What’s New in the Treatment of Proximal Humerus Fractures?

John Bell, M.D., M.S.
Associate Professor
Shoulder and Elbow Surgery
Dartmouth-Hitchcock Medical Center
Lebanon, NH
No disclosures to report
Case

71 year old female, dominant right arm, active.
• Medicare patients 65 and older
• Two groups: 1999-2000 and 2004-2005
• Looked at geographical rates of fracture
• Compared percentage treated surgically
• Compared complication rates
Fracture rate  Surgical Treatment rate
What Rate of Utilization is Appropriate in Musculoskeletal Care?

Jon D. Lurie MD, MS, John Erik Bell MD, Jim Weinstein DO, MS

CORR, 2009
>40% in many regions

Proportion of Proximal Humerus Fractures (PHF) Treated Surgically by Hospital Referral Region (2004-2005)

- 40% or More (12)
- 30% to < 40% (21)
- 20% to < 30% (55)
- 10% to < 20% (121)
- Less than 10% (55)
- Suppressed for confidentiality (42)
- Not Populated
Fracture Incidence

• 14,774 PHF in 1999-2000
  – Est 73,870 total PHF
• 16,138 PHF in 2004-2005
  – Est 80,690 total PHF
• 2.47 vs. 2.48 per 1000 Medicare beneficiaries (p=0.992)

• **NO CHANGE IN FRACTURE INCIDENCE**
Large increase in surgical treatment over 5 years

While age/sex/race adjusted fracture incidence was unchanged (accounting for aging population), the relative increase in those treated surgically over 5 years was **25%**.
Why so much variability?

• Surgeon driven?

• New technology?

• What is the evidence?

• Are we over-treating or under-treating?
HRR-Level regional variation
HSA-Level variation
Intra-Department variation
Intra-Team variation
Intra-Surgeon variation
Management of proximal humeral fractures: Surgeons don’t agree

Charles J. Petit, MD\textsuperscript{a,b}, Peter J. Millett, MD MSc\textsuperscript{b,*}, Nathan K. Endres, MD\textsuperscript{a}, David Diller, BA\textsuperscript{a}, Mitchel B. Harris, MD\textsuperscript{c}, Jon J.P. Warner, MD\textsuperscript{a}

- 8 surgeons at two affiliated Level-1 trauma centers

- All fellowship trained (3 shoulder trained and 5 trauma trained), with average of 12.6 years post-fellowship experience

- Management choices presented:
  - Non-op
  - Closed reduction under anesthesia
  - Closed reduction percutaneous pinning
  - ORIF with locking plate
  - ORIF with alternative method (eg suture fixation)
  - Hemiarthroplasty
Surgeons Don’t Agree

- 100 cases presented in blinded fashion
- Interobserver agreement (weighted kappa coefficient) \( \kappa = 0.41 \)
  - Trauma surgeons 0.44, Shoulder surgeons 0.50 (slightly better)
- Decreased options to Nonop, Locking Plate, HHR \( \kappa = 0.45 \)
  - Trauma surgeons 0.44, Shoulder surgeons 0.52
- Decreased options to Nonop and Operative \( \kappa = 0.48 \)
  - Trauma surgeons 0.47, Shoulder surgeons 0.71

Table 2
Interpretation of Kappa

<table>
<thead>
<tr>
<th>Kappa</th>
<th>Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>Less than chance agreement</td>
</tr>
<tr>
<td>0.01-0.20</td>
<td>Slight agreement</td>
</tr>
<tr>
<td>0.21-0.40</td>
<td>Fair agreement</td>
</tr>
<tr>
<td>0.41-0.60</td>
<td>Moderate agreement</td>
</tr>
<tr>
<td>0.61-0.80</td>
<td>Substantial agreement</td>
</tr>
<tr>
<td>0.81-0.99</td>
<td>Almost perfect agreement</td>
</tr>
</tbody>
</table>

Petit et al JSES 2010
Viera, Fam Med 2005
Surgeons Don’t Agree (with themselves either)

