Distal Femur Fractures

David J. Stockton, MD MASc
University of British Columbia
Department of Orthopaedics
Top 5 Learning Objectives

1) Osteology & deforming forces
2) Fracture classification
3) Treatment options and considerations
4) Surgical approaches
5) Fixation options

Introduction

• Account for 7% of all femur fractures
  • Bimodal distribution: High-energy injuries in the young, low-energy in the elderly

• Historical treatment
  • 1960’s and earlier: Skeletal traction favored
    • Neer et al. (JBJS 1967) advocated for closed, non-operative treatment based on poor results and high complications resulting from ORIF
  • 1960’s: Angled blade plate introduced and subsequently the dynamic condylar screw (DCS) plate improved fixation options
  • 1990’s: ORIF established as the standard of care (Butt et al., JBJS Br 1996)
  • 2000’s: Early iterations of the lateral locking plates improved outcomes (Weight & Collinge, JOT, 2004)
  • 2010’s: Improved plate design and ongoing experimentation with far cortical locking (FCL) and intramedullary (IM) nail design aim to improve non-union rates and allow for early weight-bearing
Osteology

- Shaft of femur aligned with anterior half of lateral condyle
- Anatomic axis 9° valgus (range 7–11°)
  - anatomic lateral distal femoral angle (aLDF) 81° (79°- 83°)
  - mechanical lateral distal femoral angle (mLDF) 87° (85° - 90°)
- Sectioned axially, distal femur is trapezoidal
  - Ramifications for:
    - Implant placement
    - Screw prominence

Injury Considerations

• Mechanism of injury
  • Young patient: high energy (MVC, fall from height)
  • Elderly: low energy fall on flexed knee

• Deforming forces
  • Quadriceps ➔ shortening
  • Hamstring ➔ shortening
  • Gastrocnemius ➔ apex posterior angulation, posterior displacement
  • Adductors ➔ varus

Injury Considerations

- Associated injuries
  - Open fracture (5-10%)
  - Knee ligament injury (up to 20% of cases)
  - Tibial plateau fracture
  - Patella fracture
  - Acetabulum fracture
  - Femoral neck fracture
  - Femoral shaft fracture

Courtesy of Jeff Potter, MD
Injury Considerations

• History
  • Mechanism of injury
  • Ambulatory status
  • Pre-existing knee arthritis

• Physical exam
  • If high energy injury: ATLS
  • Examine for other injuries
  • Neurovascular status of limb
    • Ankle-brachial index/ CT angiogram if any discrepancy in pulses
  • Inspect for soft tissue injury

Indications for CT angiogram:
1) Diminished/ absent pulse
2) Expanding hematoma
3) ABI <0.9
4) Persistent arterial bleeding
5) Damage to associated nervous structures
Injury Considerations

• Workup
  • Orthogonal X-Rays
    • **Double-density** on AP X-Ray: Hoffa fragment
    • ‘**Paradoxical notch view**’ on AP X-Ray: articular fragment in recurvatum
  • Image joint above and below
  • Low threshold for CT scan
    • Demonstrates intra-articular involvement
    • Reveals coronally oriented **Hoffa fracture**
      • 38% incidence (Nork et al., JBJS 2005)
      • Lateral > medial condyle
      • Missed ~31% of the time

Courtesy of Jeff Potter, MD
Injury Considerations

• Prior to classifying the fracture, consider:
  • Amount of displacement
  • Degree of comminution
  • Extent of soft tissue injury
  • Damage to the articular surface
  • Bone quality
  • Associated fracture of patella or tibial plateau
  • Associated neurovascular injury
  • Presence of coronal fracture line
Fracture Classification: AO/OTA

Bone: femur 3

Location: distal segment (33)

Types
A. Extra-articular (33-A)
B. Partial articular (33-B)
C. Complete articular (33-C)

Fracture Classification: AO/OTA

33
Location: Femur, distal end segment 33

Types:
Femur, distal end segment, extraarticular fracture 33A
Femur, distal end segment, partial articular fracture 33B
Femur, distal end segment, complete articular fracture 33C


Core Curriculum V5
33A: Extra-articular

33B:
Partial articular

33C:
Complete articular articular

Treatment options

- Relative indications for non-operative management
  - Patient factors
    - Medical contraindication to surgery
    - Non-ambulatory
  - Fracture factors
    - Non-displaced fracture
    - Impacted, stable fracture
    - Non-reconstructable fracture
    - Severe osteopenia
  - Surgeon factors
    - Lack of experience with operative treatment
    - Lack of appropriate instrumentation or facilities available

Though non-operative treatment is rare, outcomes may be superior to poorly conceived and executed operative treatment.
Treatment options

• Non-operative treatment
  • Long-leg cast followed by hinged knee brace
  • Early range of motion is key to avoid stiffness

