Objectives

• Recognize the anatomy of the proximal tibia
• Describe initial evaluation and management
• Identify common fracture patterns
• Apply treatment principles and strategies
  • Partial articular fractures
  • Complete articular fractures
• Discuss rehabilitation, complications, and outcomes
• Illustrate selected tibial plateau cases
Epidemiology
(burden of disease/cost to society)

• Tibial Plateau
  – Articular surface proximal tibia
  – +/- metaphyseal /diaphyseal extension
• Account for 1.2% of all fractures
• Lateral Plateau: 55-70% of fractures
• Medial Plateau: 10-20% of fractures
• Bicondylar Plateau: 10-30% of fractures
Epidemiology
(burden of disease/cost to society)

• Bimodal distribution
  – Young adults: high energy mechanism
    • Highest in 5th decade
    • Male > Female
  – Elderly: low energy mechanism
    • Osteoporotic bone
    • Female > Male

• Significant functional impairment
  – Joint incongruity, malalignment, instability
  – Post-traumatic arthritis
Anatomy

• Consist of medial and lateral plateau
  – Medial larger
  – Medial lower (concave)
  – Medial bone harder (thus less likely to fracture)
  – Lateral higher (convex)
  – Lateral cartilage thicker (3 vs.. 4 mm)
Anatomy

Medial concave

Lateral convex
Anatomy

- Bony prominences
- Intercondylar eminence (menisci & cruciate ligaments attachment)
- Tibial tubercle (patellar tendon)
- Gerdy’s tubercle (Iliotibial band)
- Tibia slope: 10 degrees posteroinferior
Anatomy

- **Lateral Meniscus**
  - Larger (cover more articular surface)
  - Commonly torn with lateral plateau fracture

- **Medial Meniscus**
  - “C” shaped
Mechanism of Injury

- Valgus producing force
  - Lateral plateau
- Varus producing force
  - Medial plateau
- Axial compressive force
  - Bicondylar plateau
- Combination
  - High energy
  - Bicondylar plateau
  - Soft tissue injury
Mechanism of Injury

- Valgus producing force
  - Lateral plateau
- Varus producing force
  - Medial plateau
- Axial compressive force
  - Bicondylar plateau
- Combination
  - High energy
  - Bicondylar plateau
  - Soft tissue injury
Mechanism of Injury

- Valgus producing force
  - Lateral plateau
- Varus producing force
  - Medial plateau
- Axial compressive force
  - Bicondylar plateau
- Combination
  - High energy
  - Bicondylar plateau
Mechanism of Injury

- **Low energy**
  - Split depression
  - Increasing age
  - Poor bone quality

- **High energy**
  - Pedestrian vs. car (bumper)
  - Fall from height
  - Motor vehicle accident
  - Axial load (knee extended)
  - Bicondylar fracture
  - Associated injuries
Associated Injuries

- Ligaments
  - MCL, LCL
  - ACL, PCL
- Menisci
  - Lateral meniscus likely if:
    - > 5mm depression
    - > 6mm condylar widening
  - Gardner J Trauma 2006
- Popliteal artery
- Peroneal nerve
- Compartment syndrome

MCL tear
Associated Injuries

- Lateral plateau
  - Tear of meniscus
  - MCL / ACL tear
- Medial Plateau
  - Fracture / dislocation variant
  - Popliteal artery injury
  - Peroneal nerve injury
- Bicondylar
  - Open injury
  - Compartment syndrome
Evaluation - History

- Mechanism of injury
- Injury factors
  - Soft tissues
  - Fracture patterns
  - Associated injuries
- Patient factors
  - Age
  - Bone quality
  - Comorbidities
- Previous level of activity
  - Function demands
Evaluation – Physical Exam

• Initial Inspection
  – Skin integrity
  – Soft tissue swelling
  – Open fracture
  – Gross deformity
  – Shortened limb
  – Neurovascular status