- Intraobserver agreement only **56.5%** (comparing survey results to the operation they actually performed)
  - Trauma surgeons 60.4%, Shoulder surgeons 50%
- Decreased options to Nonop, Locking Plate, HHR : **70.6%**
  - Trauma surgeons 60.4%, Shoulder surgeons 87.5%
- Decreased options to Nonop and Operative : **81.2%**
  - Trauma surgeons 73.6%, Shoulder surgeons 93.8%

Discussion: “This study shows a concerning lack of consistency among surgeons in their own decision making”

Petit et al JSES 2010
Let's go back to the evidence...
Displaced Proximal Humeral Fractures

PART II. TREATMENT OF THREE-PART AND FOUR-PART DISPLACEMENT*

BY CHARLES S. NEER, II, M.D.†, NEW YORK, N. Y.

From the Department of Orthopaedic Surgery, College of Physicians and Surgeons, Columbia University, and The New York Orthopaedic Hospital, Columbia-Presbyterian Medical Center, New York
For 44 years since Neer’s landmark paper,

- 3 part fractures have been treated with ORIF
- 4 part fractures have been treated with hemiarthroplasty

What, if anything, has changed since then?
Cochrane Review 2003

- Surgery restored anatomy better than nonoperative treatment
- Surgery did not result in improved function
- More complications with surgery
- Very little data to analyze
Changes in Technology

Rates of ORIF increased 28.5%, disproportionately to arthroplasty over 5 years.

What caused explosion in ORIF between 1999 and 2005?

New technology?

Perc Pinning Technique
Perc Pinning Technique
Perc Pinning Technique
Perc Pinning Technique
Locking plates
Locking plates
• 12 studies
• 791 patients
• Improvement for one year
• Constant score 74.3
• Many complications
Outcomes of ORIF

- When no complications, outcomes are good
- There is a relatively high complication rate
- Key to success is to avoid complications and rehabilitate appropriately
Complications of ORIF

• Proximal fixation failure
  – 8-11% secondary displacement
  – 3-14% Screw loosening/cut-out
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence – 5-17%
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence
- Nonunion – 5-14%
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence
- Nonunion
- Infection – 1-4%
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence
- Nonunion
- Infection
- Avascular Necrosis
  - Complete 1.8-5.5%
  - Partial 16.4%
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence
- Nonunion
- Infection
- Avascular Necrosis
- Malunion - GT malpositioned in 16%
Complications of ORIF

- Proximal fixation failure
- Periprosthetic shaft fracture
- Hardware prominence
- Nonunion
- Infection
- Avascular Necrosis
- Malunion
- Heterotopic Bone
• Patients 3.9 times more likely to have revision surgery within 1 year if primary surgery is ORIF (p=0.0257)

• Surgery in 2004-2005 was 1.47 times more likely to require re-operation than surgery done in 1999-2000 (p=0.043)
New Level 1 Evidence

5 Recent Level 1 studies comparing Operative and Nonoperative Treatment since 2011

- Two comparing locking plate to nonop
- Two comparing hemiarthroplasty to nonop
- One comparing operative to nonoperative
ORIF vs Nonop RCT #1

Internal fixation versus nonoperative treatment of displaced 3-part proximal humeral fractures in elderly patients: a randomized controlled trial

**Design**
- Level 1 RCT
- 60 Patients, mean age 74, 81% women
- Displaced 3-part proximal humerus fractures
- Randomized to ORIF with locking plate or nonoperative treatment with a sling
- 2 year outcomes (Constant, DASH, ROM, EQ-5D)
- Excluded 100% translated fractures with no bony contact, fracture dislocations, and valgus impacted fractures

**Results**
- No significant difference in Constant, DASH, or EQ5D scores
- No significant difference in ROM
- 9 patients (30%) required repeat surgery in ORIF group
- No patients in nonoperative group went on to surgery