Evidence
• Butt et al., JBJS Br 1996
  • RCT of 42 patients >60yrs old with displaced fractures to treatment with a Dynamic Condylar Screw versus skeletal traction with knee flexion exercises at 3-4 weeks
  • 53% of patients in operative group had excellent or good results, versus 32% in non-op group
  • Significantly more complications in the non-op group, many related to extended period of immobility (UTI, pressure sores, DVT, and pressure sores)
Treatment options

• **Operative indications:**
  - Majority of distal femur fractures do not meet non-operative indications

• **Operative Goals:**
  1) Anatomic reduction of articular surface
  2) Functional reduction of the metaphysis restoring length, alignment, and rotation
  3) Restoration of anatomic and mechanical axis of the limb
  4) Stable fixation
  5) Early range of motion
Surgical Approaches

• Lateral
  • Most common approach
  • Skin incision in mid-lateral line of femoral shaft, curving slightly anteriorly over lateral femoral condyle towards tibial tubercle
  • Distal extent determined by need for joint arthrotomy if intra-articular reduction needs to be performed
  • Proximal extent determined by whether fracture will be directly or indirectly reduced
  • Divide IT band in line with its fibers
  • Incise vastus lateralis fascia and elevate fibers off septum, from distal to proximal, ligating femoral artery perforating vessels


Surgical Approaches

• Swashbuckler
  • Indicated when more articular reduction and fixation is needed
  • No tourniquet (prevents medial retraction of quads)
  • Midline anterior incision, curving laterally proximally
  • Quadriceps fascia incised in line with skin incision, connecting distally with a lateral parapatellar arthrotomy
  • Fascia & IT band elevated off vastus lateralis; IT band retracted laterally and quadriceps retracted medially


Surgical Approaches

• Medial
  • Useful for isolated medial condyle fractures or severely comminuted fractures in which medial fixation is required
  • Straight medial incision extending distally to a point just anterior to adductor tubercle
  • Fascia divided in line with skin incision, anterior to sartorius
  • Vastus medialis elevated, care taken to avoid articular branch of descending geniculate artery (DGA) and muscular branch to vastus medialis
  • Muscular branch of DGA ~5cm and adductor hiatus ~16cm proximal to adductor tubercle


Surgical Approaches

• Limited anterior approach for IM nailing
  • Trans-patellar tendon incision or medial to tendon
  • Start point just anterior to femoral origin of PCL
  • Centered in shaft on AP Xray
  • Anterior edge of Blumensaat’s line on perfect lateral Xray

Reduction Tools

- Chemical paralysis
- Bump placed under knee corrects apex posterior deformity by relaxing gastrocnemius muscle
- Adequate exposure
- Femoral distractor
  - ‘Pre-load’ Shanz pins (angle them slightly away from fracture) to account for angular deformity induced by distraction
- K-wires
- Reduction clamps
  - Large Weber clamps
  - Large peri-articular reduction clamp

Courtesy of Claude Sagi, MD
Types of Fixation

• Lateral pre-contoured plates
  • May be used for most fracture patterns

• Retrograde intramedullary nail
  • Most common for AO/OTA type A fractures
  • Some simple intra-articular patterns (AO/OTA type C1 & C2)

• Dynamic condylar screw/ Angled blade plate

• Distal femoral replacement
  • Elderly, pre-existing osteoarthritis, severely comminuted, with a need to immediately mobilize

• Augmented fixation
  • Bilateral plates, plate/ nail combo

• Buried screw fixation for Hoffa fractures
Fixation Options

• Lateral pre-contoured plates

  • Modes of fixation:
    • Simple fractures: neutralization plate for an anatomically reduced fracture with lag screw fixation
    • Comminuted fractures: bridge plate
    • Vertical shear fracture fixation: buttress plate

• Available with variable-angle locking, fixed-angle locking, and non-locking options

• Have largely replaced the dynamic condylar screw and blade plate
Fixation Options

• Pre-contoured lateral plates
  • **Stress modulation**: the concept of manipulating bridge plating variables to optimize the flexibility of the construct to allow callus formation (Beltran et al. JOT 2015)
    • Titanium vs. stainless steel
    • Locking vs. non-locking
    • Unicortical vs. bicortical screws
    • Plate length
    • Screw hole fill
    • Working length
Fixation Options

• Far-cortical locking plates
  • Biomechanical and animal studies show increased and more evenly distributed callus
  • Plumarom et al., JOT 2019
    • Retrospective cohort of AO/OTA type A, C, and periprosthetic fractures
    • 42 treated with far-cortical locking plates and 15 with lateral locked plates
    • mRUST scores from blinded radiographs statistically higher in FCL group at 6, 12, and 24
    • 91% union for FCL group vs. 82% for LLP group at one year
Case Example

