Adolescent Knee Injuries

Jonathan Jennings, MD
Southern Bone and Joint Specialists
Dothan, AL

Dana Piasecki, MD
OrthoCarolina
Charlotte, NC

Outline

- Tibial Spine Avulsion
- ACL tears with Open Physes
- Osteochondritis Dissecans (OCD)
- Physeal fractures

Tibial Spine Avulsion

Tibial Spine Avulsion

- ACL avulsion
  - Adolescent soft-tissue is stronger than bone
- *Forceful hyperextension* injury
  - Traction on ACL leads to bony avulsion tibial eminence

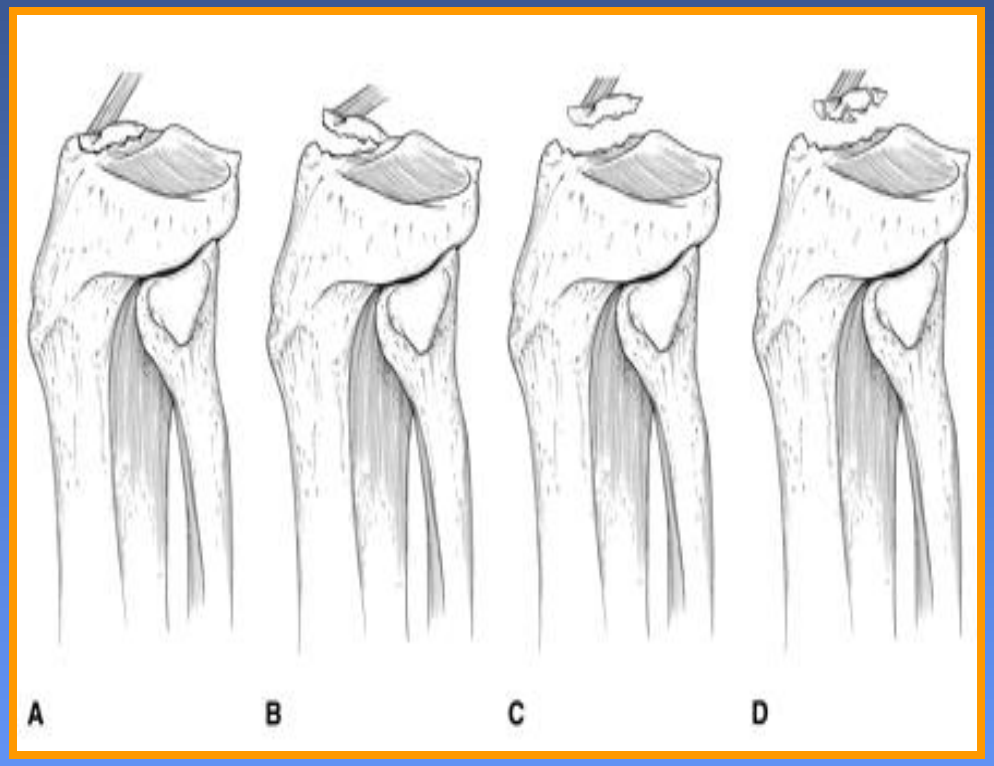
Tibial Spine Avulsion
Mechanism

- Anything which applies traction to the ACL…
- Non-contact twisting…
  - Soccer
  - Rugby
  - Skiing
- Also, *forced knee flexion with the tibia in an internally rotated position*.

40% are associated with additional intraarticular pathology

Tibial Spine Avulsion
Classification

- Based on fracture pattern and guides treatment
  - Type 1 – non-displaced
  - Type 2 – anterior cortical displacement, intact posterior hinge
  - Type 3 – completely displaced
  - Type 4 - comminuted



Tibial Spine Avulsion
Physical Exam

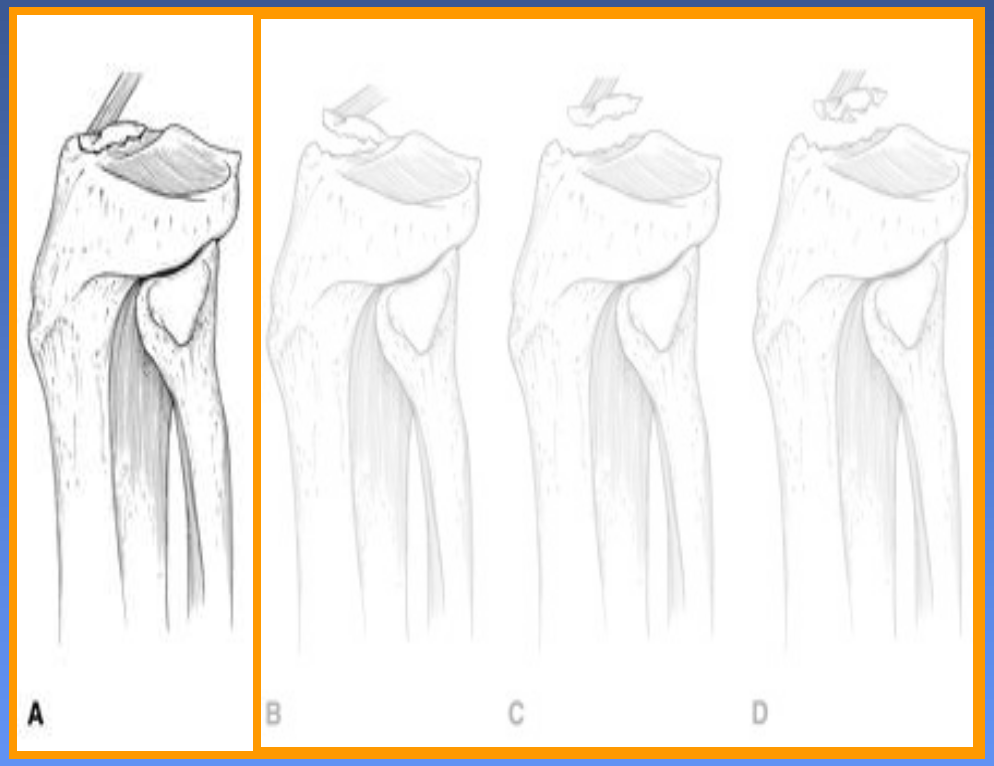
- Pain, swelling / hemarthrosis
- Positive Lachman
- XRay - Fracture line in the tibial eminence; useful in determining the degree of displacement
  - Contralateral radiographs

Tibial Spine Avulsion
MRI

- MRI…
  - Important if planning non-op care
  - Assess degree of displacement
  - ***Evaluate for concomitant injuries
    - intrasubstance ACL and PCL injuries
    - Other ligaments
    - Menisci
    - Chondral injury

