Periprosthetic Fractures

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Take Away Messages

• Assessment – Classification
  • Fracture and implant and bone

• Treatment options
  • Complete bone, stability
  • Technical tricks
    • Screws, struts, cerclage, nails

• Results
  • Heal but patient outcome poor
The Problem(s)

- Elderly, increasing number
- Poor bone quality
- Prosthesis blocks fixation possibilities
- No endosteal blood supply if cemented stem
- High stress adjacent to prosthetic stems
- Many fixation techniques - inadequate

Whose job is it?

Both Skill sets needed
Fracture needs fracture surgeon
Revision needs joint surgeon
Assessment

- **Patient:**
  - Health – comorbidities: stable or active
  - Acute status – low energy vs. high energy: trauma evaluation, medical assessment
  - Function – what can they do

- **Limb:**
  - Vascular – acute, chronic
  - Neurological
  - Skin
  - Prior incisions
Assessment

• Fracture:
  • Location
  • Morphology – simple or multi fragmentary
  • Closed vs. open

• Prosthesis – Bone Interface
  • Loose – history, x-rays, CT Scan, OR
  • Bone quality – cortical thickness, erosions
  • Type – cemented vs. non cemented
  • Facing implant condition

Assessment

• Your System
  • Fragility fracture patient
  • Prompt operative care
  • Bone health
    • Acute
    • Discharge
    • Follow-up
Diagnosis - Classification

• Consolidates the 3 most important factors
  • Site of the fracture
  • Stability of the implant
  • Quality of the surrounding bone

Vancouver Classification

Duncan CP, Masri BA. Instr Course Lect 1995; 293-204
Vancouver Classification System

- Type A: Trochanteric
- Type B: Shaft Fracture around stem
  - B1: implant stable
  - B2: implant unstable
  - B3: implant unstable / bone deficiency
- Type C: Shaft Fracture below component
  - C1: implant stable
  - C2: implant unstable
  - C3: implant unstable / bone deficiency

But what about these?
Universal Classification

The location of the fracture (involves the bone supporting the prosthesis)

- Type A: Apophyseal
- Type B: Bed of the implant
- Type C: Clear of the implant
- Type D: Dividing the bone between two implants
- Type E: Each of two bones supporting one arthroplasty
- Type F: Facing and articulating with a hemiarthroplasty implant or is distant to it

The fixation interface of the implant to bone

The adequacy of the bone stock and bone strength supporting the implant

![Bone cross sections showing different bone quality](image)
Universal Classification

• Fracture classified by AO/OTA (Müller) system

• Joints coded as:
  • I = shoulder
  • II = elbow
  • III = wrist
  • IV = hip
  • V = knee
  • VI = ankle

Universal Classification

• Code
  • Joint, AO/OTA code, UCS Type, Bed of implant
But what about these?

- Knee – V
- Femur – 3
- Distal end segment femur - 33
- Simple Transverse 33-A3
- Fracture location: B
- Well fixed, good bone quality – B1
- V33A3(B1)

But what about these?

- Knee – V
- Tibia – 4
- Proximal end segment femur - 41
- Simple Oblique 41-A3
- Fracture location: tip of implant B
- Loose?, good bone quality – B2
- V41A3(B2)
But what about these?

- Shoulder – 1
- Humerus – 1
- Shaft- 12
- Spiral wedge 12B1
- Fracture location: C
- Well fixed, good bone quality – B1
- I12B1C(B1)

Management
74 yr. old male in MVC

Well fixed, good bone stock, segmental IV32C2B1 and IV33A3CB1

Prosthesis Stability

• Determination
  • Clinical
    • Pain – pre fracture, start up
    • Infection history
    • Type of implant
  • Radiological
    • Prosthesis alignment and changes
    • Subsidence – lack of bone ingrowth or loose prosthesis
    • Osteolysis – bone quality - CT scan
Prosthesis Stability

• Intraoperative
  • Hip
    • Lindahl showed 47% of “stable” prosthesis were loose
    • Recommended surgical exploration of all cases and be prepared to revise
    • With good bone quality, may consider fixation and revise later if needed
  • Knee
    • CT maybe helpful
    • Very low fractures generally have no bone
      • Intraoperative
  • Others

Principles: Internal Fixation

• Maintain fracture environment that optimizes fracture healing
  • Indirect reduction
  • Atraumatic surgical techniques - MIPO

• Splint the entire bone (longer working length)
  • Functions as bridge plate
  • Protects osteoporotic bone

• Screws when possible rather than cables
  • Bicortical if possible
Biomechanics of Screw Fixation
Fulkerson E, Egol K, et al. J of Trauma 60(4); 830 – 835, 2006

**Principles**

- Fracture environment to optimizes fracture healing
  - Mechanical environment
    - Relative stability – fragmentation
    - Minimum plates -10 hole for simple, 14 hole for fragmented
    - Anatomical approximation – simple fracture
    - Interfragmental compression is hard to achieve in osteoporotic bone
    - Allograft strut enhance poor cortex and improve mechanical stability
      - Fractures at tip of prosthesis
Allograft Struts

• 1/2 length of femur, 2 dia. of femur on each side
• Anterior surface
• Must be contoured to fit
• Held with cerclage to plate
• Consider allograft and DMB at ends

