Physseal and Apophyseal Injuries In The Developing Skeleton

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The Disclosure slide

- Nothing to disclose
General Principles

Everybody falls down the same way!
Gravity

• Exerts same effect on a child as it does on an adult
• Pediatric skeleton has the same number of bones and muscles as adults

BUT
Critical Factor

• Pediatric bone is constructed differently

• Part of pediatric bone is still cartilaginous and joined to the bone by a PHYSIS

• The physis is generally the weak link
Regional Histology

• The presence of the physis largely governs the appearance of pediatric musculoskeletal injury

• Almost all pediatric avulsive injuries involve a physis
The Physis

- A columnar arrangement of chondrocytes with minimal matrix is always going to be weaker than bone
Physeal Fractures

- The physis is an inherent area of weakness in pediatric bone.

The Salter Harris Classification

1  
2  
3  
4  

Salter 5- A Special Case
Salter I Fracture
Salter 1 Fracture - Femur
Fusion at the distal tibia occurs asymmetrically.

- Begins at Kump’s Bump anteromedially.
- Progresses medially and laterally.
- Causes complex fractures.
Triplane Fracture
Lauge-Hansen Classification

- Classifies ankle injury by mechanism of injury
- Supination-external rotation most common
- Triplane fracture is the same mechanism!
Lauge-Hansen vs Triplane

Figure - Supination-external rotation fractures, such as the one shown here, are the most common ankle fractures in older patients. They occur in 4 stages: (1) injury causes disruption of the anterior tibiofibular ligament, (2) continuation leads to a spiral or oblique fracture of the lateral malleolus, (3) continuation may cause a posterior malleolus fracture, and (4) continuation may cause a transverse fracture of the medial malleolus.

Medial malleolus fracture

Lateral malleolus fracture

Isolated Salter-Harris Type-III injury of the lateral part of the distal tibial epiphysis. Note the external rotation of the foot and the intact anterior tibiofibular ligament attached to the fragment.

Epiphyses Apophyses

- Epiphysis contributes to bone elongation
Epiphyses Apophyses

• Apophysis is an epiphysis that does not contribute to bone elongation
• Commonly serves as an attachment point for tendons and ligaments
Little League Shoulder

- AKA proximal epiphysiolysis
- Chronic Salter 1 fracture thru physis
- Rotator cuff exerts large shear force on humeral head

Not rotator cuff but the physis concentrates at weakest point
Little league shoulder

- Edema at wide irregular physis
**Injury Variance with Age**

- After physeal closure in young throwers, labral tears predominate.

**Kim Lesion**

A incomplete tear of posteroinferior labrum related to chronic overload.
Ulnar collateral ligament connects medial epicondyle to sublime tubercle of the ulna
Medial epicondyle

- Acute vs chronic
  - Acute = fall on elbow
  - Chronic = little leaguers
- Valgus stress causes avulsion along UCL
• Usually whole epicondyle is pulled off
• Peripheral fragments may also be avulsed
• Still a physeal injury
Apophysis is surrounded by a spherical growth plate

Avulsions may run through main physis or peripheral physis
Little league elbow

- MRI shows widening of physis with edema on both sides of physis
- AAOS limits number and types of pitches a little leagues may throw
• Mixed lesions common
• Stress changes may be present at more than one level
Gymnast wrist

- Chronic physeal stress
  - May yield ulnar-plus variance
- Radiographic and MRI findings
  - Widened physis
  - Metaphyseal irregularity
  - Edema on both sides of physis
  - Premature physeal fusion
Iliac crest = Tensor fascia lata and abdominals

ASIS = Sartorius

AIIS = Rectus femoris

Ischial tuberosity = hamstrings
Tensor Fascia Lata vs Sartorius

• TFL
  – Iliac crest and ASIS
  – Broader insertion
  – Larger avulsed fragment

• Sartorius
  – ASIS
  – Smaller insertion
  – Smaller avulsed fragment
TFL avulsion at crest/ASIS

Sartorius avulsion at ASIS

Larger fragment
Displaces inferolaterally

Smaller fragment
Displaces inferiorly

White et al
Journal of Pediatric Orthopaedics, September/October 2002
MRI vs CT

- MRI can identify donor site
- CT also helpful; more intelligible

ASIS Avulsion
Ischial Tuberosity

- Includes attachment of:
  - Biceps femoris
  - Semitendinosus
  - Semimembranosus
Ischial Tuberosity

- Simple avulsions include just conjoined tendon attachment
- Severe avulsions include semimembranosus and lateral aspect of ischium peels away
Avulsed fragment can grow.

Healing leaves irregular margin.
Ischial Tuberosity

- Bilaterality is very common
Chronic Overuse

- Chronicity is common in avulsive injuries
- Chronic overuse is a major contributing factor
Extensor complex

- Long complex mechanism
- Injury at one level may include injury at another
- Bilateral injury common
Rectus femoris

- 2 origins
  - Direct head from AIIS
  - Indirect head from rim of acetabulum
• Injury occurs during running and jumping
Avulsive physeal abnormalities and standard “adult type” injuries may coexist.
The Knee

- Quad tendon invests patella
- Forms patellar tendon
- Inserts on tibial tuberosity
Patella

• Manifestation changes with age
  – Patella sleeve fracture
  – Sinding Larssen Johanson
  – Jumper’s knee
Patellar Sleeve Fracture

- A sleeve of the inferior patella pole is avulsed
- Sleeve includes epiphyseal cartilage and physis
- No periosteum involved
  - There is no periosteum on the patella
Sinding-Larsen-Johansson

- Chronic avulsive change
- Elongation and fragmentation of inferior patellar pole
Continuum of Injury

- Patellar sleeve injuries merge with chronic changes of Sinding-Larsen-Johannsson
Osgood-Schlatter

- Acute and chronic avulsions of tibial tuberosity
- Includes pieces of cartilage and bone
- Fragmentation of tibial tuberosity, tendon thickening, infiltration of Hoffa’s fat pad
Osgood Schlatter

- Acutely edema can be extensive
- Fragment displaces superiorly
Patella and Tibial Tuberosity

- More than one level common
- Bilateral common
- Chronic common
Implications

• Tibial tuberosity physis is continuous with proximal tibial physis
• Whole physis can be avulsed
Physeal Stress Changes
Intercondylar Eminence

- AKA tibial spines
- ACL inserts onto intercondylar eminence and along medial aspect of tibial spines
• Avulsion runs through immature chondro-osseous junction
• Mechanism is same as for ACL rupture
• Injury changes as skeletal maturity
• 8-14 yo avulsion
• 12-16 yo partial ACL
• >16 yo complete tear
• Dogma is that if bone breaks, ligament ok
• NOT TRUE
• Complete and partial tears of ACL frequent
• May result in later instability
Conclusions

- Mechanism injury is constant between adult and child
- Physis is always the weak link
- Pediatric avulsions generally involve the physis
- Chronic overuse predisposes to physeal avulsion