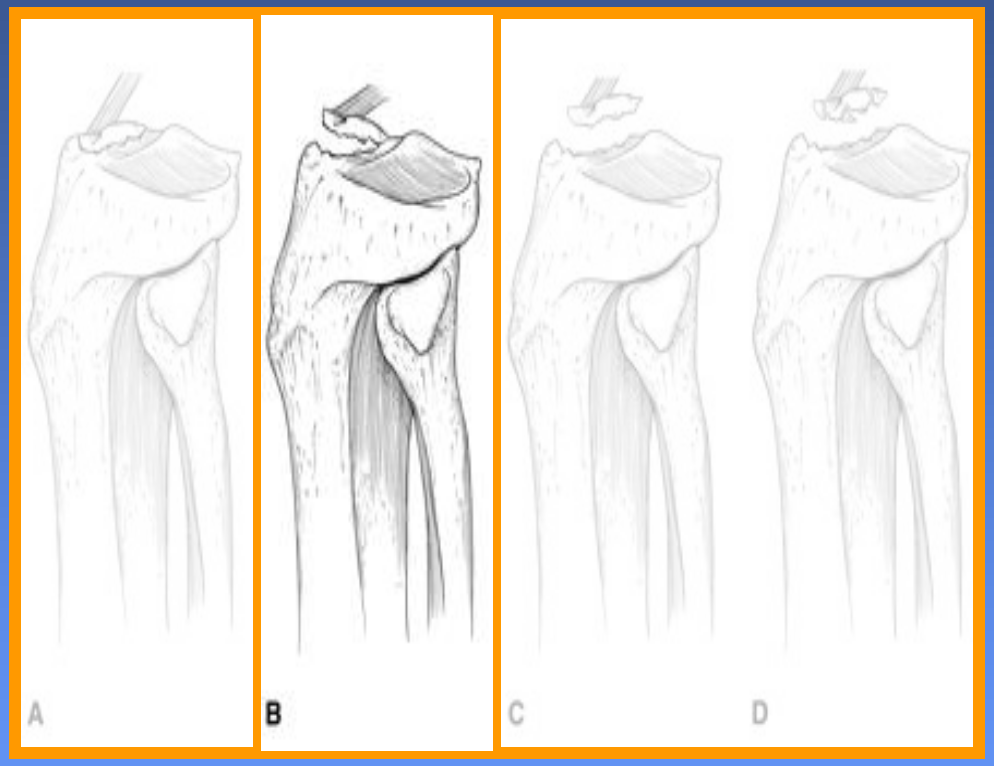
Tibial Spine Avulsion
Treatment

- *Type I fractures*
  - Non-surgical
  - Immobilization
    - Position of comfort – 20 degrees vs. extension
  - Knee immobilizer vs. cylindrical cast
    - Progress ROM after 3 wks, WB after 6 wks
  - Serial (weekly) radiographs – beware of late displacement



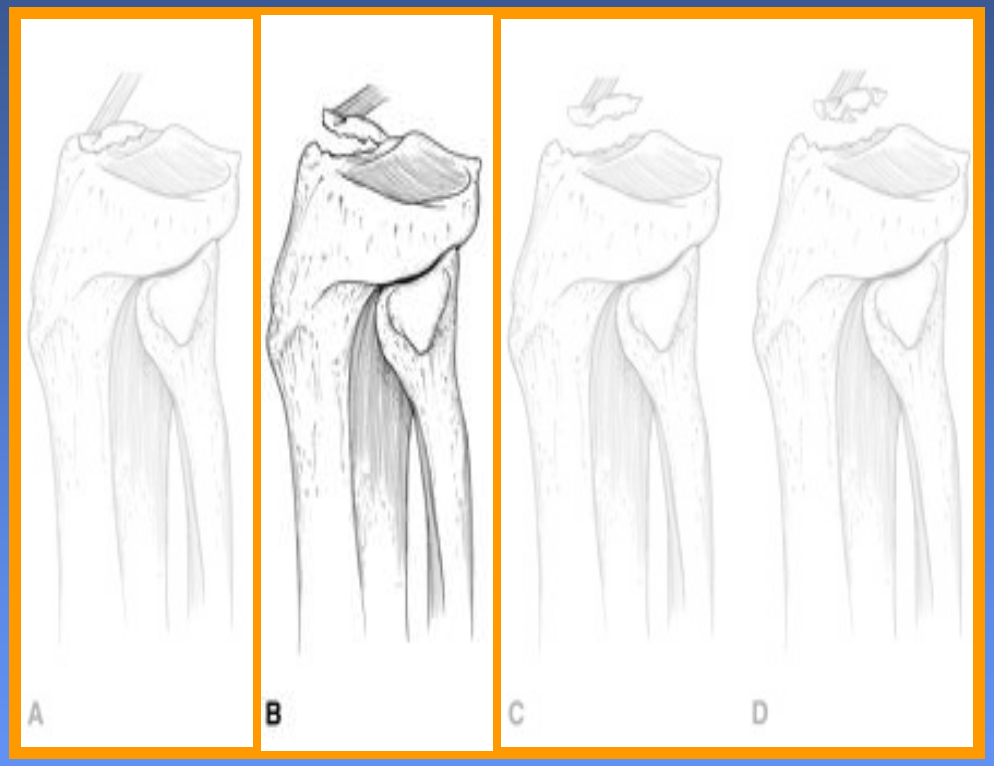
Tibial Spine Avulsion
Treatment

- *Type II fractures*
  - Closed reduction in extension
    - Need to achieve anatomic reduction
  - Immobilization in extension



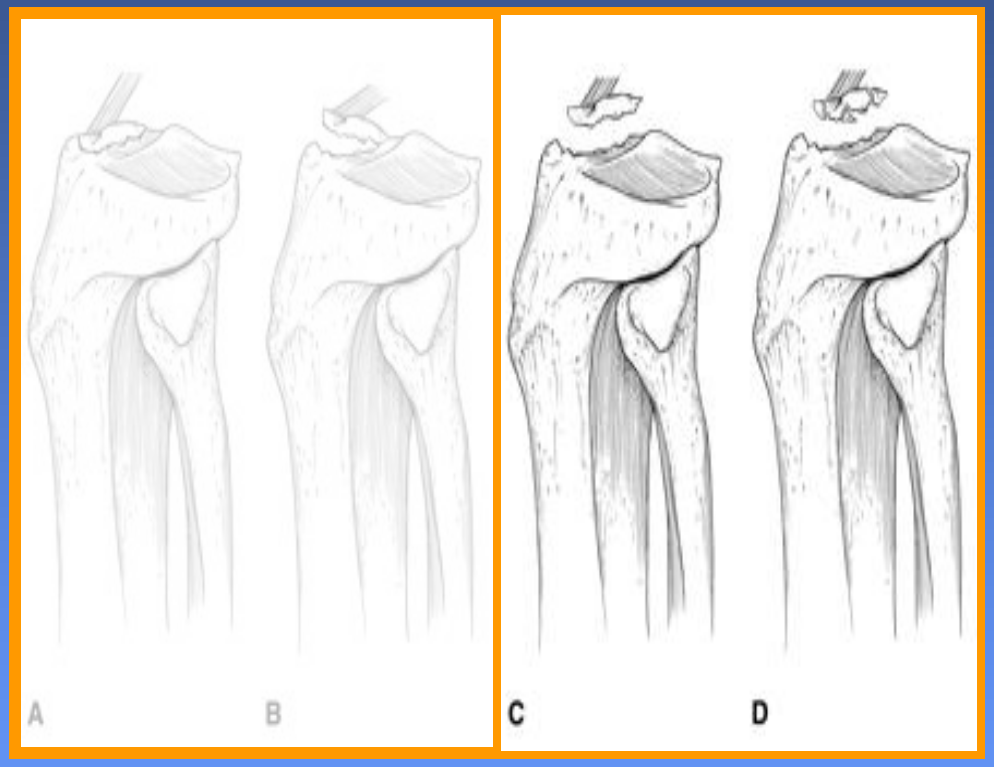
Tibial Spine Avulsion
Treatment

- *Type II fractures*
  - Operative treatment if…
    - Can't get anatomic reduction
      - Will result in notch impingement, laxity
      - May have tissue interposition (54%)
        - Anterior horns
        - Intermeniscal ligament
        - Bucket handle
    - If need to address associated intraarticular injuries



