We accept....

Femoral neck fracture in young adults
- Difficult injuries
- Early, skilled treatment essential
- Complications are potentially catastrophic
- Salvage Rx are common

FAIRED

Summary
- Describe injury pattern
- What is the standard?
- Optimal care
- Expectations
Who Risks Failure?

What is likely to affect union?
- Host factors (hormones, smoking, etc…)
- Intra-articular injury (synovial fluid)
- Vascularity
- Fracture configuration
  - Reduction
  - Fixation
    - Affected by surgeon

Friedrich Pauwels (1920’s)

• Mechanical approach

Friedrich Pauwels (1920’s)

• Classification system
Friedrich Pauwels (1920’s)


Early Surgical Rx


- 22 patients aged 20-40 (Army recruits)
- Mostly CRIF
  - 59% nonunions
  - 86% AVN

Modern Treatment


- 56 patients young patients with Pauwels’ III
  - 17% nonunions
  - 12% AVN
  - 30% failure rate
Disclosure

- I have failed Modern Treatment

- Failure is costly for the young patient


Results

"IF of femoral neck fractures and femoral neck shortening affect patient VAS scores and functional outcomes.”


Results

"IF of femoral neck fractures and femoral neck shortening affect patient VAS scores and functional outcomes.”

**Results**

"Displaced fractures and Pauwels 3 fractures shorten the most."

| Characteristic | 1 cm to 2 cm (n=232) | 2 cm to 3 cm (n=166) | 3 cm to 4 cm (n=95) | 4 cm or greater (n=20) | P
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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>54.9 ± 17.4</td>
<td>54.9 ± 17.4</td>
<td>60.8 ± 22.9</td>
<td>46.4 ± 16.5</td>
<td>0.908</td>
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<tr>
<td>Male (%)</td>
<td>56.5%</td>
<td>59.3%</td>
<td>68.9%</td>
<td>60.0%</td>
<td>0.268</td>
</tr>
<tr>
<td>Length, cm</td>
<td>77.9 ± 4.6</td>
<td>79.5 ± 5.2</td>
<td>80.4 ± 4.6</td>
<td>79.5 ± 6.8</td>
<td>0.686</td>
</tr>
<tr>
<td>Fracture type</td>
<td>15.3%</td>
<td>17.1%</td>
<td>19.6%</td>
<td>15.0%</td>
<td>0.482</td>
</tr>
<tr>
<td>Fracture length</td>
<td>7.5 ± 1.8</td>
<td>7.5 ± 1.8</td>
<td>7.5 ± 1.8</td>
<td>7.5 ± 1.8</td>
<td>1.000</td>
</tr>
<tr>
<td>Fracture width</td>
<td>2.7 ± 0.7</td>
<td>2.7 ± 0.7</td>
<td>2.7 ± 0.7</td>
<td>2.7 ± 0.7</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Modern Treatment

- Pauwels
- ……
- ……
- ……
- ……
- Swiontkowski et al.
- ……
- ……
- ?

Treatment Decisions

- Algorithms
  - Macanley et al. Femoral Neck Fractures in the Young Adult. JAAOS, 2006
Treatment Decisions

- Algorithms
  - Macaulay et al. Femoral Neck Fractures in the Young Adult. JAAOS, 2006

- Algorithm provided
  - Treatment of Femoral Neck Fractures in Young Adults

• An axially loaded, high-energy force applied to an abducted hip result in a varus-type or more oblique neck frac-
ture. The fracture pattern has a tendency to be more vertically oriented and, therefore, biomechanically more unstabilized. These characteristics have important implications with regard to selection and maintenance of early flexion and abduction, both of which are necessary for survival of the hip.
Treatment Decisions

• Algorithm provided

Treatment Decisions

• ICL Example

Treatment Decisions
Treatment Decisions

- What might have been done differently?
Treatment Decisions

• What about pre-operative planning?

Treatment Decisions

• Is evaluating this in surgery OK?

Treatment Decisions

What sort of evaluation is being done?
• 3 trauma centers
• 65 Pauwel’s III vertical neck fractures in patients <50 yo undergoing repair
• Exclusion:
  – Acetabular or femoral shaft fx
  – Arthroplasty

Collinge, Beltran, Reddix, and Mr. J Ortho Trauma submitted
Treatment Decisions

What sort of evaluation is being done?
• “AP and ‘lateral’” Xrays 65/65
  – 30/65 (55%) had adequate Xray
• “Advanced” imaging
  – 2% had dynamic/ traction views
  – 55% had CT scan (25/30 trauma scans)

Finding: Half went to OR with this radiographic work-up

Fracture Morphology

• Confirmed vertical fracture
Fracture Morphology

- External rotation deformity
- Fracture rarely transverse

Fracture Morphology

- Comminution
  - Young 95%
- Apex inferiorly on calcar

Fracture Morphology

- Loss of the calcar buttress: 50%
Fracture Morphology

Understanding fracture morphology
• Oblique- Cranial shear
• Oblique- Posterior shear + comminution
• Calcar defect
• +/- osteopenic bone
• +/- segmental bone loss

