Proximal Humerus and Humeral Shaft Fractures: AKA Bad Actors...

James Ostrander MD
Catherine Fedorka MD
Proximal humerus fractures

- Third most common fracture only behind hip and distal radius
- Account for about 5% of all fractures

Court-Brown CM, Caesar B. Injury. 2006; 37(8): 691
Anatomy

• Humeral head neck shaft angle average 135°
• Head is retroverted average of about 20° (range - 6 to 45) from the shaft and center of rotation is posterior medial

Courtesy of www.thetraumapro.com

Blood Supply

- Major blood supply from posterior humeral circumflex artery (64% of the humeral head)
Neer Classification

I
Minimal displacement

II
Anatomic neck

III
Surgical neck

IV
Greater tuberosity

V
Lesser tuberosity

VI
Fracture-dislocation

Displaced Fractures

<table>
<thead>
<tr>
<th></th>
<th>2 Part</th>
<th>3 Part</th>
<th>4 Part</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Articular surface

JAAOS 2017 25:42-52
Metaphyseal extension and risk of AVN

- Hertel et al: Correlation of metaphyseal extension and risk of AVN
  - Risk for AVN
    - < 8 mm of calcar intact on head
    - Loss of medial hinge

Hertel et al. JSES 2004; 13(4): 427-433
Non Operative management

• The majority of proximal humerus fractures can be treated without surgery
  – Minimally displaced 2, 3 and 4 part fractures
  – < 5 mm displaced of the greater tuberosity
  – < 20 degrees of angulation of the head
  – Elderly low demand patients

• Goals: Immobilization followed by early rehab for STABLE fractures
• Longer immobilization with delayed rehab for unstable fractures
Surgical vs Nonsurgical Treatment of Adults With Displaced Fractures of the Proximal Humerus
The PROFHER Randomized Clinical Trial

Amar Rangan, FRCS(T&O); Helen Handoll, DPhil; Stephen Brealey, PhD; Laura Jefferson, PhD; Ada Keding, MSc; Belen Corbacho Martin, MSc; Lorna Goodchild, MSc; Ling-Hsiang Chuang, PhD; Catherine Hewitt, PhD; David Torgerson, PhD, for the PROFHER Trial Collaborators

**PROFHER TRIAL**
Prospective Randomized trial from the UK.

250 patients with displaced proximal humerus fractures randomized to OP or non-OP
Followed for 2 years

**NO DIFFERENCE IN OUTCOMES OR COMPLICATIONS**

SO why do we OPERATE?
Meta-analysis of RCTS

9 articles
513 patients

"Operative treatment did NOT significantly improve functional outcome of Health related quality of life. Instead, operative treatment for PHFs led to higher incidence of postoperative complications"
Surgery

• When to operate
  – Displaced 2 part fracture (especially young active person)
  – Displaced 3 and 4 part fractures
  – Varus angulation > 20 degrees
  – Fracture dislocation
  – Polytrauma patient
Options

- Closed reduction and percutaneous pinning
  - Right patient with correct fracture pattern
  - Patient needs to be compliant
  - Must use threaded Steinman pins
  - Avoid nerves!

- Locking proximal humeral nail
  - Concern for shoulder pain and RTC violation
  - Studies show no higher rate of complications though compared to ORIF

- Open Reduction Internal Fixation (Our preference)
Locking intramedullary nails compared with locking plates for two- and three-part proximal humeral surgical neck fractures: a randomized controlled trial

Mauro E.C. Gracitelli, PhD*, Eduardo A. Malavolta, PhD, Jorge H. Assunção, MD, Koki E. Kajima, PhD, Paulo R. dos Reis, MD, Jorge S. Silva, PhD, Arnaldo A. Ferreira Neto, PhD, Arnaldo J. Hernandez, PhD

Department of Orthopedics and Traumatology, School of Medicine, University of São Paulo (USP), São Paulo, Brazil

Background: Previous studies have shown good clinical results in patients with proximal humeral fractures (PHFs) treated with locking intramedullary nails or locking plates. Our study compared the clinical and radiographic outcomes in patients with 2- and 3-part surgical neck fractures.