• Document the Exam!!!
Evaluation – Physical Exam

- **Low energy mechanism**
- Knee swelling
- Limited knee ROM
- Tender to palpation
- Able to assess knee stability
  - Varus/valgus stress
  - 0 and 30 degrees
  - Lachman’s exam for ACL deficiency
Evaluation – Physical Exam

- **High energy mechanism**
- Advanced Trauma Life Support (ATLS)
  - Resuscitation
  - Limb threatened
- Soft tissue integrity
  - Open fracture
  - Abrasions
  - Blisters
- Compartment syndrome
- Knee stability exam
  - Difficult to perform
Evaluation – Physical Exam

• Soft tissue assessment

• Know
  – Gustilo & Anderson open fractures classification
  – Tscherne - closed fractures classification

• Avoid missing compartment syndrome

• Determine timing of surgery
  – Skin wrinkles present?
Evaluation – Physical Exam

- Document NV status
- Neurologic
  - Peroneal nerve
- Vascular
  - Ankle-Brachial Index
  - ABI > 0.9
Evaluation – Physical Exam

- ABI
- Screening test
  - LE injuries with concerns for vascular injury
- Obtain systolic pressure
  - Uninjured upper extremity (Brachial)
  - Injured LE limb (Ankle)
  - BP cuff just proximal to the ankle
  - DP or PT pulse
Evaluation – Physical Exam

• ABI < 0.90
  – Predictable of arterial injury
  – Vascular consult
  – Proceed with arteriogram

• ABI > 0.90
  – Admit for observation
  – Followed with serial noninvasive exam

• Johansen et al J Trauma
  – Injured Extremities
  – ABI
  – Sensitivity = 95%
  – Specificity = 97%

• Mills et al J Trauma 2004
  – Knee dislocation
  – ABI
  – Sensitivity and Specificity = 100%
Evaluation - Radiographic

- Plain X-ray knee/tibia
  - AP
  - Lateral

- Obliques of knee
- Internal or external rotation
Evaluation - Radiographic

- Tibial plateau view
- Normal tibial slope
  - 10 degrees posteroinferior
Evaluation - Radiographic

- CT scan
  - Surgical consideration exists
  - Complex fractures to assist in surgical planning
  - Assessing
    - Depression
    - Comminution
    - Fracture line (coronal split-medial side with bicondylar plateau)
  - Obtain CT after applying traction (ex fix)
Evaluation - Radiographic

- MRI scan?
- Subtle nondisplaced fracture line
- Gardner JOT 2005
- Noted high associated soft tissue injuries
  - Lat. meniscus: 91%
  - Med. Meniscus 44%
  - ACL
  - PCL
Classification

- **Schatzker**
  - Type I: Split fracture of the lateral plateau
  - Type II: Split depression fracture of the lateral plateau
  - Type III: Pure depression fracture of the lateral plateau
  - Type IV: Medial plateau (possible fracture / dislocation)
  - Type V: Bicondylar plateau fracture
  - Type VI: Plateau fracture with metaphyseal / diaphyseal dissociation
Classification

• **AO / OTA** (41- Proximal section)
• **Type A: Extraarticular fracture** (41-A)
• **Type B: Partial articular fracture** (41-B)
  – B1: Pure split
  – B2: Pure depression
  – B3: Split depression
• **Type C: Complete Articular fracture** (41-C)
  – C1: Simple articular, Simple metaphyseal
  – C2: Simple articular, Multi-fragmentary metaphyseal
  – C3: Multifragmentary articular
Classification

- Unicondylar fracture
- Schatzker I, II, III
- AO/OTA (41-B)
  - Partial articular

![Diagram of fracture types: Split, Split-depression, Central depression]
Classification

- Unicondylar fracture
- Schatzker IV
- AO/OTA (41-B)
  - Partial articular
  - Medial plateau
  - Fracture / dislocation
  - Displaced, higher energy
  - Vascular injury concern