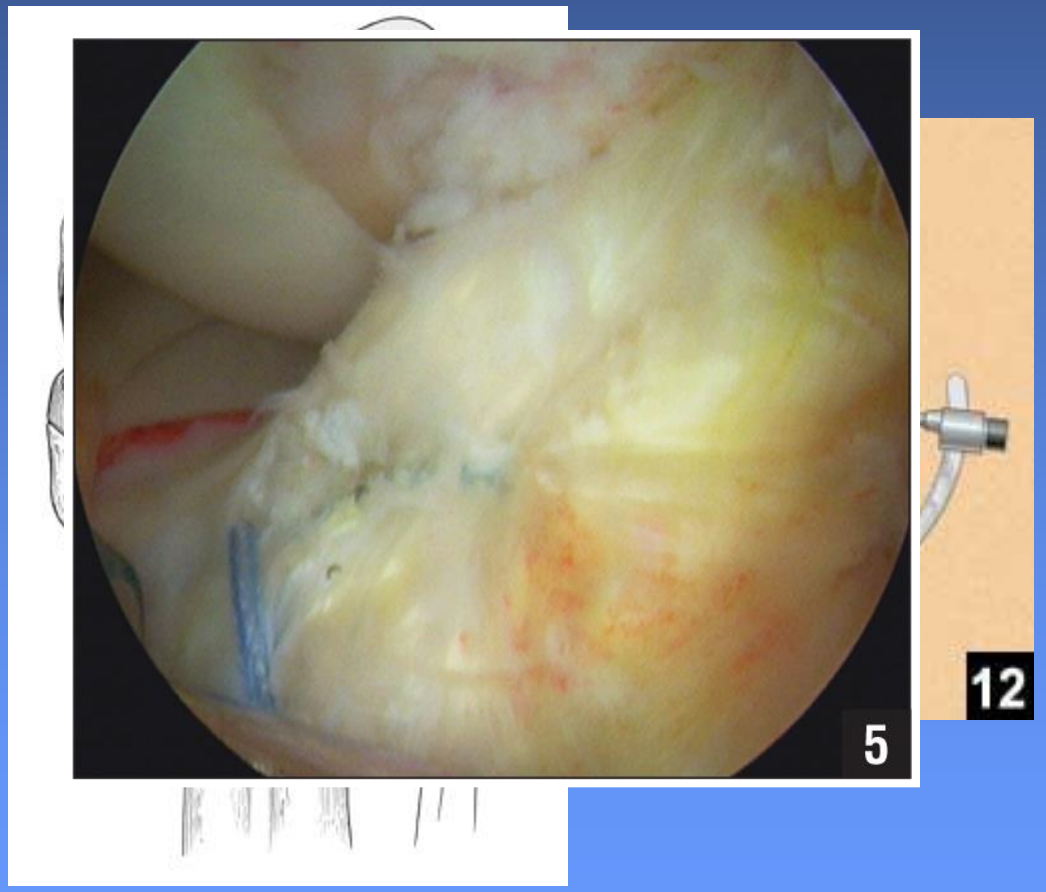
Tibial Spine Avulsion
Treatment

- *Type III – IV*
  - All need surgery
  - Arthroscopic assisted versus ORIF
    - Surgeon's comfort level and expertise
  - Suture versus screw fixation…no good comparative studies



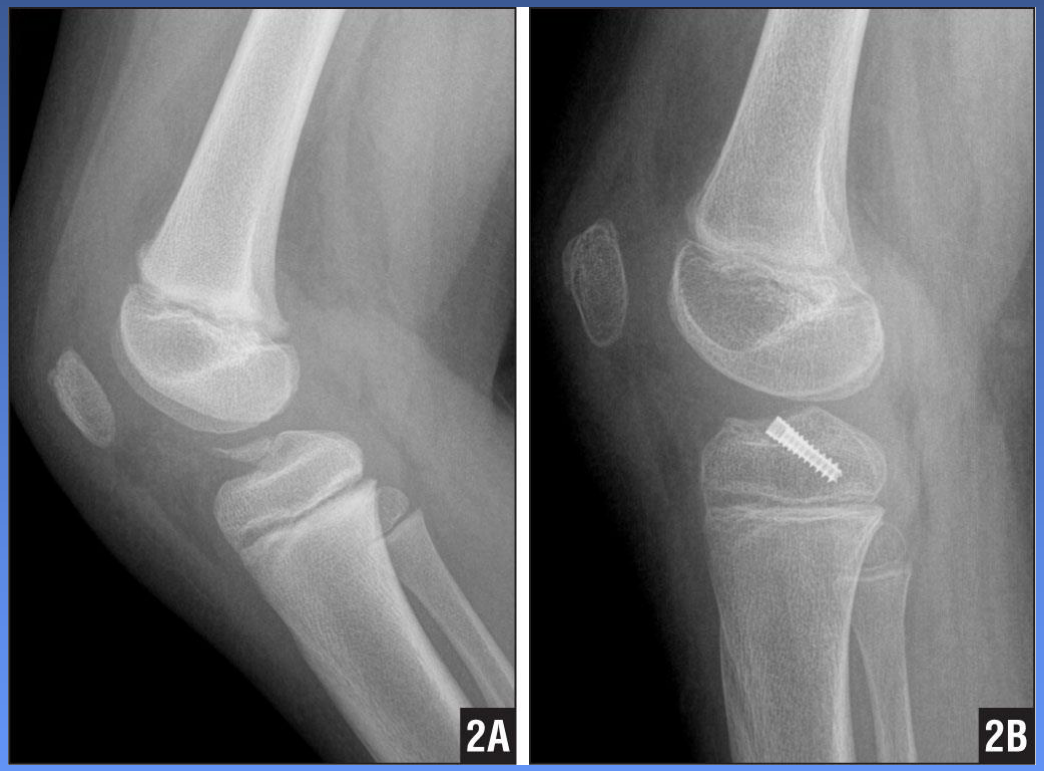
Tibial Spine Avulsion
Treatment

- *Type III – IV*
  - Suture fixation
    - Great for Type IVs
    - Want both ligament and bone purchase
    - Bone tunnels / bridge
    - Pros:
      - Little risk of physeal disturbance
      - No need for hardware removal



Tibial Spine Avulsion
Treatment

- *Type III – IV*
  - Screw fixation
    - Well documented results
    - Antegrade or retrograde
    - Pros
      - Earlier mobilization and range of motion
    - Cons
      - Retained or proud hardware can be problematic
      - Possible growth disturbance in crossing open physis



Tibial Spine Avulsion
Outcome

- Regardless of treatment, residual laxity in 10-20%
  - Likely due to attenuation at injury
- Rarely causes clinically significant instability or adverse functional outcomes.
  - Few require conventional ACL reconstruction

Tibial Spine Avulsion
Rehab

- Variable - quality of fixation, compliance, nature of the fracture

- Types 1-2
  - Immobilized 2-6 weeks, TTWB
    - Longer for preadolescent, noncompliant
    - Radiographic union 6-12 weeks
  - Followed by progressive protected WB / ROM
  - Isometric quad exercises to minimize atrophy