Methods: In this prospective, randomized controlled trial, 72 patients with 2- or 3-part surgical neck PHFs were randomly assigned to receive fixation with locking intramedullary nails (nail group) or locking plates (plate group). The primary outcome was the 12-month Constant-Murley score. The secondary outcomes included the Disabilities of the Arm, Shoulder and Hand score, the visual analog scale pain score, the shoulder passive range of motion, the neck-shaft angle, and complication rates.

Results: There was no significant mean treatment group difference in the Constant-Murley score at 12 months (70.3 points for the nail group vs. 71.5 points for the plate group; P = 0.750) or at individual follow-up assessments. There were no differences in the 3-, 6- and 12-month Disabilities of the Arm, Shoulder and Hand scores, visual analog scale scores, and range of motion, except for the medial rotation at 6 months. The neck-shaft angle was equivalent between the groups at 12 months. There were significant differences over 12 months in total complication rates (P = 0.002) and reoperation rates (P = 0.041). There were no significant differences for the rotator cuff tear rate (P = 0.672).

Conclusion: Fixation of PHFs with locking plates or locking intramedullary nails produces similar clinical and radiologic results. Nevertheless, the complication and reoperation rates were higher in the nail group.

Level of evidence: Level I: Randomized controlled trial; Treatment study
© 2016 Journal of Shoulder and Elbow Surgery Board of Trustees.

Keywords: Randomized controlled trial; recovery of function; bone nails; bone plates; comparative study; shoulder fractures; postoperative complications

Table III: Complications according to treatment group

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Nail group (n = 32)</th>
<th>Plate group (n = 33)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complex regional pain syndrome</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Infection</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Insufficient reduction</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Loss of reduction of greater tuberosity</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Loss of reduction of humeral head</td>
<td>3 (9)</td>
<td>1 (3)</td>
<td>.355</td>
</tr>
<tr>
<td>Hardware problems</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>.041</td>
</tr>
<tr>
<td>Implant failure</td>
<td>0 (0)</td>
<td>0 (0)</td>
<td>1.00</td>
</tr>
<tr>
<td>Implant loosening</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Primary screw protrusion</td>
<td>2 (6)</td>
<td>1 (3)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Screw “cut-out”</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Secondary screw protrusion</td>
<td>2 (6)</td>
<td>0 (0)</td>
<td>.733</td>
</tr>
<tr>
<td>Wrong screw positioning</td>
<td>3 (9)</td>
<td>0 (0)</td>
<td>.499</td>
</tr>
<tr>
<td>Osteonecrosis</td>
<td>2 (6)</td>
<td>0 (0)</td>
<td>.238</td>
</tr>
<tr>
<td>Reoperation</td>
<td>0 (0)</td>
<td>3 (9)</td>
<td>.041</td>
</tr>
<tr>
<td>Refracture</td>
<td>0 (0)</td>
<td>1 (3)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Complete rotator cuff tears</td>
<td>4 (13)</td>
<td>2 (6)</td>
<td>.672</td>
</tr>
<tr>
<td>Subscapularis</td>
<td>1 (3)</td>
<td>0 (0)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Supraspinatus</td>
<td>3 (9)</td>
<td>2 (6)</td>
<td>&gt;.999</td>
</tr>
<tr>
<td>Shoulder stiffness</td>
<td>4 (13)</td>
<td>2 (6)</td>
<td>.427</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total number of complications</td>
<td>28</td>
<td>10</td>
<td>.001</td>
</tr>
<tr>
<td>Number of patients with complications</td>
<td>33 (104)</td>
<td>7 (21)</td>
<td>.271</td>
</tr>
</tbody>
</table>

No. Not applicable.

- Prospective randomized trial
- 72 patients with 2 or 3 part PHF
- No clinical outcome differences
- Higher rate of complications and reoperation in the nail group
- No significant increased risk of RTC problems (4 nail vs 2 Plate)
Tips and Tricks to Survive ORIF
Set up

- Beach Chair vs Supine
  - PICK WHERE YOU ARE MOST COMFORTABLE
- Make sure you can get ORTHOGONAL Views preferably without having to move the arm
- Check that you can get the views before you prep and drape!