Split fracture, medial plateau
Classification

- Bicondylar fracture
- Schatzker V, VI
  - V: Medial tibial plateau split and Lateral split depression
  - VI: Plateau with metadiaphyseal dissociation
- AO/OTA (41-C)
  - Complete articular

Bicondylar fracture  Metadiaphyseal dissociation
Treatment Principles

- Soft tissue management
  - Surgical timing is important
  - Wringles in the skin
- Temporary Stabilization
  - Staged protocol
  - Barei et al. JOT 2004
  - Egol et al. JOT 2005
Treatment Principles

- Anatomic reduction of articular surface
  - Obtain and maintain
- Reduce condylar width
- Address meniscal injuries
- Restore mechanical axis
  - metadiaphysis
- Stable fixation
- Early ROM
Treatment Options: Nonsurgical

- **Patient factors**
  - Elderly
  - Nonambulatory
  - Pre-existing arthritis

- **Injury factors**
  - Articular incongruity
  - <5 mm, elderly, sedentary activity
  - Stable Varus / Valgus stress
    - < 5 -10 degrees instability

71 y/o male, multiple med. comorbidities
Nonsurgical – Technical Pearls

- Immobilize 1-2 weeks
- Knee immobilizer or hinge knee brace
  - Locked in extension
- Start ROM
  - Controlled motion
  - Start 0-30 degrees and advance as tolerated
  - Goal- 90 degrees at 4wks
- NWB 6-8 weeks

Radiographic F/U
Weekly for first 3 weeks
Indications for Surgery

• Absolute indications
• Open tibial plateau
• Associated compartment syndrome
• Associated vascular injury
Indications for Surgery

- Relative indications
- Axial malalignment
  - Instability in full extension
- Articular incongruity
  - >3mm in young, active
- Condyle widening
Indications for Surgery

- Displaced bicondylar
- Most if not all medial plateau
Timing of Surgery

Low Energy:
Fixed electively and early

High Energy:
Be patience
Temporary External Fixation

- Knee spanning external fixation
- Ligamentotaxis
- Improve fracture fragment gross alignment
  - Length and alignment
- Minimize further damage to articular surface
- Soft tissue assessment and wound care
Temporary External Fixation

• Candidates for external fixation
• Axially unstable tibial plateau fracture
  – Bicondylar fracture
  – Schatzker type V and VI
• Fracture / Dislocation
  – Schatzker type IV
External Fixation: Patient set up

- Supine
- Radiolucent operating table
- C-arm fluoroscope
  - Contralateral side
- Sterile towel bump
  - Allow 5-10 degrees knee flexion
- 2 pins in femur
  - Anterior or lateral
- 2 pins in tibia
  - Antero-medial
Implants – External Fixation

• Large external fixator system
• 5 mm half threaded schanz pins
  – Self drilling
  – Different length available
• Connecting rods and Clamps
• Compressive dressing
  – Ext. fix sponges
  – Retention clip
External Fixation - Pearls

- Mark knee joint and fracture sites
- Schanz pins placement out of zone of future surgical incisions
- Pre-drilling for good bone quality
- Avoid skin tension by pins
- Pin spread to improve construct stability
External Fixation - Pearls

• Placement of metal clamps
  – Away from knee joint and fracture zone
  – Allows better imaging

• Padded prefabricated posterior splint
  – Offload heel

• Compressive dressing
  – Stabilize pin-skin interface
  – Minimize pin-skin motion
Temporary Stabilization - Case Example

- Staged protocol
  - Knee spanning external fixation
  - Restore length, alignment, rotation
- Definitive ORIF 10-21 days
- Wait for soft tissue
- CT scan
- Preop plan
ORIF- Patient Set Up

• Radiolucent operating table
• C- arm fluoroscope
  – Contralateral side of injured limp
  – Exception: Medial plateau- ipsilateral side
• Buttock bump
• Tourniquet
• Extremity positioners
  – Sterile towel bump
  – Leg ramp
  – Radiolucent for imaging
Patient Set Up - Technical Pearls