<table>
<thead>
<tr>
<th></th>
<th>ORIF</th>
<th>Nonoperative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Range of Motion</strong></td>
<td>120°</td>
<td>111°</td>
<td>0.36</td>
</tr>
<tr>
<td><strong>Abduction</strong></td>
<td>114°</td>
<td>106°</td>
<td>0.28</td>
</tr>
<tr>
<td><strong>Constant Score</strong></td>
<td>61</td>
<td>58</td>
<td>0.64</td>
</tr>
<tr>
<td><strong>DASH</strong></td>
<td>26</td>
<td>35</td>
<td>0.19</td>
</tr>
<tr>
<td><strong>EQ-5D</strong></td>
<td>0.70</td>
<td>0.59</td>
<td>0.26</td>
</tr>
</tbody>
</table>
**ORIF vs Nonop RCT #2**

### Surgical Treatment With an Angular Stable Plate for Complex Displaced Proximal Humeral Fractures in Elderly Patients: A Randomized Controlled Trial

*Tore Fjølæstad, MD,* †Margrethe O. Hole, PT, †Inger Anette Hynås Hovden, MD, ‡Judith Blücher, MD, § and Knut Siromsøe, MD, PhD*

*J Orthop Trauma • Volume 26, Number 2, February 2012*

### Design

- **Level 1 RCT**
- 50 patients, age 60 or older (mean 72)
- Displaced 3- or 4-part proximal humerus fractures
- Randomized to ORIF with locking plate or nonoperative treatment
- 1 year outcomes (Constant score, ASES patient self-assessment score)
- *Instead of excluding 100% translated fractures, these authors performed closed reduction under anesthesia*

### Results

- No significant difference in in Constant score, or self-reported ASES score
- Significant improvement in radiographic outcomes in ORIF group
- 7 patients with 11 screws with intra-articular penetration
- Updated data at 2 years show that there is a huge improvement between 6-12 months in both groups, no change after 12 months
HHR vs Nonop RCT #1

Hemiarthroplasty versus nonoperative treatment of displaced 4-part proximal humeral fractures in elderly patients: randomized clinical trial

- **Design**
  - Level 1 RCT
  - 55 patients, mean age 77, 86% women
  - Displaced 4-part proximal humerus fractures
  - Randomized to hemiarthroplasty or nonoperative treatment with a sling
  - 2 year outcomes (Constant, DASH, ROM, EQ-5D)
  - Excluded 100% translated fractures with no bony contact, fracture dislocations, and valgus impacted fractures

**Results**

- No significant difference in Constant or DASH scores
- Improvement in EQ-5D score
- No significant difference in ROM
- 3 patients (11%) required repeat surgery in HHR group
- 1 patient in nonoperative group went on to surgery

<table>
<thead>
<tr>
<th></th>
<th>HHR</th>
<th>Nonoperative</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forward Flexion</td>
<td>93º</td>
<td>95º</td>
<td>0.85</td>
</tr>
<tr>
<td>Abduction</td>
<td>86º</td>
<td>87º</td>
<td>0.87</td>
</tr>
<tr>
<td>Constant Score</td>
<td>48.3</td>
<td>49.6</td>
<td>0.81</td>
</tr>
<tr>
<td>DASH</td>
<td>30</td>
<td>37</td>
<td>0.25</td>
</tr>
<tr>
<td>EQ-5D</td>
<td>0.81</td>
<td>0.65</td>
<td>0.02</td>
</tr>
</tbody>
</table>
HHR vs Nonop RCT #2

Hemiarthroplasty for Humeral Four-part Fractures for Patients 65 Years and Older
A Randomized Controlled Trial
Harm W. Boons MD, Jon H. Goosen MD, PhD, Susan van Grinsven MSc, Job L. van Susante MD, PhD, Corné J. van Loon MD, PhD

Design
• Level 1 RCT
• 50 patients over 65 years old (mean 70)
• Displaced 4-part proximal humerus fracture
• Randomized to hemiarthroplasty or nonoperative treatment in a sling
• 1 year f/u
• Constant Score, SST, pain, strength

No significant difference in Constant score, SST score at 3 or 12 months
• Slightly improved strength in nonoperative group at 3 and 12 months
• Less pain in operative group at 3 months, but no difference at 12 months
• 1 reoperation in each group
A New Cochrane Review 2012