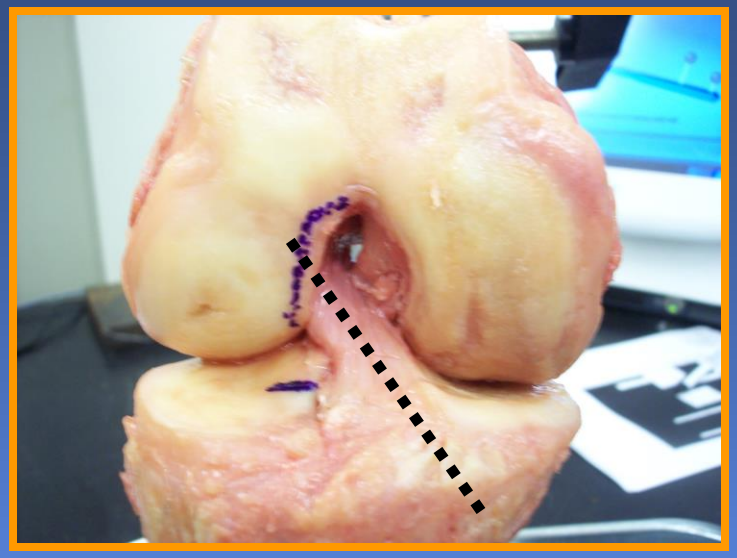
Tibial Spine Avulsion
Rehab

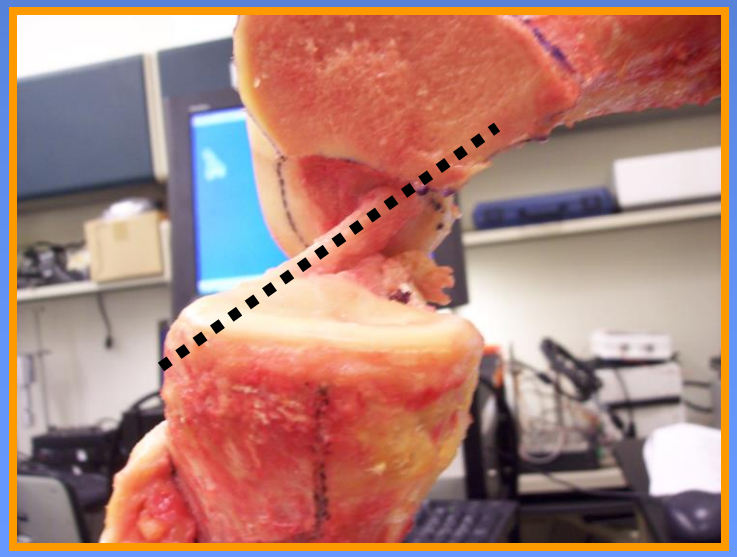
- Post surgical
  - Tailored to patient, but rehab mirrors ACL reconstruction with screw fixation
    - *Versus* delayed ROM/WB x 3-4 wks for suture fixation

ACL Tear with Open Physes

Anatomy
Ligament

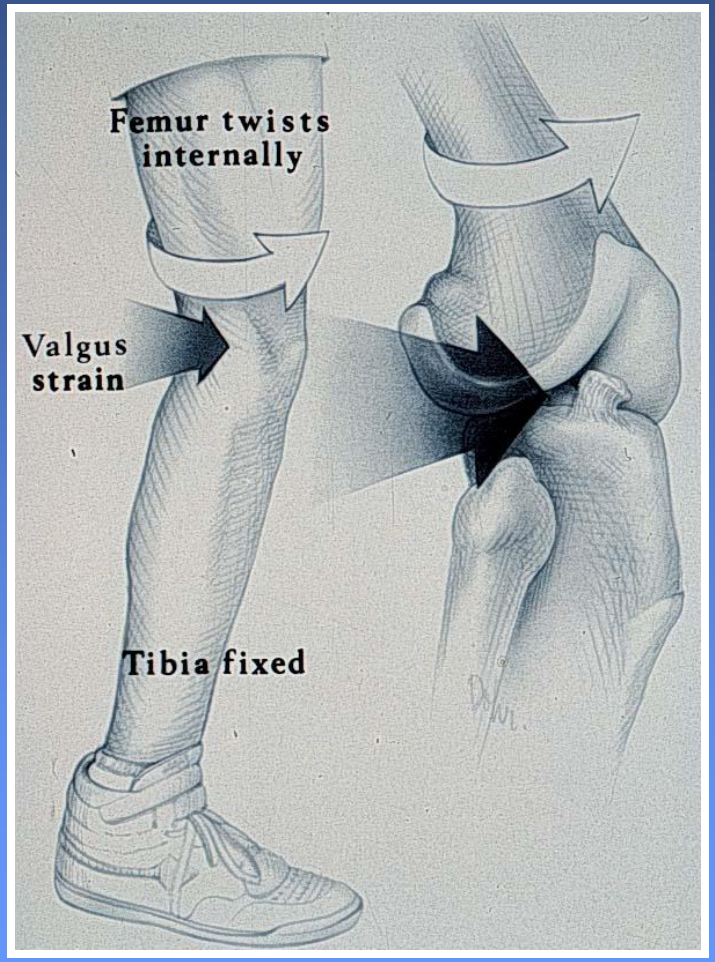
- 10-11 mm “cylinder”
- Oblique course
  - Medial to lateral
  - Anterior to posterior





History

- **Acute**
  - Noncontact (70%) twisting/pivoting event
  - Painful "POP"
  - Immediate swelling (w/in 6-12 hrs), with inability to RTP
    - *Stanitski et al, DeHaven et al*: Hemarthrosis in adolescent athlete = ACL tear in 65-75%
- **Subacute/Chronic**
  - Functional instability during change-of-direction activities



Physical Exam

Lachman

Anterior tibial translation with knee at 20-30 of flexion, tibia neutral.

Graded relative to opposite knee…

- Grade I: 1-5 mm laxity
- Grade II: 6-10 mm laxity
- Grade III: >10 mm laxity

- ***Modifier***: "A" soft endpoint
  "B" no endpoint

KT-1000: >3mm STSL indicates tear

Physical Exam

Pivot Shift

1). Abduct, ER (ITB)
2). Valgus, then ext → flex

Most sensitive when patient asleep on the table…

- Grade I: Glide
- Grade II: Jump
- Grade III: Lock

Indications

- **In isolation, surgery is indicated if…**
  - You need the ACL to ***function***…
    - Desire to return to cutting/pivoting activities
  - You need the ACL to ***protect***…
    - The younger and more active you are, the greater the lifetime "endangerment"

For most patients <40 yo = SURGERY

Open Physes

- **Outcomes of non-op management are generally poor**
  - High rate of meniscal/chondral injury without significant activity modifications
- **Assessing maturity**
  - Tanner staging
    - In boys, PHV usually precedes axillary hair
  - Menarche for girls
    - PHV precedes onset, growth ceases 2 yrs after
  - Bone Age (G/P Atlas)
- **Stratify into one of three groups**
  - Pre-pubescent ($\geq$2 yrs growth remaining)
  - Pubescent (<2yrs growth remaining)
  - Mature (bone age 15 for girls, 16 for boys)

Open Physes

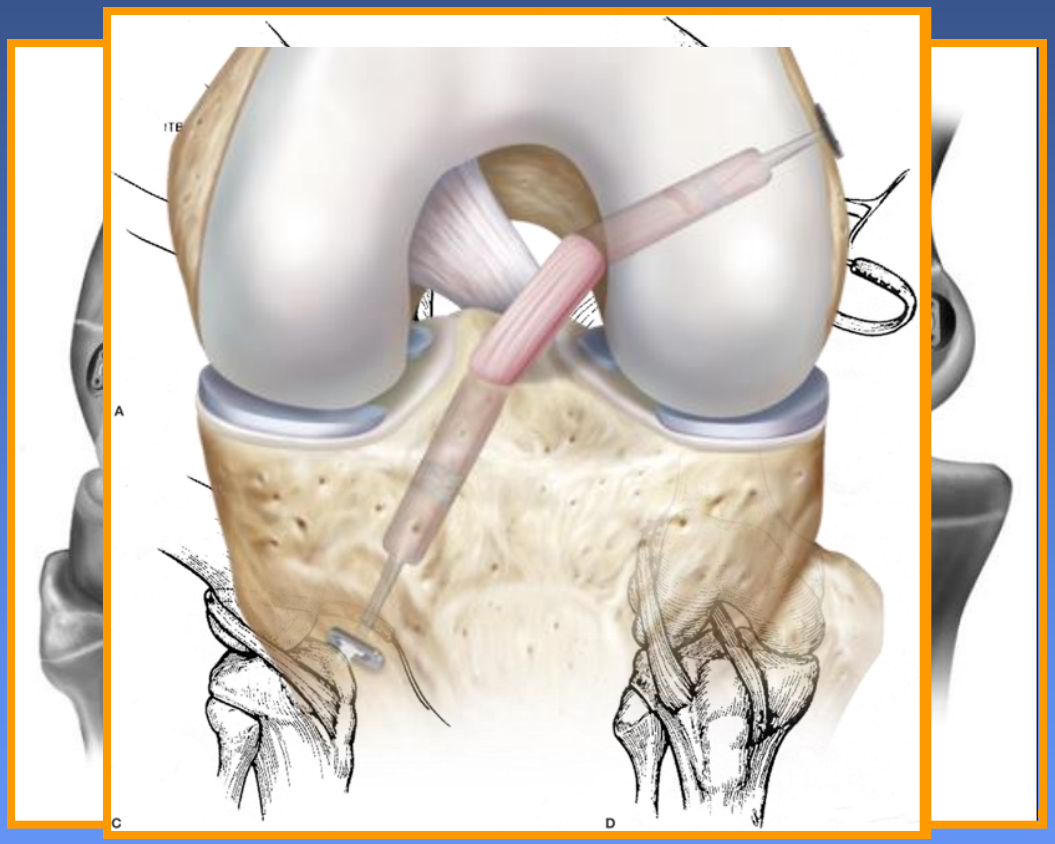
Normal Growth at the Distal Femur and Proximal Tibia by Sex and Skeletal Age*