- IV bag pump - buttock bump
  - Deflated allows easier access to posteromedial tibia
Patient Set Up - Technical Pearls

- IV bag pump-buttock bump
  - Inflated allows neutral leg alignment for anterolateral approach
ORIF- Equipment

• Headlamps
• Femoral distractor
• Osteotomes
• Bone tamps
• Fracture reduction instruments
• K-wires
ORIF- Implant options

- Unicondylar fracture
- Conventional non-locking plate
  - “L” or “T” plate
  - Buttress
- Pre-contoured periarticular plates
- Raft screws alone
  - 3.5mm or 4.5mm
- Locking plate
  - Osteoporotic bone
ORIF- Implant Options

- Angular stable (Locking) implants
- Precontour for proximal tibia
- Bicondylar tibia plateau with metadiaphyseal involvement
- Spanning or bridging across fracture zone
- Selected fracture, allows stabilization of medial plateau
External Fixation

- Limited internal fixation
  - Small incisions or percutaneous
- Thin-wire ring fixators
  - Connect to the shaft
  - Fixation distally with 5mm half-pins
- Advantages
  - Minimize soft tissue injury
- Still need to reduce articular surface!!!
ORIF- Fixation Summary

• Fixation based on fracture type
• Type I, II, III: Buttress plates with raft screws
• Type IV: Medial plate (buttress)
  – Be cognizant of any impaction of lateral joint line
• Type V, VI:
  – Important to understand plate function
  – Pattern dictates fixation
  – Single lateral base fixed angle implant
  – Dual plating (lateral and posteromedial)
Surgical Approaches

• Anterolateral
  – Lateral plateau involvement
  – Combination with medial for complex plateau

• Posteromedial
  – Medial plateau
  – Coronal split

• Posterior

• Dual approaches
  – Anterolateral
  – Posteromedial

Copyright by AO Foundation, Switzerland
Surgical Approach: Anterolateral

- Most common approach
- Lazy S or Inverted L
- Curvilinear incision centered over Gerdy’s tubercle
- Extend distally of the anterior compartment fascia
  - 1 cm off tibial crest
  - Subperiosteal elevate muscle
- Extend proximally midaxial line of knee joint
- Full thickness skin flaps
Surgical Approaches: Anterolateral

- Incise and elevate IT band and anterior compartment fascia
- Subperiosteal dissection off lateral tibial crest and not thru compartment muscle
- Submeniscal arthrotomy
- Inspect the meniscus
  - Tag
  - Repair as needed
Surgical Approach: Posteromedial

- Straight incision
- Posterior border of proximal tibia
- Avoid Saphenous nerve and vein
- Interval between Medial head gastrocnemius and hamstrings (Pes anserine tendons)
Surgical Approach: Posteromedial

- Interval between
- Hamstrings (Pes anserine tendons)
- Medial head gastrocnemius
Surgical Approaches: Posteromedial

- Pes anserine tendons
  - Retracted
  - Tagged and divided for more exposure
- Posterior to superficial MCL
- Medial gastroc muscle elevated off tibia
- Subperiosteal elevate popliteus and soleus muscles
Surgical Approaches

- Other surgical approaches
- Direct medial or midline parapatellar anterior
  - Isolated medial tibia fractures
- Direct posterior approach
  - Posterior shear fractures
  - Prone
  - Inability to treat anterolateral fracture
Treatment of Specific Schatzker Fractures Types
Schatzker Type I Split
Schatzker Type I Split

- Goals:
  - Restore articular congruity
    - Articular step off
    - Condylar widening
  - Open vs. percutaneous
  - Fixation
    - Lag screws
    - Buttress plate
Schatzker Type II Split-Depression
Schatzker Type II Split-Depression: Surgical Tactics

- Submeniscal arthrotomy
- Full visualization of articular surface
- Repair lateral meniscus
- Femoral distractor
- Elevate articular depression
- Reduce condylar widening
  - Large pelvic reduction clamp
- Temporary K-wires
Schatzker Type II Split-Depression

