Fixation of Periprosthetic TKR
Fx’s: What to look for, What to consider, What to do…

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Disclosure

• Design Team
  • Depuy / Synthes
  • Biomet

• Educational Consultant
  • Depuy
  • Biomet
Etiology

• 0.3 to 2.5% TKR’s

• Risk Factors
  • Osteopenia
  • Osteolysis
  • Having a TKR
    • Decreased BMD 6-12 mo post-TKR
    • Notching? (0.5-52% TKR’s)
      • 1.5% of notched femurs (Gujarathi N, et al: Acta Orthop 2009)

• Low vs High Energy Mechanisms

• Morbidity and MORTALITY
Considerations

- Fracture location
- Implant stability
- Bone quality
Anatomy
Trapezoid cross section
Deforming Forces
Radiographic Evaluation

- Good Quality AP and Lateral
- CT scan
- Angiography
  - Asymmetric pulses
  - ABI <0.9
In 2017...

• WE SHOULD OPERATE unless:
  • Patient too medically unfit
  • Completely undisplaced fracture?
Goals of Treatment

• *Stable fixation* of the meta-diaphyseal fracture

• *Avoid complications*: malunion, nonunion, infection, arthrotfibrosis

• *Allow early movement* and rehabilitation
  • Minimize disability and maximize return to function
Achieving goals
Achieving goals
Achieving goals

Tornetta, J Trauma 1995
TKA Classification
Rothman Institute 2006

Type I: Good Bone Stock, Well Fixed Component
   IA non displaced-potential nonoperative (Rorabeck I)
   IB Displaced fx- operative (Rorabeck II)

Type II: Good Bone stock but loose or poorly positioned component
   -Revision with long stem components

Type III: Good or Poor bone stock with loose component
   --Revision TKA (Rorabeck III)

- Kim, et al. CORR, 446. 2006
# Decision Matrix

<table>
<thead>
<tr>
<th>Bone Stock Implant</th>
<th>Good</th>
<th>Bad</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good</strong></td>
<td>Nail vs. Plate</td>
<td>Revise vs. ORIF/Augment</td>
</tr>
<tr>
<td><strong>Bad</strong></td>
<td>Revise</td>
<td>Revise with long stem</td>
</tr>
</tbody>
</table>

*Note: Bad* indicates a more severe condition requiring more comprehensive treatment options.
Options

- IMN
- ORIF
- Supplements
  - CaPhos
  - Allograft
  - BG substitutes
- Revision TKR
Options

- What’s best to decrease r.r. nonunion?
  - IMN
  - Locked implants
  - Conventional plating / struts
  - Non-op

415 case meta-analysis
- IMN
- Locked implants
LISS vs Blade Plate

Higgins TF et al (JOT 2007)

• LISS
  • Less subsidence
  • Greater resistance to failure
  • Findings regardless of BMD

• LISS w/ multiple fixed angle devices that are multiplanar
Uni vs Bicortical screws…
Locking implants…

Simulation of Normal Cortical Bone**
Axial load required to displace selected plate/screw constructs by 0.5 mm

<table>
<thead>
<tr>
<th>Construct Type</th>
<th>Load (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 mm cortex screws, bicortical</td>
<td>+6%</td>
</tr>
<tr>
<td>4.0 mm locking screws, unicortical</td>
<td>+18%</td>
</tr>
<tr>
<td>4.0 mm locking screws, bicortical</td>
<td>+36%</td>
</tr>
<tr>
<td>5.0 mm locking screws, bicortical</td>
<td></td>
</tr>
</tbody>
</table>

**Simulation of normal cortical bone performed with 40 lb/ft² foam
Osteoporotic Bone

Simulation of Osteopenic Bone*
Axial load required to displace selected plate/screw constructs by 0.5 mm

<table>
<thead>
<tr>
<th>Construct Type</th>
<th>Load (N)</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.5 mm cortex screws, bicortical</td>
<td>100</td>
<td>+17%</td>
</tr>
<tr>
<td>4.0 mm locking screws, unicortical</td>
<td>200</td>
<td>+82%</td>
</tr>
<tr>
<td>4.0 mm locking screws, bicortical</td>
<td>400</td>
<td>+91%</td>
</tr>
<tr>
<td>5.0 mm locking screws, bicortical</td>
<td>600</td>
<td></td>
</tr>
</tbody>
</table>

*Simulation of osteopenic bone performed with 15 lb/ft³ foam
Options

• Can we increase pull-out strength w/ ORIF and osteopenia?

