
d/t 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
  most common complaint
  olecranon and medial hardware removal
    after fracture union (18/12)
    1 plate at a time in bicolumn fractures
  both plates with a single surgery - fracture risk
Summary

ORIF indicated for most displaced patterns
Chevron intra-articular osteotomy
UN transposition
TEA excellent alternative in patient with osteopenia
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 screw
Epicondyle: Screw + buttress plate
Healed
Loss of 20° ext
Case 2:  
43 y/o female fell from horse
Chevron intra-articular approach
TB screw
ORIF medial column
Extensile exposure required intra-op
Antegraded IM nail for humeral Fx

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

The Secret to Success is Knowing Who to Blame for Your Failures.