Courtesy of AO.com
Approach

• Prefer the deltopectoral approach
  – Less risk to axillary nerve
  – Can fully expose and extend as needed

• Alternate:
  – Antero-lateral approach
    • Must expose and protect the axillary nerve
    • DO NOT ATTEMPT TWO INCISION TECHNIQUE!
Control the Tuberosities

• First step after exposure:
  – Get 2-3 sutures in the infraspinatus/supraspinatus
  – Get 1-2 sutures in the subscapularis
  – This allows control of the head in 3 part fractures and allows access to the head in 4 part fractures
Preserve your blood supply

• **DO NOT STRIP YOUR PERIOSTEUM**
  – Will increase risk of AVN

• Plate placement lateral to bicipital groove
Reduction

• DO NOT BE AFRAID TO USE REDUCTION TOOLS:
  – Cobb
  – Reduction clamps
    • JUST MAKE SURE YOU RESPECT THE ANATOMY

• Reduction maneuvers depend on the fracture pattern
Varus Fracture

• Use a cobb to elevate the head and K-Wire

• Use the plate as a reduction tool

ASES Point Counterpoint
Vumedi video: Dr. Xavier
Three Part fractures

• In 3 part fractures you can tie sutures from LT and GT together to provisionally reduce to make it into a two part fracture
• Use your other sutures to control rotation and varus/valgus then Kwire
Four Part fractures

- Use sutures in tuberosities to open up and expose the head
- Can use a reduction tool to reduce the head
  - Use some kind of bone graft to fill the void
  - Hold reduction with k-wires
- Close tuberosities down over the graft
BONE GRAFTING

• Cancellous chips and commercially available allografts
  – Can use to fill void in 4 part or 3 part fracture

• Structural allograft
  – Fibular strut
  – Femoral or humeral head
  – ICBG
Fibular strut

• A few studies show good outcomes using a fibular strut to add structural support

• Tips
  – Use only on younger patients
  – Try to avoid on patients who have high risk of conversion to arthroplasty
  – Use the smallest graft possible

• Very difficult to remove if you need to convert to arthroplasty
Femoral head graft

- My preferred method
  - Gives structural support
  - No cortical bone though so easier to revise
  - More anatomic

Femoral head graft

- Get an idea of size of graft you will need
- Defrost a femoral head allograft
- Cut in half (keep other half in case first one doesn’t work)
- Shape into a trapezoid
  - Leave some rounded head surface to support the humeral head
  - Shape to size you want- (use micro saw and burr)
    - Takes some trial and error
  - Smaller end what will go into the shaft

Proper plate position

Pictures from AO.com
Screw Placement

- **Head screws**
  - Place under fluoro
  - Uni-cortical locking- DO NOT VIOLATE SUBCHONDRAL BONE
  - Subtract 4 mm from what you measure to prevent screw penetration if collapse/AVN

- **CALCAR SCREW**
  - PLACE IT LOW!
  - Through graft if using one
Case example

• 56 year old RHD female who owns a contracting business fell through floor boards sustaining a right proximal humerus fracture on 3/27

• PMH HTN
Injury x-rays
Plan

• What would you do????
  – ORIF
    • Graft?
  – Hemi?
  – Go nuts and do a RSA?
Immediately postop
About 6 months postop
1 year postop: AVN

Even with an anatomic reduction- AVN still happens....AKA bad actors!
Complications of locked plating for proximal humeral fractures—are we getting any better?

Florian Haasters, MD, PhD, Georg Siebenbürgner, MD, Tobias Helsen, MD, Mark Daferner, MS, Wolfgang Böcker, MD, PhD, Ben Ockert, MD, PhD

*Department of Trauma Surgery, Ludwig-Maximilians-Universität, Munich, Germany
†Department of Knee, Hip and Shoulder Surgery, Schön-Klinik Munich-Harlaching, Munich, Germany

Background: Complication rates reported after locking plate fixation of proximal humeral fractures still range up to 40%. Whether modifications of surgical techniques, use of primary shoulder arthroplasty, or a fracture-specific management resulted in decreased complication rates during recent years remains unclear. Therefore, the aim of this long-term observation study was to analyze the incidence of complications and revision surgery after locked plating.