- 6 trials comparing surgical and nonsurgical treatment in 270 patients
- Pooled results show no significant difference in outcome
- Significantly more delayed or secondary surgeries in the operative groups.
  - One extra operation for every nine surgically treated patients
Original Investigation

Surgical vs Nonsurgical Treatment of Adults With Displaced Fractures of the Proximal Humerus
The PROFHER Randomized Clinical Trial

Amar Rangan, FRCS(Tr&Orth); 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

CONCLUSIONS AND RELEVANCE Among patients with displaced proximal humeral fractures involving the surgical neck, there was no significant difference between surgical treatment compared with nonsurgical treatment in patient-reported clinical outcomes over 2 years following fracture occurrence. These results do not support the trend of increased surgery for patients with displaced fractures of the proximal humerus.
Summary of Best Evidence

• Now SEVEN Level-1 RCTs comparing operative to nonoperative treatment (5 in the past 4 years)
  – **Consistent** - All essentially show equivalence in shoulder scores and function
  – **Surprising** – Both in terms of equivocality and disappointing outcomes
  – **Misleading**? - 3 studies were underpowered, many had other methodological flaws, eg exclusion criteria
  – **Confusing** - What are we supposed to do with this data?
Why so much variability?

- Surgeon driven?
  - Probably
- New technology?
  - Definitely
- What is the evidence?
  - Op = Nonop
  - Consistently disappointing
- Are we over-treating or under-treating?
  - We are probably overtreating based on this evidence
Are we following the data?


<table>
<thead>
<tr>
<th>Year</th>
<th>Patients with proximal humeral fractures (No.)</th>
<th>Surgically treated fractures (No.)</th>
<th>Surgically treated fractures (%)</th>
<th>Patients in Medicare database (No.)</th>
<th>Fracture incidence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>53,593</td>
<td>8684</td>
<td>16.20</td>
<td>25,375,062</td>
<td>0.2112</td>
</tr>
<tr>
<td>2010</td>
<td>54,101</td>
<td>7742</td>
<td>14.31</td>
<td>25,626,128</td>
<td>0.2111</td>
</tr>
<tr>
<td>2011</td>
<td>55,507</td>
<td>8044</td>
<td>14.49</td>
<td>26,101,098</td>
<td>0.2127</td>
</tr>
<tr>
<td>2012</td>
<td>55,394</td>
<td>7680</td>
<td>13.86</td>
<td>26,505,506</td>
<td>0.2090</td>
</tr>
<tr>
<td>Change 2009-2012, %</td>
<td>3</td>
<td>-12</td>
<td>-14</td>
<td>4</td>
<td>-1</td>
</tr>
</tbody>
</table>
What’s New?

- New advances not reflected in recent Level 1 data may tip the balance toward surgical treatment:
  - Focus on inferomedial fixation
  - Use of **structural bone grafting** for unstable patterns
  - Use of **reverse shoulder arthroplasty**
Allograft Strut Augmentation

• Consider strut when medial cortex is disrupted
Allograft Strut Augmentation

Bae et al, JBJS Br 2011
Allograft Strut Augmentation

Bar chart showing initial stiffness under increasing axial load after static testing in both groups (LP, locking plate alone; LPSG, locking plate with a fibular strut graft).

Typical load-displacement curves after static testing under increasing axial load (LP, locking plate alone; LPSG, locking plate with a fibular strut graft).

Bae et al, JBJS Br 2011
What else might help

- Consider strut when medial cortex is disrupted
- Add heavy suture augmentation through rotator cuff to plate and screw constructs
What else might help

- Consider strut when medial cortex is disrupted
- Add heavy suture augmentation through rotator cuff to plate and screw constructs
- Try to get long inferomedial locking screws into the head\(^1\)

\(^1\)Gardner et al JOT 2007
Another big change in technology
Patient-Specific Approach
Patient-Specific Approach
Complications

- Up to 15% infection (5.1% in large series (4x rate in TSA))
- Up to 20% hematoma rate