• PMMA or TCP w/ locking screws

• 5x increased pull-out strength to conventional plating

Collinge et al: JOT 2007
Patient NC
NC – F/U
Should 90-90 strut-plate be standard?

Biomechanical Evaluation of Periprosthetic Femoral Fracture Fixation

By Rad Zdero, PhD, Richard Walker, MD, James P. Waddell, MD, FRCS(C), and Emil H. Schemitsch, MD, FRCS(C)

- 90-90 strut / plate stronger than
  - Conventional plate
  - Locked plate ± cables

- Biomechanical study with THR’s

- WHAT ABOUT THE BLOOD SUPPLY???
Problem – Should we double plate?

Varus Collapse and shortening
Double-Plating of Comminuted, Unstable Fractures of the Distal Part of the Femur

  - 9 patients
  - Functional outcomes
    - 5 good results
    - 4 fair results
  - 1 patient with > 100° knee flexion
  - Neurovascular concerns medially

- WHAT ABOUT THE BLOOD SUPPLY???
Double-Plating of Comminuted, Unstable Fractures of the Distal Part of the Femur

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  - Functional outcomes
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    - 4 fair results
  - 1 patient with > 100° knee flexion
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- WHAT ABOUT THE BLOOD SUPPLY???
Saving the Blood Supply

- 10 cadaveric femurs

- CPO vs MIPPO
  - 16 hole LC-DCP

- Dye injection

- ALL MIPPO specimens with intact nutrient and perforating arteries

(Farouk & Krettek, JOT, 1999; Injury 1997)
Indirect Reduction of Metaphyseal Component
Effect of Keeping Periosteum

• Maintenance of b.s.
• Higher union rates
• Lower complications
• Less bone grafting

DF Implants

- Multiple “little blade plates”
- Difficult to get around implants

Issues with unicortical shaft screws
Locked Screws & Osteoporosis

- Cortical thickness
- Canal dilatation
- Working Length
  - Screw
- Bi-cortical Lock

(Gautier, Injury, 2003)
Fixed angle device with angular options???
Is polyaxial locking strong enough???

Results of Polyaxial Locked-Plate Fixation of Periarticular Fractures of the Knee

By George Haidukewych, MD, Stephen A. Sems, MD, David Huebner, MD, Daniel Horwitz, MD, and Bruce Levy, MD

- 56 peri-articular knee fractures
- 12 open
- All treated w/ POLY-AX plate

- 94% union
- No varus progression
- No screw or plate failures
What about the tibia?
Tibia TKR fx’s

- **Intra-op**
  - Metaphyseal
  - Tubercle osteotomy

- **Post-op**
  - Non-displaced
  - Displaced

Figure 1. Mayo fracture classification of periprosthetic tibial fractures.
Tibia TKR fx’s

- Intra-op
  - Metaphyseal
  - Tubercle osteotomy

- Post-op
  - Non-displaced
  - Displaced

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**TABLE 2. Classification of Postoperative Periprosthetic Tibial Fractures**

<table>
<thead>
<tr>
<th>Major Anatomic Pattern</th>
<th>Subcategory</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Tibial plateau</td>
<td>A. Well fixed prosthesis</td>
</tr>
<tr>
<td>II. Adjacent to stem</td>
<td>B. Loose prosthesis</td>
</tr>
<tr>
<td>III. Distal to prosthesis</td>
<td>C. Intraoperative</td>
</tr>
<tr>
<td>IV. Tibial tubercle</td>
<td></td>
</tr>
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Inter-prosthetic Fx

• Between TKR and THR

• Between TKR and Hip Fixation

Span Femur with LONG PLATE !!!
IMN

• Retrograde

• Antegrade
Retrograde Nailing

• Less invasive?
• Technically difficult
  • Purchase
  • Stability
Retrograde Nailing

• BUT…

• Ineffective or complicated w/ “boxed” TKR

• Limited distal fixation (osteoporosis)

• Increase risk prosthetic infection

• Increase risk of polyethylene damage / 3rd body
Intramedullary Nails

• Are they more stable than plates?