Hartsock, JAAOS Jan 2014

Locked Plates

Bicortical Fixed Angled Locking Plates

Unicortical Fixed Angled Locking Plates

Variable Angled Multi holed Locking Plates
Plate Constructs - Mechanics

• Tested metal plate laterally with bicortical screw fixation distally and proximally
• Cerclage with cables thru plate X 4
• Screws unicortical x 4
• Stable fracture versus unstable fracture pattern

• Screws better than cerclage < stiffness especially with unstable fracture pattern

Lever, J. J of Ortho Surgery and Research 5: 45, 2010

Enhance Stability

Cerclage

• through or attached to plate
• must have screw fixation with it

Variable angled screws with plate attachment
Principles

• Enhance the fracture environment that optimizes fracture healing
  Biological
    - Bone grafting — autogenous or allograft or both
    - Bone graft substitutes — DMX
    - BMP

Biomechanics

• Torsional capacity ↓ 55-65% of intact femur for all plates and nails (effect of a screw hole)
• Axially loading
  • Plate: similar load bearing capacity to intact with over lap plate and IDD>10cm
  • Nail: IDD no effect if AP screws used — as close as need be
    • Lateral- medial screws ↓ load capacity by 22%

Piendl, Mazurek et al, OTA 2003
74 yr. old male in MVC

Options

Management

Limited access thru 3 incisions, LCP, BMP + allograft
Follow-up 15 months

78 yr old male who tripped on a rug

IV32B(B2)

Hip, femur, wedge fracture of shaft, bone stock poor prosthesis stability?
Uncemented Femoral Component

Management: Revision
74 yr. old male in a MVC

- Hip IV
- Femur 3
- Proximal shaft 32
- Multifragmented fracture 32C
- Bone quality good B2
- Implant loose
- IV32CB2

Assess acetabular problems and may need to treat

Revision Principles

- Loose prosthesis + fracture at stem
- Good bone stock (B2)
- Revision of stem with adequate fracture fixation
  - Revision stem bypasses fracture by 2X outer diameter of diaphysis (4 to 6 cm)
  - Fracture fixation – struts, plates, cerclage, allograft
- Non cemented – no cement at fracture site
Revision Principles

- Poor bone stock – PROBLEM (B3)
- Revision of stem + bone stock operation
  - Allograft, struts,
  - Proximal femoral allograft prosthesis composites

Unstable Prosthesis and No Bone Stock

Proximal Femoral Allograft Prosthesis Composite
80% union to shaft
### Results: BI Fractures

<table>
<thead>
<tr>
<th></th>
<th>Lindahl</th>
<th>Haddad</th>
<th>Beals</th>
<th>Ricci*</th>
<th>O’Toole</th>
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<td>Death</td>
<td>13%</td>
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<td>17%</td>
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<td>Infection</td>
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<td>7%</td>
<td>3%</td>
<td>0%</td>
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<tr>
<td>Nonunion</td>
<td>33%</td>
<td>2%</td>
<td>13%</td>
<td>0%</td>
<td>5%</td>
<td>8/14 no struts</td>
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<td>Refracture</td>
<td>24%</td>
<td></td>
<td>2%</td>
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<tr>
<td>Q of Life</td>
<td>poor</td>
<td>52%</td>
<td>27%</td>
<td>70%</td>
<td>worse</td>
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### Fractures Proximal to Total Knee Replacement
Non Operative vs. Operative

Operative treatment best accomplishes these goals

Classification

- Lewis and Rorabeck (1997)
  - Based on fracture displacement and prosthesis stability

- Unified Classification System
Treatment Goals

- Restore axial alignment
- Stable fixation
  - Consider impaction (shortening up to 2 cm)
  - Plate whole length of bone
- Maintain fracture environment suitable for bony healing
- Return to pre-injury mobility
  - ROM as soon as possible

Treatment Options

- Retrograde intramedullary nail
- Locked plating
- Revision with stemmed prosthesis, allograft, or tumor prosthesis
Retrograde IMN vs ORIF

- Limited literature
- PS vs CR
- Canal diameter considerations
- TKA Notch vs canal diameter & alignment
- Femoral stem above?

Retrograde Nailing

- Is the notch open or closed?
  - Post cruciate sparing

- If open, is it large enough?
  - Narrow notch and closed box seen in posterior stabilized knees
Retrograde Nailing

- Problems:
  - Stability - toggle
  - Alignment

  • Uniplanar interlocking bolts
  • Bone quality
  • Capacious distal metaphysis
  • Distal fracture patterns
  • Malalignment

Clinical Evidence?

<table>
<thead>
<tr>
<th>LISS</th>
<th>Retrograde Nail</th>
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<tbody>
<tr>
<td>Markmiller M, CORR, 2004</td>
<td>Jabczenski FF, J. Arthroplasty, 1995</td>
</tr>
<tr>
<td></td>
<td>Bezwada HP, J. Arthroplasty, 2004</td>
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</tbody>
</table>
73 year old female

POST OP 12 WEEKS
48 yr male, MVC,

83 yr. old female with 3 stable comorbidities
Allograft-Prosthetic Composite

Constrained Rotating Hinge
Constraint comes at a price!

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