	Skeletal Age							
	Girls (N = 50)				Boys (N = 50)			
Percentile	9 yr 3 mo	11 yr 3 mo	13 yr 3 mo	15 yr 3 mo	10 yr 3 mo	12 yr 3 mo	14 yr 3 mo	16 yr 3 mo
Femur†								
90th	6.7	3.4	1.1	0.1	8.9	5.7	2.2	0.3
75th	5.8	3.2	1.0	0.1	8.3	5.2	1.8	0.2
50th	5.2	2.8	0.7	0.0	7.2	4.8	1.4	0.1
25th	4.8	2.4	0.6	0.0	6.3	4.1	1.2	0.1
10th	4.3	2.2	0.4	0.0	5.3	3.4	1.0	0.0
Tibia‡								
90th	4.2	1.9	0.6	0.1	5.8	3.6	1.1	0.1
75th	3.7	1.8	0.4	0.1	5.3	3.3	0.8	0.0
50th	3.3	1.6	0.3	0.0	4.6	3.0	0.7	0.0
25th	3.0	1.5	0.2	0.0	4.0	2.6	0.5	0.0
10th	2.8	1.2	0.1	0.0	3.4	2.0	0.3	0.0

* Growth in cm; skeletal ages assessed from the Greulich-Pyle atlas
† Total distal femur growth × 71%
‡ Total proximal tibia growth × 57%

Open Physes

- **Risk of growth disturbance**
  - Rare (only 15 cases in 2002 Herodicus survey)
  - Animal studies: Keep tunnels small (≤8mm), perpendicular and use soft-tissue grafts
- **Pre-pubescent**
  - Multiple options
    - Trans-epiphyseal (Anderson)
    - Partial transphyseal (Anderson)
    - Hybrid (transtibial, over-the-top femur)
    - Non-anatomic (ITB, Kocher)
    - Conventional transphyseal



Hui et al AJSM 2012: **16 prepubescent (Tanner 1,2), mean age 12, with transphyseal soft-tissue grafts; no growth arrest at 2 yrs**

Open Physes

- **Pubescent**
  - Most recommend conventional transphyseal reconstruction with soft-tissue grafts
    - *Calvo et al AJSM 2014:* 27 pts mean age 13, no growth disturbances at 10 yrs
  - *Shelbourne et al*: Can use BTB, just avoid the physes
- **Mature**
  - Treat as an adult

Post-op Rehab

- *Phase I (0-6 wks):* Period of protection
  - WBAT without assist by POD #10
  - Hinged knee brace locked in extension for WB and sleeping x 6 wks (auto), 2 wks (allo)
  - ROM: Immediate A+AAROM as tolerated, prone heel hangs for extension
    - Goals: 0-90 by 2wks, 0-120 by 6wks
  - Strengthening: closed-chain only strengthening 0-45 when FWB

Post-op Rehab

- *Phase II (6-12 wks): Advance strengthening*
  - ROM: Continue to progress motion
    - If PHH 3-5 cm, flexion <120, consider medrol dosepak, static progressive brace
  - Strengthening: closed-chain only strengthening 0-90
    - Running (linear) at 4 mo if adequate ROM, quad control

- *Phase III (3-6 mo): Sport-specific conditioning*
  - Advance ROM, strengthening further
  - Agility and plyometrics (*if strength adequate*)
  - RTP @ 6-8 mo

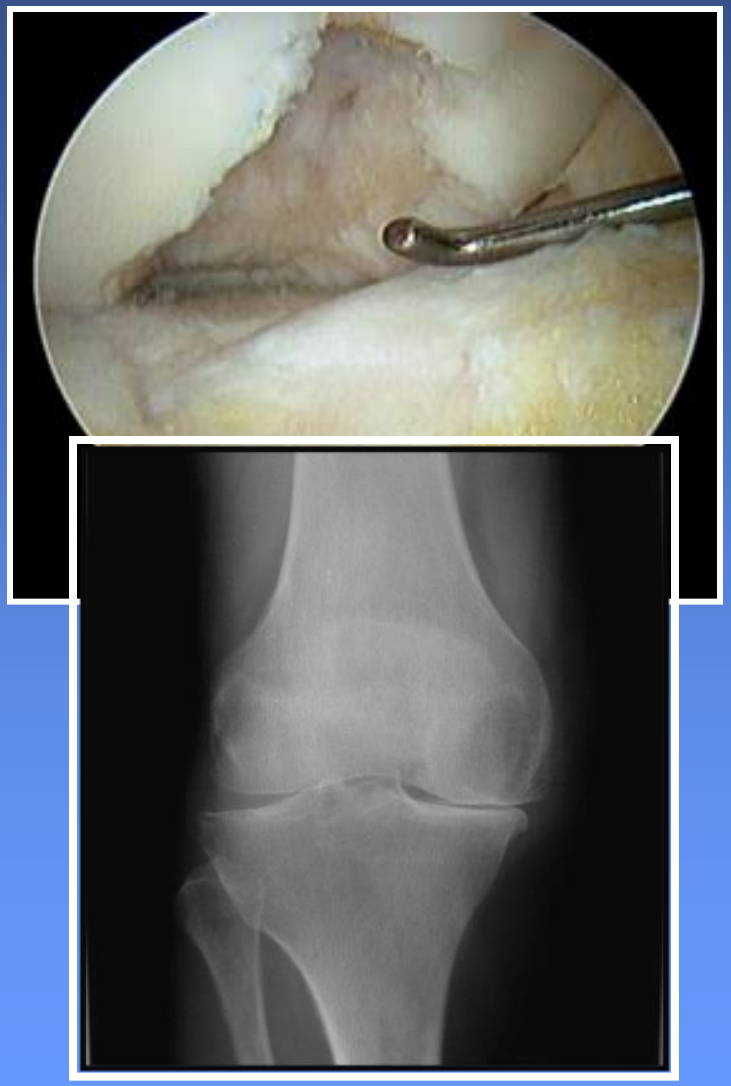
Osteochondritis Dissecans (OCD)

Osteochondritis Dissecans

- Focal destruction of subchondral bone
  - Separation, fragmentation
- Secondary damage to overlying cartilage

Epidemiology

- Relatively uncommon
  - Incidence 0.02 - 0.03%
- Peak at 10-15 yrs of age
- Boys > Girls (2:1)
- Knee most common (elbow, ankle)
  - Bilateral in 30%
- Left untreated, can progress to arthritis
  - *Linden et al JBJS 1977*
  - *Twyman et al JBJS 1991*



