Knee Injuries in Skeletally Immature Athletes
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General Concepts
- Increased rate and ability of healing
- Higher strength of ligaments compared to growth plates
- Continued growth
- Children are NOT just small adults

No Disclosures

Growth Around the Knee
- Distal Femoral Physis
  - 1 cm growth per year
  - 70% growth of the femur and 37% growth of the lower limb
- Proximal Tibial Physis
  - 0.7 cm growth per year
  - 55% growth of the tibia and 25% growth of the lower limb

Evaluation
- Injury mechanism
  - Contact vs. Non-contact
  - “Pop” or “snap”
  - Able to continue playing
  - Displacement or spontaneous reduction of patella
  - Presence of Effusion
  - Ligamentous laxity
    - Apparent varus/valgus laxity may be due to a physeal injury

Topics
- Distal Femur Fractures
- Proximal Tibia Fractures
- Tibial Tuberosity Fractures
- Tibial Eminence Fractures
- Pediatric ACL Tears
- Patellar Dislocations

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Distal Femur Fractures
- 7% of physeal injuries of the lower extremities
- Complex shape of the physis results in increased risk of focal physeal injury
- High-velocity trauma in younger juvenile patients
- Low-energy sports injuries, usually hyperextension, in adolescents

Classification
- Plain radiographs may be equivocal for type I fractures
- Oblique X-ray, contralateral films or consider MRI/CT
- Stress radiographs have fallen out of favor
- Salter-Harris II fractures account for 54% of these injuries

Treatment
- Nondisplaced – Immobilization for 4 to 6 weeks
- Displaced – Gentle closed reduction (90% traction, 10% manipulation) or Percutaneous pin/screw fixation
- Intra-articular extension of fracture – ORIF

Complications
- Growth Arrest (40-90%)
  - 64% for type IV
  - 58% for type II
  - 49% for type III
  - 36% for type I
- Leg Length Discrepancy (22%)
- Angular Deformity (24%)
- Repeat X-rays every 6-12 months
- Consider MRI to detect physeal bar

Proximal Tibia Physeal Fractures
- 3% of lower extremity physeal injuries
- Metaphyseal attachment of ligaments
- Hyperextension Mechanism
- Apex posterior angulation of metaphysis can cause injury to popliteal artery
- May auto-reduce to innocuous position

Management
- High index of suspicion for concomitant injuries
  - Vascular injury (5-7%)
  - Anterior compartment syndrome
  - Peroneal nerve injury
  - Ligamentous and meniscal injuries
- Classification and treatment similar to distal femoral fractures
- Pes anserinus may be interpositioned into fracture site for type II fractures

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Tibial Tuberosity Fractures
- Salter Harris Type III proximal tibia fractures
- 14-15% of proximal tibia fractures
- Violent contraction of the quadriceps or sudden passive flexion of the knee against a contracted quadriceps
- 90% are sports related
- Occur near end of growth - average age is 15
- Differentiate from Osgood-Schlatter’s disease

Treatment
- Most require operative fixation with k-wires or cancellous screws
- Anterior compartment fasciotomy may be indicated
- Immobilize in LLC or HKB for 4-6 weeks
- Return to sports requires 3 to 5 months
- Growth concerns not as common
  - genu recurvatum may develop in younger patient

Clinical Findings
- Patella Alta
- Knee held flexed at 20 to 40 degrees
- Unable to actively extend leg
- Anterior compartment swelling
  - Anterior compartment syndrome
    - Injury to the anterior tibial recurrent artery

Tibial Spine Fractures
- ACL insertion at chondroepiphysis, which is weaker than ACL
- 2% of knee injuries in children
- 8 to 14 years of age
- Usually associated with a plastic deformity or partial tear of ACL as well

Ogden Classification

Myers and Mckeever Classification

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**Treatment**
- Closed Management of Type I and reducible Type II with cast immobilization at 10 degrees for 6 weeks
- Open or arthroscopic treatment to achieve anatomic reduction with sutures or screws
- Inter-meniscal ligament or anterior horn of medial meniscus may be interposed
- Pull of attached anterior horn of lateral meniscus may be impediment to reduction

**Pediatric ACL Tears**
- History and exam is similar to adults
- Non-contact injuries associated with a "pop" and effusion
- Poor neuromuscular control and landing mechanics
- Older thinking was that tibial eminence fractures were pediatric equivalent of ACL tears
- Narrower notch width is associated with higher likelihood of tearing ACL vs. tibial eminence fracture

**Complications**
- Arthrofibrosis
  - Begin early ROM exercises at 4 weeks
  - Extension block from malunion or prominent hardware
- Residual laxity or instability
  - Up to 64% of patients at 4 years follow-up
  - Much less likely in children under 10

**Work-Up**
- Plain X-rays and MRI
  - Assess growth plates and additional injuries
  - Standing long-leg films
  - pre-existing LLD or alignment abnormality
- Assessment of maturity (chronologic, skeletal and physiologic age)
- Tanner stage
- PA hand and wrist X-ray for assessing bone age

**Pediatric ACL Tears**
- Increased incidence due to growth in popularity of youth sports, especially for females
- Athletes participating in high-school sports has doubled in past 40 years (1972 Title IX legislation)
- National Survey of Athletic Trainers in 2012
  - Female soccer players tore ACL 14.08 per 100,000 exposures
  - Male football players tore ACL 13.87 per 100,000 exposures

**Treatment**
- Non-operative treatment indicated for partial tears <50% and in select cases of complete tears
- Poor compliance limits success of treatment
- Overall incidence of meniscal tears 4% for operative vs. 67% for nonoperative
- Nonoperative patients unlikely to return to play

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Surgical Management

- Concern for physeal damage leading to growth arrest or angular deformity
- Few reports of this in literature with use of proper techniques
- Alternative fixation techniques
  - Physeal-sparing with combined intra-articular and extra-articular reconstruction using ITB
  - All-epiphyseal
  - Partial or complete transphyseal

Patellar Dislocation

- Non-contact injury that presents with acute hemarthrosis
- Patient may self-describe the dislocation and subsequent reduction
- Predisposing anatomy
  - Genu valgum, Femoral Anteversion, External tibial torsion, Patella Alta, Trochlear dysplasia, Hypermobility, Weak VMO

Surgical Management

- Minimize tunnel diameter
- More central and vertical tunnel drilling
- Soft tissue grafts that occupy <5% of the cross-sectional area have not been shown to cause growth arrest
- Quadrupled hamstring autograft is best choice
- Metaphyseal fixation

Evaluation

- If not reduced on presentation, gentle knee extension with medial force to achieve reduction
- Aspiration of hemarthrosis may be considered
- Assess for patella alta, tenderness over medial retinaculum and apprehension on lateral patellar translation
- Plan X-rays (merchant view) and MRI
  - Osteochondral fractures and loose bodies
  - MPFL, VMO and concomitant injuries

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Treatment

- Nonoperative management
  - Preferred for most first-time dislocations
  - Immobilization for 3 weeks with rehab program focusing on strengthening of VMO

- Operative management
  - Indicated in setting of osteochondral fracture or loose body, recurrent dislocations, significant injury to medial stabilizers with VMO retraction
  - MPFL repair vs. reconstruction
  - Distal realignment may be indicated
  - Lateral release rarely, if ever, indicated

Thank You