• Traditionally suggested to be biomechanically more advantageous to plates $\Rightarrow$ SHAFT FX’s

• Immediate WB’ing?
Comparison of the LISS and a retrograde inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty
Bong M et al J Arthroplasty 2002

- Laboratory biomechanical model
- Nail
  - Greater resistance to varus load and torsional load
- LISS
  - Greater resistance to valgus load w/ bone loss
Comparison of the LISS and a retrograde inserted supracondylar intramedullary nail for fixation of a periprosthetic distal femur fracture proximal to a total knee arthroplasty
Bong M et al J Arthroplasty 2002

• BUT…

• Did not address osteoporotic model

• Did not address all types TKR or LOW peri-prosthetic fracture

• Did not address model w/ varus bone loss
Biomechanical Evaluation of the Less Invasive Stabilization System, Angled Blade Plate, and Retrograde Intramedullary Nail for the Internal Fixation of Distal Femur Fractures

Michael Zlowodzki, MD,* Scott Williamson, BS,† Peter A. Cole, MD,* Lyle D. Zardiackas, PhD,† and Philip J. Kregor, MD‡

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**AXIAL LOADING:**

- **IMN < LISS**
  - LOAD-TO-FAILURES
  - LOW BMD
- **IMN > LISS**
  - LOAD-TO-FAILURES
  - HIGH BMD
Retrograde IMN

• Require accurate reduction
• May require supplemental fixation
• High union rates
• Risk valgus and extension deformity
Antegrade IMN
Extreme Nailing
Nailed Cementoplasty

Bobak, The Journal of Arthroplasty, 2010
Distal Femoral Plating Technique
GOALS

• Biologic preserving !!!
  • Respect soft tissues

• Restoration of:
  • Mechanical axis
  • Length
  • Alignment / Rotation

Biologic Felony
Non-articular or Simple Split

- Lateral approach
- ***Limited surgical dissection
- Percutaneous plate insertion

- Metaphysis Indirect Reduction
  - Bumps
  - Femoral Distractor
  - Percutaneous Pins
  - External fixator
REDUCTION CLAMP
Results of polyaxial locked-plate fixation of periarticular fractures of the knee. Surgical technique.
Results of polyaxial locked-plate fixation of periarticular fractures of the knee.

Surgical technique.

Plate Placement Problems

• Prior to complete plate fixation, must confirm appropriate location *distally and proximally*!!!
Plate Placement Problems

• Prior to complete plate fixation, must confirm appropriate location **distally and proximally!!!**
Plate Placement Problems

• Prior to complete plate fixation, must confirm appropriate location
  distally and proximally!!!
Plate Placement Problems

MALALIGNMENTS

USUALLY VALGUS

Diagram Courtesy of George Haidukewych, MD
Diagram Courtesy of George Haidukewych, MD
DISTRACTION
MALALIGNMENT
MALPOSITION

Diagram Courtesy of George Haidukewych, MD
NONUNION
LOSS OF FIXATION

Diagram Courtesy of
George Haidukewych, MD
- CHALLENGES

- SITUATIONS FOR SPECIAL CONSIDERATION

- SALVAGES
RetroIMN for PP FEMUR FXs

- Distal 1/3 Fx’s around Primary TKR
  - No “box” (CR)
  - If “box” (PS) with:
    - Removable polyethylene plug
    - Pre-existing hole
      - Try to avoid “making a hole” with a metal cutting burr

- Less Invasive?

- More biologically friendly?
CHALLENGES

• Lack of access
  • “Box” (PS) without ability to pass
  • Revision TKR
  • THR above

• Iatrogenic damage
  • Patella or tibia polyethylene

• Limited Distal Fixation

• Limited offerings that actually “Dial-in-Deformity”
  • Worse with CR or PS ???
DEFORMITY

Due to entry access
APEX-POSTERIOR

Lack of purchase in distal fragment
VALGUS
DIFFERENT ANATOMY PER PERSON
DISTAL ANGULATION
Nails CAN BE very FORGIVING at times…
Patient has full extension and >90 degree flexion!