Classification

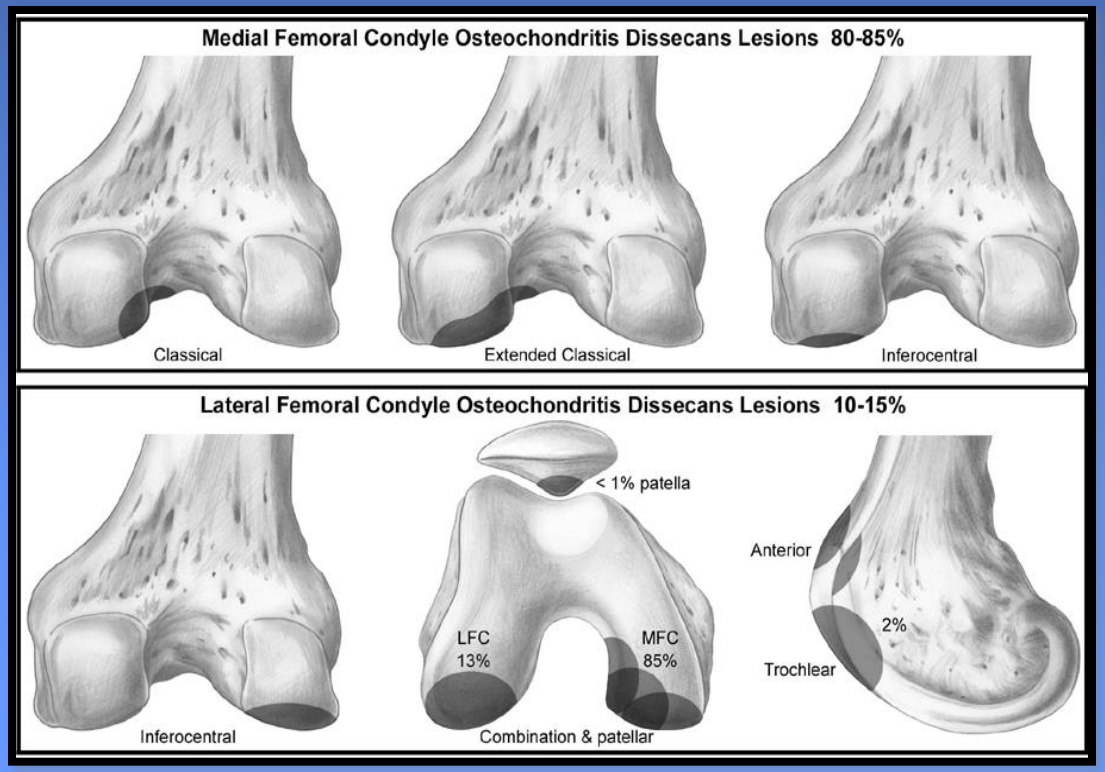
- Based on skeletal maturity
- Juvenile OCD
  - Open growth plates
  - *Better prognosis*
- Adult OCD
  - Closed growth plates
    - Previously asymptomatic JOCD lesions that didn't heal
  - *Worse prognosis*

Presentation

- Pain and swelling with activity
  - Antalgic gait, leg externally rotated (Wilson sign)
- Mechanical symptoms (catching, locking)
  - Unstable lesions, loose bodies

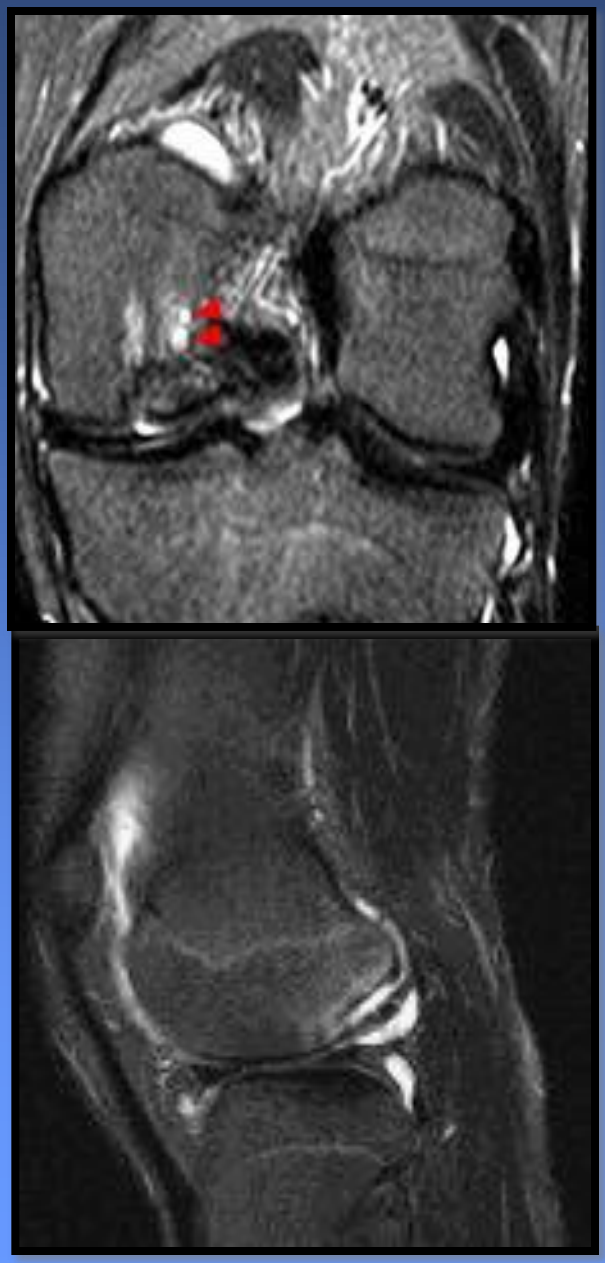
X-rays

- Localize lesion
  - Classic location lateral aspect of MFC
  - MFC >> LFC > PF



MRI

- Assessment of stability
  - Unstable = worse prognosis
  - More likely to cause mechanical symptoms
- Criteria for instability
  - High signal (fluid) beneath lesion
  - Cartilage breach
  - Subchondral cysts



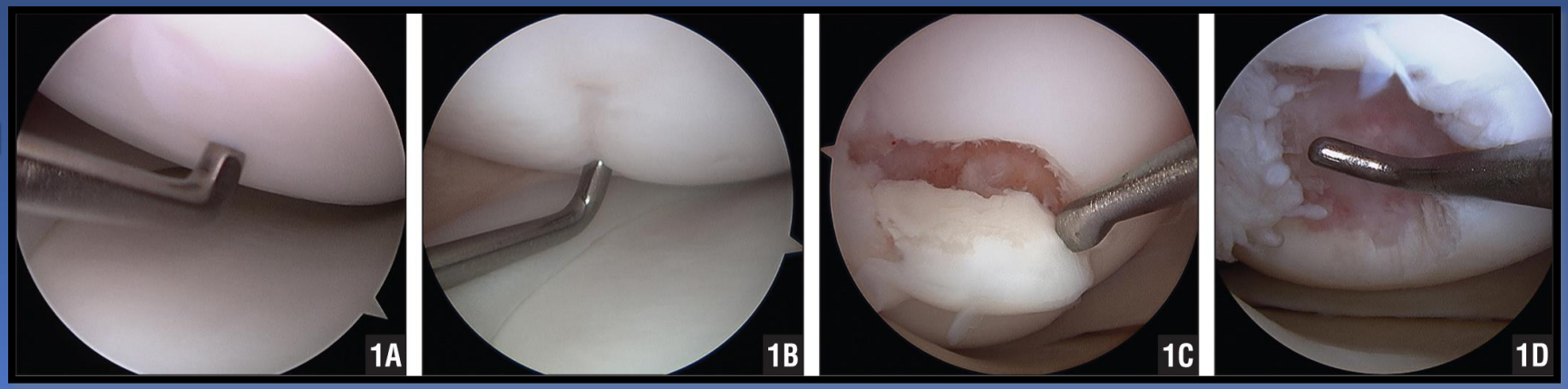
Treatment

- Non-surgical
  - Younger patients with open physes (JOCD)
  - Stable lesions
- Surgery
  - Failed non-op
  - Unstable lesions, AOCD