• 59 year old male, workplace injury where a 250lb marble slab fell on his leg
• Pre-existing severe knee osteoarthritis

Courtesy of Jeff Potter, MD
2 week post-op X-Ray

Final 1 year follow-up X-Ray

Courtesy of Jeff Potter, MD
Fixation Options

- Dynamic Condylar Screw (DCS) plate
- Less Invasive Stabilization System (LISS)
- Evidence:
  - COTS group, JOT 2016
    - RCT comparing LISS (28 patients) vs the DCS (24 patients)
    - 52% of LISS group healed at 12 months vs. 91% in the DCS group
- Both have largely been replaced by modern implants that have variable angle/ fixed angle, and non-locking options

Fixation Options

- Limitations of lateral locked distal femur plates: non-union
  - Up to 31%
  - Rodriguez et al., JOT 2016
    - Retrospective study including 271 supracondylar femur fractures
    - Nonunion rate 13%
    - Plate material (stainless steel) and those with high rigidity scores were associated with nonunion
    - Rigidity score included: plate material, presence of screws across main fracture, and proximal screw density
  - Ricci et al., JOT 2014
    - Retrospective study including 335 AO/OTA Type A or C fractures
    - Nonunion rate 19%
    - Risk factors for reoperation to promote union include open fracture, diabetes, smoking, increased BMI, and shorter plate length
Fixation Options

• Intramedullary nail
  • Minimizes disruption of soft tissues
  • Improved designs (multiple distal screw options and ability to lock distal screws to the nail) have expanded their indications
  • Retrograde nail should extend to the level of the lesser trochanter, or at least allow two proximal interlocking screws
  • Antegrade nails may be an option for high supracondylar fractures or segmental fractures
  • Reduce fracture prior to reaming

Fixation Options

• Dynamic condylar screw/ angled blade plate
  • Currently, used at times for nonunion/ revision scenarios
  • Stiff constructs (stainless steel)
  • Condylar screw & blade must be inserted parallel to joint
  • Position in the articular fragment is critical to avoid malreduction

Case Example

- 68 year old man, left leg crushed when trailer fell off a jack and onto his leg
- Open left segmental, comminuted distal femur fracture

Courtesy of Mike Moran, MD
2 week follow-up X-Rays

Courtesy of Mike Moran, MD
• Distal femur & shaft fracture nonunion established at one year

• Persistent pain, no infectious symptoms, skin healed with no draining sinus, CRP normal
Intra-op image confirming DCS placement

Union by 6 months post-op

Courtesy of Mike Moran, MD
Fixation Options

• Distal femur replacement
  • Advantages
    • Immediate weight-bearing, eliminates risks of nonunion, malunion, fixation failure, and post-traumatic OA (Meluzio et al. Injury 2020)
  • Disadvantages
    • Limited salvage options in cases of osteolysis, loosening, periprosthetic fracture, or infection
Fixation Options

• Lateral plate augmented fixation with
  • Medial pre-contoured distal tibia plate
  • Medial 3.5mm recon plate
  • Retrograde IM nail

• May be useful to avoid varus failure and permit early weight-bearing

• Fontenot et al. J Orthop Trauma 2019
  • Biomechanical study using 28 synthetic femora
  • Both Lateral plate plus medial recon plate & lateral plate plus nail exhibited higher stiffness and load to failure

• Wright et al. J Orthop Trauma 2020
  • Dual plate fixation had slightly higher torsional and axial stiffness

Fixation Options

• Hoffa fracture fixation
  • Caused by shear moment through posterior condyle
  • Do not miss these fractures
  • Require independent screw fixation-prior to plate- in the sagittal plane
  • Flexion of knee helps to reduce fragment
  • Fixation outside articular margin when possible; buried/ headless screw when not
  • Very small posterior fragment may require posterior to anterior screw

Post-surgery Rehabilitation

• Traditional had been NWB for up to 12 weeks

• New evidence suggests immediate or early weight-bearing does not increase fixation failure rate
  • Poole et al., BJJ 2017
    • Case series of 127 fractures in patients with mean age 73 years old fixed with lateral distal femur locking plate
    • 84% were allowed to weight-bear immediately. At minimum 1 year follow-up, 95% united and only 3% required re-operation for failure of fixation
  • Lieder et al., JOT 2020
    • Retrospective cohort of 135 patients with AO/OTA Type A and periprosthetic femur fractures allowed to either weight bear immediately or touch-down weight bear
    • No difference in adverse events (11% WBAT vs. 19% TDWB) including early fixation failure, nonunion, or infection

• Range of motion initiated immediately post-op

• Involve primary care physician and/or endocrinologist if osteoporosis is a concern
References


References