Methods: Between February 2002 and December 2013, 788 patients (aged 67.4 ± 17.3 years) with displaced proximal humeral fractures were treated with locking plate, primary hemiarthroplasty (HA), or reverse shoulder arthroplasty (RSA). Standardized follow-up included radiographs at 1 day, 6 weeks, and 3, 6, and 12 months. Complications and unplanned revision surgery were prospectively recorded over the complete follow-up.

Results: Of 788 patients, 646 (82%) were treated with locking plate, 82 (10.4%) with HA, and 60 (7.6%) with RSA. Mean follow-up was 14.8 ± 3.8 months. The mean complication rate associated with locked plating was 12.8%, and revision surgery was necessary in 11.6%. Within the last 5 years, the loss of fixation rate markedly decreased from 14.3% to 4.8%; simultaneously, an increased use of RSA was observed.

Conclusion: The overall complication rate of locking plate osteosynthesis for proximal humeral fractures has been decreasing considerably within the last years. Among others, this might be due to an increased use of primary RSA for complex fracture types. In addition to a precise surgical technique, choosing the adequate treatment for each individual fracture to avoid complications and revision surgery is of utmost importance.

Level of evidence: Level IV; Case Series; Treatment Study

Keywords: proximal humeral fracture; locked plating; primary arthroplasty; long-term; outcome; complication, revision

Proximal humeral fractures are the seventh most common...
21 % COMPLICATION RATE!
Humeral Shaft Fractures

• ~3% of all fractures

Court-Brown CM, Caesar B. Injury. 2006; 37(8): 691
Anatomy

• All about the radial nerve

14 cm average lateral epicondyle

Leaves intermuscular septum ~10 cm above lateral epicondyle

Primary radial nerve injury from 4-22%

Iatrogenic Radial nerve injury 3%

Jawa et al. JBJS 2006; 88:2343
Papasoulis et al. Injury 2010; 41: e21-27
Updegrove et al. JSES 2018; 27, e87
Operative versus Non operative treatment

• Humerus is forgiving
  – Can accept deformity
  – Klenerman (JBJS 1966) found that < 20 degrees AP, < 30 degrees varus/valgus, and < 2-3 cm short ok

• Who to treat non op
  – Isolated injury
  – Maintains alignment in splint/brace
  – No Brachial Plexus injury (radial nerve NOT a Contra-indication)
Interestingly, rumor has it Sarmiento sustained a humerus fracture and lasted < a week in the brace before fixing it.
Good functional outcomes with Bracing

• Shields et al: No difference between op and non op in PROs
• Koch et al: 95% union rate in 67 fractures treated with bracing. Three patients had slight limitation of ROM that was not functionally limiting.
• Matsunaga et al: RCT bracing vs ORIF.
  – 0% nonunion ORIF vs 15% bracing
  – No other clinically significant clinical outcome
• Denard et al: 150 Operative vs 63 Brace patients
  – Nonunion: 8.7 % OP vs 20.6% nonop
  – Malunion rate 1.3 % OP vs 12.7% non op
  – No difference in time to union or final ROM between groups

Koch et al. JSES 2002; 11: 143-150
Shields et al. Injury 2015; 47:914-18
Matsunaga et al. JBJS Am. 2017; 99:583-592
Denard et al. Orthopedics 2010; 33.
When to Operate

• Cannot maintain acceptable alignment
• Cannot tolerate bracing
• ?Proximal 1/3 or Distal 1/3 fractures (controversial- higher rates of nonunion or mal-union in some studies)
• Poly-trauma
• Nerve injury with vascular injury, high velocity GSW, Severe soft tissue injury, secondary nerve injury after fracture manipulation
• Brachial plexus injury
Multiple approaches for operative treatment