Nonsurgical Treatment

- Crutches, bracing
  - 4-6 weeks
- Activity modification X 4-6 mo
  - No running, jumping, sports
- If symptoms resolve and healing on x-rays, gradual return to sports
- ***Roughly 50% will heal***
  - *Cahill, JBJS, 1997*

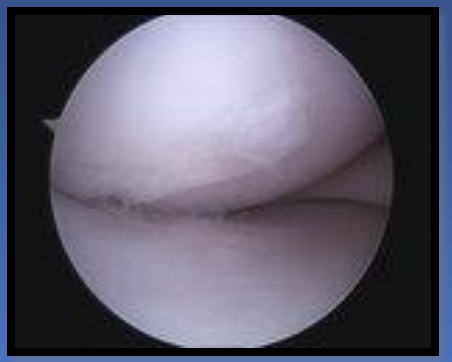
Surgical Treatment

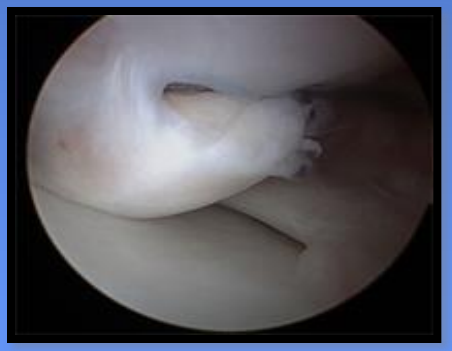


- Stability (*Guhl, CORR, 1982*)
  - **Grade 1**, normal cartilage
  - **Grade 2**, fragmentation in situ
    - Breeched cartilage but stable
  - **Grade 3**, partial detachment
    - Unstable, hinged fragment or flap
  - **Grade 4**, complete detachment
    - Loose body

Surgical Treatment

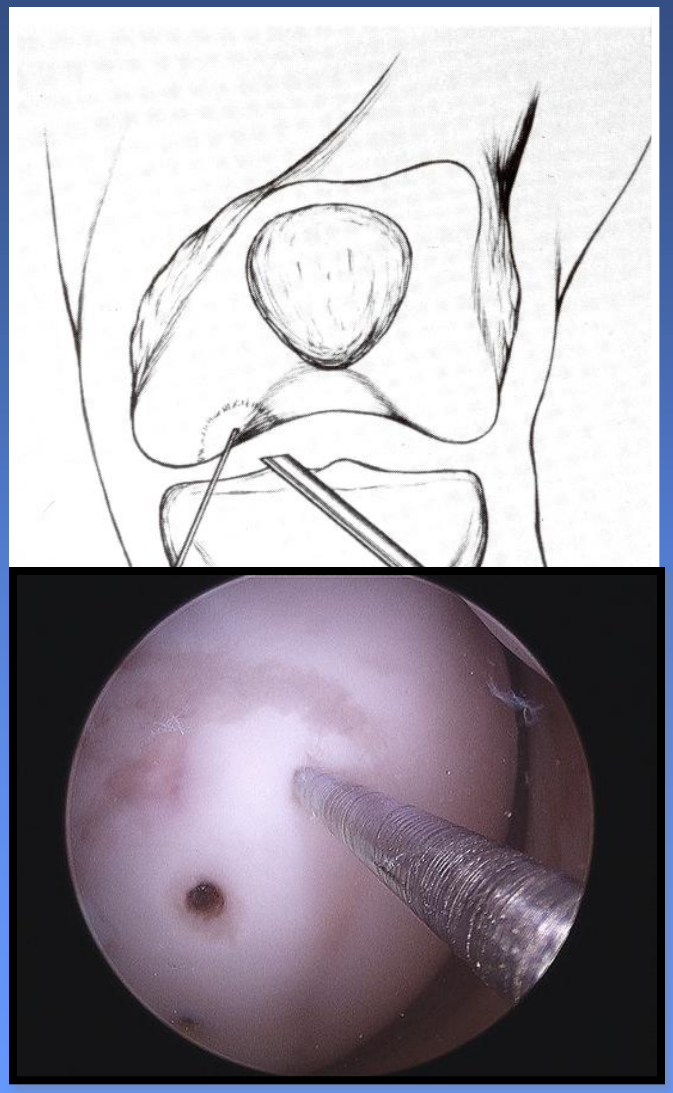
- Reparative Techniques
  - *Poor results with fragment excision = try to get it to heal*
  - Stable lesions with open physes (JOCD)
    - Drilling to increase blood supply
  - Unstable lesions, closed or closing physes (AOCD)
    - Screw fixation + / - bone grafting





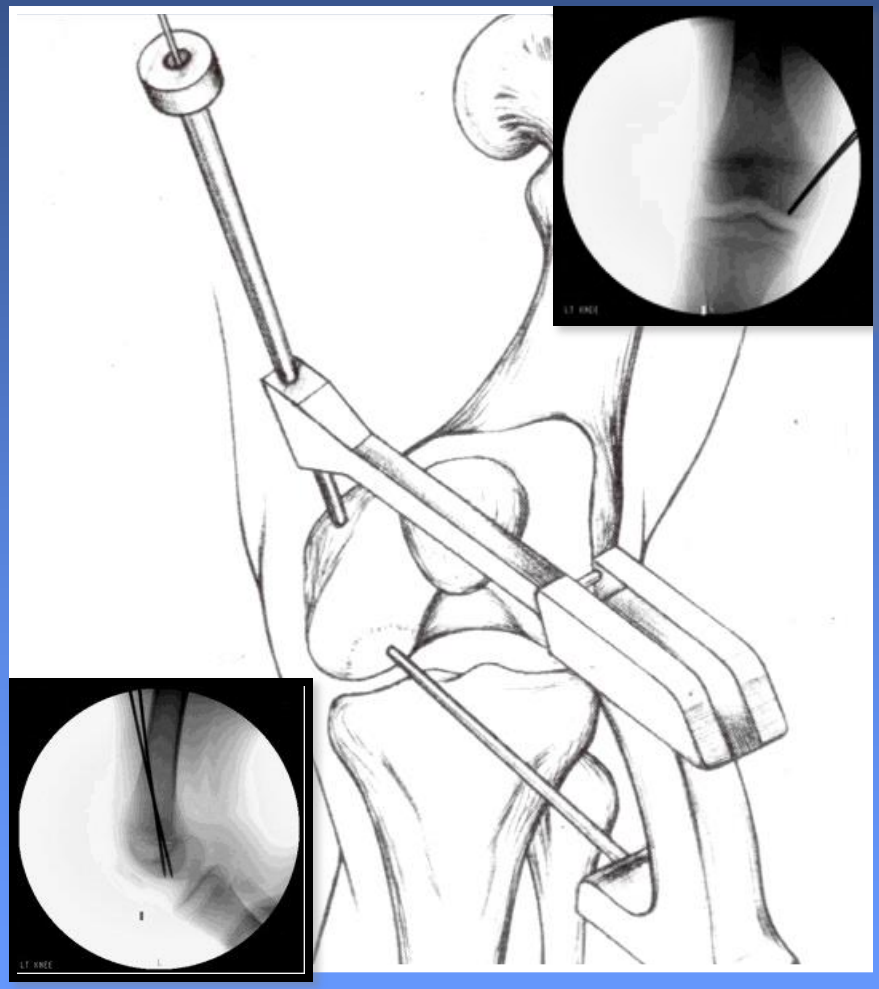
Reparative Techniques
Drilling

- Antegrade drilling
  - Arthoscopic
    - Standard portals or percutaneously
  - Some damage to cartilage
    - May drill thru nonarticular location e.g. notch, gutter
- G / E results in >80%
  - *Kocher et al AJSM 2001*
  - *Louisia et al KSSTA 2003*
  - *Kouzelis et al KSSTA 2006*