*Propionibacterium acnes*
Complications

- Infection
- Instability

-up to 31% (3% in primary)
Complications

- Infection
- Instability
- Acromion fracture

-43% in RA (5-7% in large series)
Complications

Nerot Classification

- Infection
- Instability
- Acromion fracture
- Scapular notching

Found in 96% of f/u x-rays at avg 38 mo (46% Grade 3-4) Werner JBJS 2005 (58 pts)
Complications

- Infection
- Instability
- Acromion fracture
- Scapular notching
- Glenoid
Complications

- Infection
- Instability
- Acromion fracture
- Scapular notching
- Glenoid
- Neurologic injury

Causes

- Plexus stretch
- Arm lengthening
- Intra-operative traction
- Laderman JBJS 2011 – nerve injury 10.9x more likely in RSA than standard arthroplasty
Complications

- Infection
- Instability
- Acromion fracture
- Scapular notching
- Glenoid
- Neurologic injury
- Periprosthetic fracture
Complications

- Infection
- Instability
- Acromion fracture
- Scapular notching
- Glenoid
- Neurologic injury
- Periprosthetic fracture
- Implant dissociation
Practice is changing

- Rosas *et al* JSES 2015
Reverse shoulder arthroplasty for treatment of proximal humeral fractures in older adults: a systematic review

Ana Mata-Fink, MD⁵,⁶, *, Mary Meinke, BA⁶, Charlene Jones, BA⁶, Bokyung Kim, BA⁶, John-Erik Bell, MD, MS⁵

Primary Aim: to evaluate the range of motion and functional outcomes of reverse shoulder arthroplasty in older adults with proximal humerus fractures and to compare them with those of hemiarthroplasty.
15 studies that met inclusion criteria
- 6 studies with concurrent hemiarthroplasty data

Reverse shoulder arthroplasty: 377
- Mean age range: 70-86 years

Hemiarthroplasty: 504
- Mean age range: 69-77 years

Majority women

Average follow-up: 3.6 years
## Forward flexion

### Mean Difference

<table>
<thead>
<tr>
<th>Study of</th>
<th>Mean Difference</th>
<th>IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallinet et al.</td>
<td>44.00</td>
<td>[19.81, 68.19]</td>
</tr>
<tr>
<td>Garrigue et al.</td>
<td>32.00</td>
<td>[1.84, 62.16]</td>
</tr>
<tr>
<td>Sirveaux et al.</td>
<td>10.00</td>
<td>[-6.14, 26.14]</td>
</tr>
<tr>
<td>Young et al.</td>
<td>7.00</td>
<td>[-11.58, 25.58]</td>
</tr>
<tr>
<td>Total (9 Studies)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heterogeneity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test for Heterogeneity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard Error</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21° [3.92, 37.94]

- Favours Hemilaminectomy
- Favours RSA
External rotation

-5°
Functional scores

<table>
<thead>
<tr>
<th>Study or Observer</th>
<th>IV, Random, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gallinet 2</td>
<td>0.92 [0.27, 1.58]</td>
</tr>
<tr>
<td>Hanssens</td>
<td>0.98 [-0.04, 2.01]</td>
</tr>
<tr>
<td>Sirveaux</td>
<td>0.09 [-0.44, 0.62]</td>
</tr>
<tr>
<td>Garrigues</td>
<td>0.84 [-0.02, 1.70]</td>
</tr>
<tr>
<td>Young 2003</td>
<td>-0.09 [-0.96, 0.79]</td>
</tr>
<tr>
<td>Boyle 2011</td>
<td>0.34 [0.05, 0.62]</td>
</tr>
</tbody>
</table>

Total (95% CI): 0.44 [0.13, 0.74]

Test for overall effect: $I^2 = 50$

*Standard mean difference*
Conclusion

The results show improved forward flexion and functional outcome scores with reverse shoulder arthroplasty.

Use of reverse shoulder arthroplasty is a reasonable alternative to hemiarthroplasty for experienced shoulder surgeons in the treatment of proximal humerus fractures in older patients.
Case

71 year old female, dominant right arm, active.