DO THESE LIL' GUYS SPRAIN OR BREAK?

Mary Vacala ATC, MSFAS PA

Musculoskeletal development

• At birth only a few epiphyses have begun to ossify
• The others are cartilaginous & thus invisible on x-ray
• One can approximate a child’s age from the number & configuration of ossification centers.

Copyright Disclosure

I have permission to use the pictures of all my Little Patients, Nieces, and Nephews.

AFTER I gave them candy.

Speaker Disclosure

• Shareholder
  ◦ Sanovas, Inc.
• Educational Consultant
  ◦ Ferring Pharmaceuticals
• I have no financial relationships or other support relevant to this talk to report
• I have no potential conflicts of interests relating to this lecture
Blood supply to the metaphyses

Arteries & veins that form the vascular bed of growing metaphyses have sluggish blood flow.
This increases the risk of thrombosis & deposition of bacteria during periods of bacteremia.
Therefore pediatric patients are at greater risk of hematogenous osteomyelitis.

KIDS BONES ARE DIFFERENT

Epiphyseal growth plates in children have not completely ossified.
The periosteum in children is thicker, more metabolically active, less easily torn, and more easily stripped from the bone.

Skeletal injuries involving sites where ossification is incomplete

Often not detected on plain x-ray films
May not reflect the extent of the injury
This necessitates greater reliance on clinical findings.
15% of all children fractures involve Physes

- The growth plate is 2-5 times weaker than joint capsule or ligaments.

During puberty

Prior to closure the physis is weaker than nearby ligaments. As a result injuries near joints tend to result in physeal disruption rather than in ligamentous tearing. Sprains & dislocations are less likely in this age group.

History

- Important - however difficult-child is in pain, afraid, anxious & parents are anxious as well.
- MOI: type & direction of the force
- Position of the involved extremity at the time of the injury
- Events immediately following the injury
- Presence of underlying disorders
- Possibility of open contamination
- Always watch for abuse

Physical Exam

Establish a rapport
- Older infants & toddlers do well sitting on parents lap

Examine uninjured limb first

Visual inspection  Note gross position of extremity
Note deformity, distortion, angulation, or shortening
Examine overlying soft tissues for evidence of swelling, ecchymosis, abrasions, punctures or lacerations.
Initial x-ray is often negative-follow-up x-rays often disclose evidence of healing
Careful palpation should disclose focal tenderness
Discomfort on motion in some planes
Limited ROM can be minimal
Look at the clinical picture
If it looks like a fracture
Smells like a fracture
Treat it as if it is a fracture until proven otherwise
Reassess in 2-3 weeks with new x-rays to look for healing bone.

CLASSIC SIGNS OF FRACTURE
Pain
Tenderness
Loss of function
Deformity
Swelling/bruising
Crepitus

Assess neurovascular function
Check integrity of pulses & speed of capillary refill
Test sensory & motor function distal to INJURY
Check strength & sensation compare bi-lateral
Evidence of N/V compromise necessitates urgent, often operative tx.
Before & after reduction determine if the procedure itself has impaired function.
Can be present in a patient with normal distal pulses & good peripheral perfusion.
Suspect in pt.’s who c/o intense muscle pain, aggravated by stretching the muscle in an area distal to a displaced fx.
Persistence of intense pain after fx. Reduction should provoke suspicion of ischemia
PAIN BEYOND NORMAL IS A WARNING SIGN

X-ray Assessment
Two views at 90’ angles are obtained
AP & lateral most commonly
Oblique views helpful
Include joints immediately proximal & distal to a fractures long bone.
Often need comparison views of opposite side
Tomograms, MRI, & CT sometimes indicated
Treatment

Proper splinting, bracing, casting
ORIF
Elevation
Ice
X-ray assessment
<table>
<thead>
<tr>
<th>Salter I</th>
<th>Salter-Harris Type I</th>
</tr>
</thead>
<tbody>
<tr>
<td>◦ Epiphysis separate from shaft and Metaphysis through the physis</td>
<td>An injury to this area will cause a fracture to the weakest point, the cartilaginous growth plate, and spare the stronger joint capsule, ligaments and tendons.</td>
</tr>
<tr>
<td>◦ Most common in newborns and young children</td>
<td>◦ $S=$ Injury thru the physeal growth plate only, usually with displacement.</td>
</tr>
<tr>
<td>◦ Prognosis excellent</td>
<td>◦ No involvement of the adjacent metaphysis or epiphysis</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Salter-Harris II</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Through the physis with separation of physis from metaphysis, but with a small metaphysis triangle fracture</td>
</tr>
<tr>
<td>• Most common overall epiphyseal fracture</td>
</tr>
<tr>
<td>• Prognosis excellent although joint instability is possible</td>
</tr>
</tbody>
</table>
Salter–Harris II

SH II of proximal tibia (large arrow for fracture of proximal tibial metaphysis, arrowhead for separation of epiphyseal growth plate) fracture of shaft of proximal fibula (small arrow).