- Fill defect
  - Allograft
  - Autograft
  - Bone substitutes
- Buttress plate
  - Nonlocking: Most
  - Locked: osteoporotic bone
- Subchondral raft screws
Schatzker Type III Pure Depression

Central depression
Schatzker Type III Pure Depression

- Surgical technique
- Open approach
  - Submeniscal
- Arthroscopic
- Elevate depressed fragment
- Fill defect
- Stabilization
  - Subchondral raft screws
Schatzker Type III Pure Depression

• Surgical technique
  • Submeniscal
  • Arthroscopic
• Elevate depressed fragment
• Fill defect
• Stabilization
  • Subchondral screws
Schatzker Type IV Medial plateau

Split fracture, Medial plateau

CT post ext. fix
Schatzker Type IV Medial plateau

- Surgical approach
- Posteromedial
  - Interval between
  - Pes anserine tendons and Medial head gastrocnemius
Schatzker Type IV Medial plateau

- Don’t forget about possible lateral plateau depression
- Bone tamp to elevate
- May need anterolateral incision to reduce depression
Schatzker Type IV Medial plateau

- **Fixation**
  - Straight medial plating
  - Posteromedial plating
  - Combination
Schatzker Type V, VI Bicondylar

Bicondylar fracture

Metadiaphyseal dissociation
Classic Fracture Pattern

- Bicondylar Fxs
  - 2 classic components:
    - Lateral split depression
    - Posteromedial / coronal split
Schatzker Type V, VI
Bicondylar

- Preop plan is important
- Review x-rays and CT scan
- Identify all fractures
Schatzker Type V, VI Bicondylar

- Preop plan is important
- Review x-rays and CT scan
- Identify all fractures
Schatzker Type V, VI
Bicondylar

- Dual incisions
- Reduce medial plateau
  - K-wires
  - Antiglide plate
- Reduce lateral plateau
  - Tamp up depression
- Restore condylar width
  - Large king tong clamp
- Connect articular block to diaphysis
Schatzker Type V, VI
Bicondylar

• Maintain reduction
• Dual plating
Schatzker Type V, VI
Bicondylar

- Restore mechanical axis
- Cannot accurately assess with fluoro
- Often need intraoperative plain films
Schatzker V, VI Bicondylar

- Single lateral fixed angle implant
  - Ability to capture medial condyle with laterally based implant
  - Medial apex cortical contact with minimal comminution
Rehabilitation

- Postoperative Care
- Antibiotic x 24 hours
- +/- drain
- Knee brace
  - For comfort until able to do straight leg raise (SLR)
  - Associated ligamentous injuries
- Elevate leg
- NWB 10-12 weeks
Rehabilitation

- Physical therapy
- Early ROM
- CPM
- Strengthening
  - Isometric quad sets
  - Heel slides
  - SLR
- Gait training
  - Crutches
  - D/c crutches when able to walk without limp and pain
Complications

- Infection
  - Surgery timing is important
  - Careful soft tissue handling
  - Prolong operative time

- Nonunion
  - Aseptic
    - Metadiaphyseal junction
  - Septic
  - Opened fracture

Aseptic Nonunion  Revised with ICBG
Complications

- Contractures
  - Arthrofibrosis
  - Encourage early ROM and physical therapy
  - May require knee manipulation
  - Arthroscopic lysis of adhesion
- Post Traumatic Osteoarthritis

4 yr. F/U
Outcomes

• Lansinger et al. JBJS Am 1986
• 102 fractures, 20 yr.. F/U
• 90% excellent or good results
  – Despite some incongruity
• 10% fair or poor
  – > 10mm depression persisted

• Conclusion
  – Instability (lateral or medial with knee extended)
  – Should be operative
Outcomes

• Honkonen JOT 1995
• 131 fx, 7.6 yr. mean F/U
• 76 operative, 55 nonoperative
• Risk factors for post-traumatic arthritis
  – Increase age
  – Removal of meniscus
  – Articular incongruity
  – Instability
  – Malalignment
Outcomes