Table 1

<table>
<thead>
<tr>
<th>Fracture Location</th>
<th>Surgical Approach</th>
<th>Concerns and Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proximal</td>
<td>Deltopectoral</td>
<td>Axillary nerve, Deltoid detachment, Anterior humeral circumflex artery</td>
</tr>
<tr>
<td></td>
<td>Anterolateral (continuation of deltopectoral with splitting of brachialis muscle)</td>
<td>Radial nerve (distally between brachialis and brachioradialis), Brachialis split</td>
</tr>
<tr>
<td>Middle (Proximal)</td>
<td>Posterior (triceps split)</td>
<td>Radial nerve, Failure of adequate exposure proximally with triceps split technique</td>
</tr>
<tr>
<td>Middle (Distal)</td>
<td>Posterior (triceps split or paratricipital)</td>
<td>Radial nerve, Ulnar nerve (with medial exposure)</td>
</tr>
<tr>
<td>Distal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extensile</td>
<td>Deltopectoral with anterolateral extension</td>
<td>Axillary nerve, radial nerve</td>
</tr>
<tr>
<td></td>
<td>Posterior with triceps reflection$^2$</td>
<td>Radial/ulnar nerves</td>
</tr>
</tbody>
</table>


Carroll et al. JAAOS 2012; 20:423-433
Midshaft fractures

• Prefer anterior-lateral approach for true midshaft fractures
• Avoid the radial nerve

• Approach: Brachialis splitting proximally
  – Distally between brachialis and brachioradialis the nerve can be found
  – Can do minimally invasive plate osteosynthesis with this approach
Distal 1/3 fractures

• Prefer posterior approach
  – Can also use for mid-shaft if you prefer

• Gerwin and Hotchkiss showed with lateral elevation of the lateral and medial heads of the triceps you can expose 94% of the humerus

Distal 1/3

- Patient lateral on a bean bag with arm over a radiolucent paint roller or bone foam or blankets on radiolucent arm board
- Straight posterior incision
- No tourniquet or Sterile Tourniquet
- Make full thickness flaps
- Identify the posterior brachial cutaneous nerve laterally
- Follow it up until it meets the radial nerve proper at the intermuscular septum
- ID nerve and protect
- Lift and mobilize triceps off of bone and fix.
Fixation

• You need Rigid Fixation
  – AO techniques
    • Compression plating transverse fractures
    • Bridge plating comminuted fractures
    • Lag techniques and neutralization plates for spiral fractures or any oblique or comminuted fracture amenable to lag screws
  – Large frag plates often used
  – 8 Cortices above or below if possible
  – Dual Plates- Shown to be biomechanically stronger
  – Can use minifrag plates for reduction then neutralize with Larger plate
  – Do not be afraid to extend to a long proximal humerus plate and get fixation in the head.
Dual Plating

Internal Fixation of the Distal Humerus: A Biomechanical Comparison of Methods

David L. Helfet and *Robert N. Hotchkiss
Department of Orthopaedic Trauma, University of South Florida, Florida Orthopaedic Institute, Tampa, Florida; and
*Department of Orthopaedic Surgery, University of Texas at San Antonio, San Antonio, Texas, U.S.A.

Summary: Three commonly used configurations of various implants used for fixation of distal humeral fractures were quantitatively compared. The double plate construct, irrespective of plate type (½ tubular and/or 3.5 mm reconstruction plate), was significantly stronger, both in rigidity and fatigue testing, than cross screws or the single “Y” plate. If rigid stabilization of supracondylar or bicondylar distal humeral fractures is desired, then two plate constructs, at right angles (the ulna plate medially, the lateral plate posteriorly), are biomechanically optimal. Key Words: Distal humerus—Internal fixation—Biomechanical testing.

Rubel et al JBJS 2002: Dual plating of humeral shaft fractures biomechanically stiffer than all other constructs
Fixation

- You want strong enough fixation to allow early motion and weight bearing.

– GO BIG OR GO HOME!
References

- Kancherla et al. Management of Acute Proximal Humerus Fractures. JAAOS. 2017 (25); 42-52
- Rangan et al. Surgical Vs Nonsurgical Treatment of Adults with Displaced Fractures of the Proximal Humerus: The PROFHER Randomized Clinical Trial. JAMA. 2015. 313(10): 1037-1047
- www.ao.com (Pictures for talk)
- www.orthobullets.com (pictures for the talk)
- www.ao.com (Pictures for talk)
Thank you