LOL – Seriously?
SS
Left Side

10 months from IMN
Limited ROM

“Why am I in PAIN !!!”

Nails CAN BE very FORGIVING at times… but NOT ALWAYS !!!

INADEQUATE STABILITY WITH CURRENT IMN ALONE
SOME ANSWERS FOR DENSITY OF FIXATION

- Multi-lock screws
  - Multi-directional support with fixed angle screw within a screw
    - LISS vs Blade idea

- Screw configuration
  - Additional screws
  - Take advantage of PM and PL condyles

- Plate attachment to Nail
  - ALL OF THE ABOVE !!!
SCREW CONFIGURATION
PLATE ATTACHMENT
WHERE COULD WE GO WITH THIS?

• Plate – Nail combo’s

  • Fx “needing” a nail with a THR above or rev TKR below
  
  • Metaphyseal Nonunions requiring better fixation

  Distal femoral nonunion: treatment with a retrograde inserted locked intramedullary Nail
  
  • 25% union rate of nonunions with retrograde IMN alone

  • Osteoporosis

  • Avoid deformity (Distal Femur, Proximal & Distal Tibia)

  • “Dial-in” stability

• LINKED NAIL / PLATE COMBOS…
Patient BP

Periprosthetic tibia

Subtroch fx above stemmed tkr
Reasonable operation choice done wrong...
77 yo male periprosthetic fracture
77 yo male periprosthetic fracture
77 yo male periprosthetic fracture
77 yo male periprosthetic fracture

Locked screws in Fx Zone
Excessively Rigid Fixation
Short segment proximal fixation
NOT Balanced Fixation
Multiple cerclage
Dissection to get “Chicken Claw”
77 yo male periprosthetic fracture
EV – vacation in Mexico gone wrong
JZ

Distal Femoral Fx 10 yrs ago w/ 4 time nonunion s/p platings above TKR

THR above that had previous fx at stem tip

Non-ambulator x 2.5 years

***INFECTED***
ROUND 1

RESECTION ATROPHIC NU

ANTIBIOTIC PLATE
ROUND 2: Nail - Plate

Current IMN offering
Can promote
APEX POSTERIOR:

Future Directions ➔
Distal angular options?
LINKED Plate / Nail BOTH:
Proximally & Distally w/ IMN
2.5 months post-definitive op
Uses walker – 1st time in 2.5 yrs
Proximal and Distal N/P Linkage

CALLUS
PLATE-NAIL SUMMARY

- Improve “reliability” and “feasibility” of current retrograde IMN usage
  - Improve stability – DISTAL FRAGMENT
  - Decrease late deformity

- Allow for improvement with ease of REDUCTION

- PREVENTATIVE Tx of potential Interprosthetic fx

- Allow for expanded IMN nailing indications

- Can “dial-in” desired amount of STABILITY
Future directions

• Implants to accommodate tibia IM fixation

• Modular implants
  • Modular Plate
  • Modular Nail / Plate or Locking washer

• Mating Implants
  • TKR with THR above
Top 5 DO’s

• Complete radiographs
  • Implant or bone incompetence

• Distal Femur Fx’s if implant stable
  • INDIRECT reduction techniques

• Distal Femur Fx’s retrograde IMN
  • Check box status
  • “Healthy” incision
    • Don’t ream polyethylene
    • Don’t leave reamings in joint

• Consider polyaxial implants and bone substitute augmentation

• If THR above, span both implants

Top 5 DON’Ts

• Don’t accept axis deviations → implant wear

• Don’t leave loose implants

• Don’t use incompetent fixation
  • Allograft with cables ONLY
  • Wires only
  • Screws only or NON-Balanced plate fixation

• Don’t delay post-op ROM

• Don’t delay surgery in elderly
  • Systemic manifestations similar to hip fx’s
Thank you