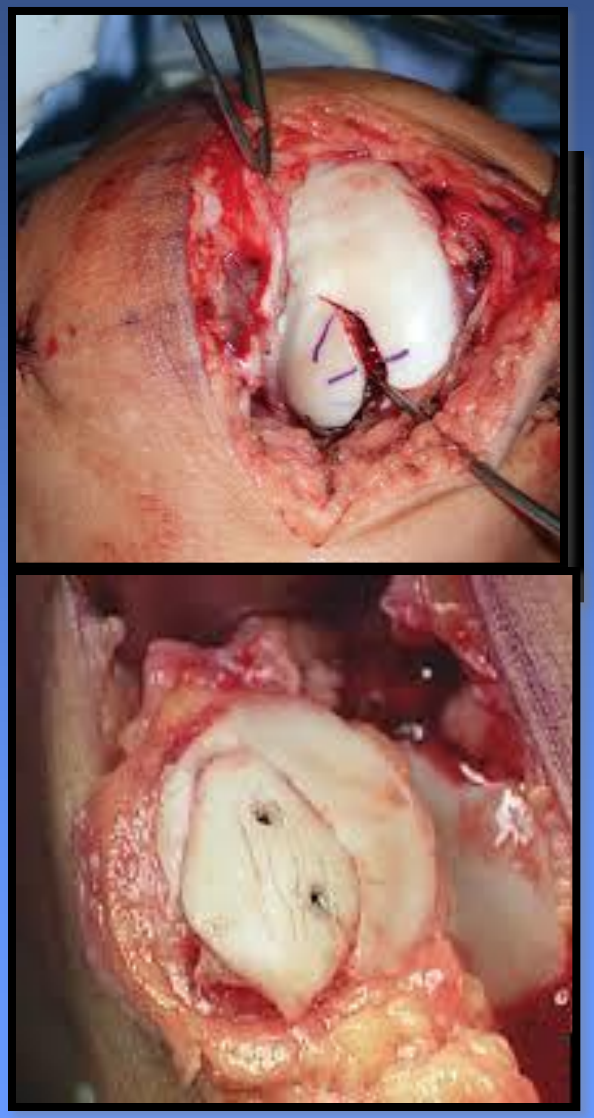
Reparative Techniques
Drilling

- Retrograde drilling
  - C-arm + / - scope
    - ACL guide
  - Avoids damaging cartilage, but…
    - More difficult
    - Risk of incomplete drilling of lesion



Reparative Techniques
Reduction and Fixation

- Arthroscopic or open
- Need sufficient bone and intact cartilage
- Bone graft if necessary
  - Proximal tibia or intercondylar notch



Reparative Techniques
Reduction and Fixation

- Internal fixation
  - Metal or absorbable headless variable pitch screws
    - 2 or more, recessed beneath cartilage
  - Compression
    - Enhances healing, stability
- Protected weight bearing for 6 weeks
- Early motion

Reparative Techniques
Reduction and Fixation

- Remove screws when stable (≥8-10 wks)
  - Allows confirmation of healing, debridement
- G/E results in 86%-100%
  - *Makino et al AJSM 2005*
  - *Gomoll et al Orthopedics 2007*
  - *Dines et al Arthroscopy 2008*

Restorative Techniques

- When repair fails or is not possible
  - Inadequate bone, fragmentation, incongruous reduction
- Replace damaged cartilage with hyaline or hyaline-like tissue

Restorative Techniques
Fresh Osteochondral Allograft

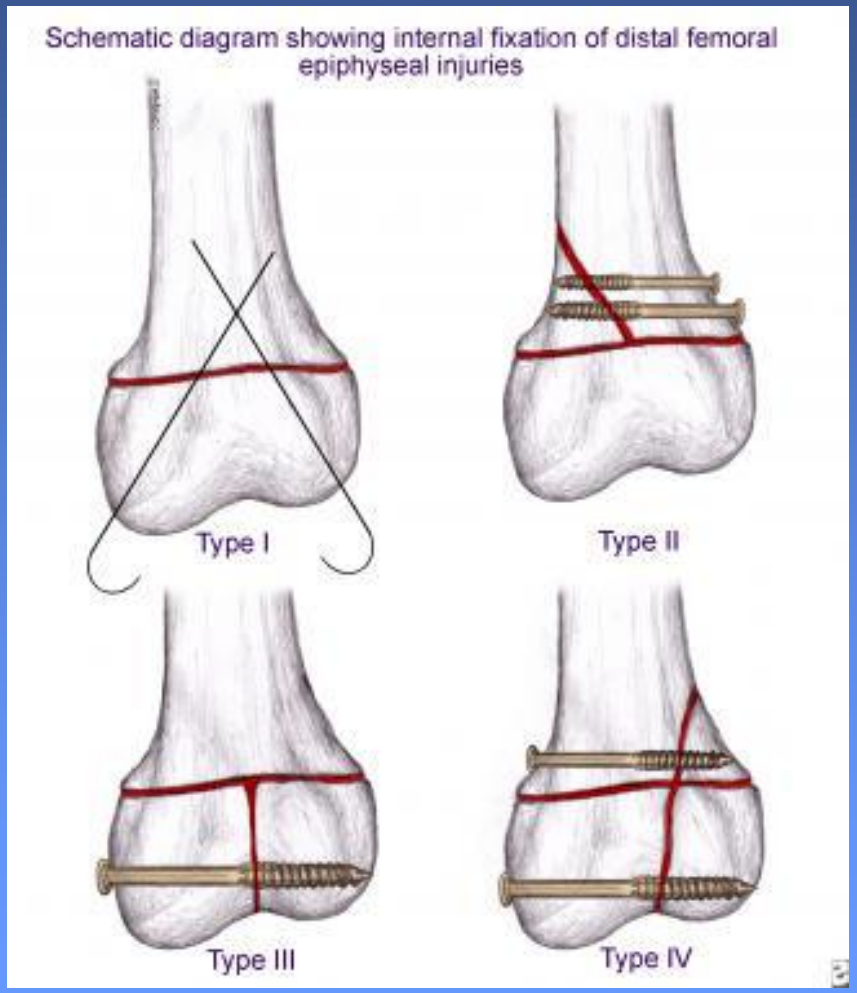
- Fresh or cryopreserved sized-matched graft
- Replaces bone and cartilage
  - Mature hyaline cartilage
- G/E results long term in 75-90%
  - *Gross et al JKS 2002*
  - *Emmerson et al AJSM 2007*
  - *McCulloch et al AJSM 2007*

Distal Femoral Physeal Fractures

- Physeal (growth plate) injuries must always be considered in patients with open physes
- In general, skeletal maturity
  - 14 – females
  - 16 – males
- Distal femur – 9 mm growth/yr
- Proximal tibia – 6mm growth/yr

Distal Femur Physeal Fractures

- Direct trauma with rotation
- Most commonly valgus or hypertension
- Typically, Salter-Harris II fracture



Proximal Tibial Physeal Fractures

- Tibial tubercle fractures
- Eccentric quadriceps contraction
- Coming down from jump with knee flexed
- Basketball, football, sprinters
- Physeal fractures

Physeal Injuries Around the Knee

- Nondisplaced fractures can heal well with casting and NWB for 4-6 weeks
- Displaced fractures often require closed versus open reduction and screw fixation

Physeal Fractures
Complications

- Physeal injury resulting in limb length discrepancy or angular deformity
- Distal femur fractures 30-50% physeal arrest
- Tibial tubercle fractures – recurvatum deformity
- Important to look for these injuries in skeletally immature patients!

Thank You