• Stannard et al. JOT 2004
• 34 AO/OTA type 41C
• Mean F/U 21 mo.
• LISS implant
• All healed, mean 15.6 weeks
  – 1/34 malalignment, 0 deep infection, 2 superficial
• 18% implant related pain
  – Careful attention to detail can decrease painful HW
Outcomes

• Barei et al. JBJS Am 2006
• Retrospective
• Eval dual incisions and dual plating
• 83 AO/OTA Type 41C3
• Mean F/U 59 mo.
• Correlated with outcomes
  – Age, polytrauma, articular reduction
• Residual dysfunction is common
Outcomes

• Rademakers et al JOT 2007
• 109 fractures, Long-term F/U (5-27 yr.)
• 69% unicondylar, 31% bicondylar
• Mean ROM 135 degrees
• Functional results (Neer, HSS knee scores)
  – Unicondylar had better results vs.. bicondylar
• 31% post-traumatic arthritis, most are tolerable
• Malalignment > 5 degrees correlated with increased DJD
• No differences with patient’s age
Outcomes

• Canadian Orthopaedic Trauma Society JBJS Am 2006
• Level I evidence PRCT
• ORIF vs. Circular fixator
• Displaced Bicondylar (AO/OTA type 41 C1-3)
• 2 yr. F/U, similar results
  – Quality of reduction
  – Residual limb-specific and general health deficits
• Circulator fixator
  – Less EBL, less inpatient hospital stay
• ORIF with higher complication rate
Outcomes

• Katsenis et al. JOT 2009
• Limited internal fixation and circular fixation
• Retrospective, 3 and 5 yr. F/U
• Knee function and Post-traumatic arthritis
• 129 fx
• Excellent or good
  – 82% at 3 yr.. 78% at 5 yr..
• High incidence of post-traumatic arthritis at 5yr
  – Functional results still satisfactory
References

- Gardner MJ. *J Trauma* 2006;60(2):319-323.
References

- Hansen, Matthias; Pesantez, Rodrigo. AO Surgery Reference: Online reference in clinical life.
Selected Cases

- Schatzker II
Selected Cases

- Schatzker II
Selected Cases

- Schatzker II
- ORIF
- Buttress plate
- Raft screws
Selected Cases

Bicondylar with metadiaphyseal fracture
Selected Cases

Bicondylar with metadiaphyseal fracture

- Ext Fix
Selected Cases

Bicondylar with metadiaphyseal fracture

- ORIF
Selected Cases

Bicondylar with tibial tuberosity fracture

• Must address tuberosity
  – Allow early ROM

• Options for tuberosity fixation
  – Lag screws
  – Plates/screws
Selected Cases

Bicondylar with tibial tuberosity fracture

CT scan
Selected Cases

Bicondylar with tibial tuberosity fracture

- **ORIF**
- **Posteromedial approach**
  - 3.5mm recon plate
  - Buttress
- **Anterolateral approach**
  - Precontour plate
- **ORIF tuberosity**
  - Percutaneous
  - Lag screws
Selected Cases

Bicondylar with tibial tuberosity fracture

Temporary Ext. Fix
Selected Cases

Bicondylar with tibial tuberosity fracture

CT scan
Selected Cases

Bicondylar with tibial tuberosity fracture

- ORIF
- Posteromedial approach
  - 3.5mm recon plate
  - Buttress
- Anterolateral approach
  - Precontour plate
- ORIF tuberosity
  - 1/3 tubular plate
Summary: Tibial Plateau Fractures

• Understand the fracture pattern
• Respect the soft tissues
• Partial articular (Schatzker 1-3)
  • Buttress: plates and/or interfragmentary screws
• Beware of medial plateau (Schatzker 4)
• Complete articular (Schatzker 5,6)
  • External fixation
  • Preop plan
  • ORIF
    • Obtain and maintain
THANK YOU