All we have to offer is 3 cannulated screws? or a SHS +/- AR screw?
Fracture Morphology

So now what?
• Better idea of obtaining reduction
  – Open (vs. closed)
• Not everyone gets the same construct (?)
  – Fixed angled devices with rotational control?
  – Buttress plating the neck?
• Modelling for Lab studies

Case Example 1
Reduction

• Must overcome deformity and muscle forces

External rotation

Reduction

Ideal reduction is **ANATOMIC**
– Restores muscle lengths, levers
– Restores fracture stability
  • Optimizes fractures mechanics
  • Interdigitates bony interstices

• Acceptable?: ≤15° valgus, ≤10° AP
• NO varus is acceptable

Reduction

• Leadbetter Technique
  – Flex the hip to 90°, slight adduction
  – In-line traction with the femur
  – While maintaining traction, IR to 45°
  – Slowly move into slight abduction and full extension, while maintaining traction and internal rotation

• Lots of others
Quality of Reduction

Assessed inter-rater reliability of surgeons using reduction grading systems
Reviewed series of femoral neck ORIF’s
5 scales used vs. “clinical impression”

Karanicolas et al. Interobserver Reliability of Classification Systems to Rate the Quality of Femoral Neck Fracture Reduction. JBJS-Am 2004

“Overall impression” used in practice

Trauma trained surgeons better reliability for assessment of quality of reduction, vs. non-trauma and trainees
• Excellent neck exposure

• Traction (or not)

• Joy stick(s)
  - Rotate
    - Push/pull(?)
    - Provisional fixation

• Bone hook
  - Pull (rotate)
**FIGURE 4.** A, A 16-year-old female involved in a high-speed motor vehicle accident. The patient sustained a left external iliac artery injury requiring emergent repair. The reduction was then temporarily held with a 3.5-mm pelvic reconstruction plate (D and E). Definitive fixation was placed percutaneously using small incisions (F and G). The bone hook prevents subluxation through the acetabular fracture.

**Fixation**

- **Clamps**
- **Small or mini-frag plates**

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<table>
<thead>
<tr>
<th>Fixation Method</th>
<th>Femoral Head Displacement at 500N (mm)</th>
<th>Change in Inferior K-wire at 500N (mm)</th>
<th>Change in Superior K-wire at 500N (mm)</th>
<th>Load to Failure (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cancellous lag screws</td>
<td>2.1 (2.3)</td>
<td>2.6 (1.6)</td>
<td>1.9 (2.2)</td>
<td></td>
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<tr>
<td>Sliding Hip Screw</td>
<td>0.4 (0.3)</td>
<td>1.3 (0.5)</td>
<td>0.6 (0.2)</td>
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</tr>
<tr>
<td>Results</td>
<td></td>
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</tbody>
</table>

"The SHS outperformed 3 cannulated screws in Pauwels 3 femoral neck fractures."
Comparing 4 Constructs

• Mechanical testing
• 3 cannulated screws vs SHS vs DCS vs crossed lag screws
• Young cadavers (21-58)
• Pauwels 3
• Flat cut
• No comminution

Results

“The DCS and crossed screws outperformed 3 parallel cannulated screws and the SHS in Pauwels 3 femoral neck fractures.”

Table: Force at 2 mm displacement (N)

<table>
<thead>
<tr>
<th></th>
<th>Force at 2 mm displacement (N)</th>
<th>Force at 4 mm displacement (N)</th>
<th>Force at 6 mm displacement (N)</th>
<th>Stiffness (Nm/mm)</th>
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</thead>
<tbody>
<tr>
<td>CS</td>
<td>1798.3, 34.04</td>
<td>1818.7, 34.54</td>
<td>1831.8, 36.72</td>
<td>2125.6, 54.71</td>
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<tr>
<td>SHS</td>
<td>2962.5, 34.04</td>
<td>2979.1, 34.72</td>
<td>2985.7, 34.89</td>
<td>3233.7, 34.35</td>
</tr>
<tr>
<td>DCS</td>
<td>1012.3, 34.04</td>
<td>1023.7, 34.89</td>
<td>1030.1, 34.62</td>
<td>1052.5, 34.35</td>
</tr>
<tr>
<td>LSC</td>
<td>326.5, 41.04</td>
<td>329.7, 41.85</td>
<td>332.1, 42.10</td>
<td>334.3, 42.30</td>
</tr>
</tbody>
</table>

Values with * indicate a significant difference with CS (p < 0.05). Values with † indicate a significant difference with SHS (p < 0.05).

Fixation

Buttress Plate Augmentation

• Mechanical testing
• 4 constructs
• Sawbones IV
• Pauwels 3
• No comminution
Buttress Plate Augmentation


“Medial buttress plating improves resistance to vertical fixation failure for cannulated screws and SHS.”

Summary: Case 2

ED X-rays

Summary: Case 2
Summary: Case 2

Femoral neck Fx in young adult
- Assessment
- Pre-op planning
- Reduction
- Fixation
- Complication management

Conclusions

Pauwels III femoral neck Fx in young adult
- We need to understand the injury better
- Requires a thoughtful solution
Thank You