Salter–Harris III

- Intrarticular fracture through epiphysis
- Uncommon
- ORIF is often necessary
- Make sure reduction is adequate!

Prognosis may be poor

Salter-Harris III

Multiple CT scan images depicting a displaced Salter-Harris III fracture of the distal anterolateral tibial epiphysis (Tillaux fracture).
**Salter-Harris IV**

- Intrarticular: Through epiphysis, physes, metaphysis
- Poor prognosis, lost blood supply
- Needs perfect reduction

**SH- IV**

- Displaced fracture of the proximal tibia.
- The lateral portion of the epiphysis and the medial portion of the epiphysis are independently displaced. (free-floating fragments).

**SH- IV**

- Thurston-Holland fragment
- Large metaphyseal component
**Salter-Harris IV**

- SH IV with 2 bone fragments at the medial distal tibia—one at the metaphysis, one at the epiphysis.
- Fracture passes thru the epiphyseal plate.
- The articular cartilage can be damaged resulting in chronic disability.
- These injuries can produce joint deformity with angulation more likely at the knee and ankle.

---

**Salter-Harris V**

- Product of a crushing injury
- X-ray dx. almost impossible to make at time of injury
- Distinction between this & Type I often possible only when a subsequent growth abnormality is appreciated
  - Crushing of physis
  - Poor prognosis
  - Early X-Ray negative
  - Rarely occurs
  - HX is diagnostic

---

**SH V**

- Must be strongly suspected whenever the MOI includes significant compressive forces.
- This is the initial injury x-ray of a child’s ankle that was subjected to significant compressive and inversion forces.
- Demonstrates minimally displaced fractures of the tibia and fibula with apparent maintenance of distal tibial physisal architecture.
Role of Imaging

• Plain films - Standard of care may not adequately assess SH-I, SH-V.
• CT-3D reformatting useful in surgical planning.
  • Can assess bone bar formation.
  • Allows for evaluation of complex triplane fractures.
• MRI-Sensitive detection of fractures when plain films equivocal and evaluation of physis damage.

Treatment of Epiphyseal Injury

• Type I & II
  • Closed reduction & cast immobilization
  • Heals well, 95% do not affect growth
• Type III and IV
  • Anatomic reduction by ORIF since intraarticular, & also to prevent growth arrest
  • Injury can cause the growth plate to stop altogether or slow down.
• Type V
  • High incidence of growth arrest
  • No specific treatment
TREAT THE PATIENT NOT THE X-RAY

Fx. Treatment principles

- The younger the child the greater the capacity for regeneration
- Healing is rapid
- Shorter time period of immobilization
- Nonunion is rare
- In planning fx. reductions remodeling capability & the addition of overgrowth must be considered.

Recovery time

The recovery time will also depend on the classification of the fracture.

- **Type one, type four, and type five** – approximately four to six weeks healing time
- **Type two** – approximately six weeks healing time
- **Type three** – up to six weeks healing time

If all else Fails???

- **Cast it**

  1. Repeat offenders
  2. Sprain vs. SH Fx.
  3. Protect the child from sport
  4. Over zealous coach/parent
  5. Talk to the child
  6. Remove in 3 weeks
Fx. Treatment principles

- Bone ends must overlap to account for overgrowth
- A degree of angulation can be accepted because this will remodel.
- Casted or splinted
- ORIF is usually reserved for S-H Type III & IV.
  and certain open fx’s

Amount of angulation

- Angulation & degree of overlap of fx. fragments can not be stated in numeric terms.
- Acceptable position is determined by the child’s age, the nature & position of the fx., bone involved, appearance of adjacent tissues, & presence or absence of systemic injuries.
  Remodeling has its limitations
- Rotational & angular deformities which are not in the axis of the adjacent joint motion are not effectively remodeled.
  ANGULATION IN THE PLANE OF JOINT MOVEMENT IS MOST LIKELY TO IMPROVE WITH GROWTH AND REMODELING.

ANATOMIC REDUCTION

- Gold standard with adults
- May cause limb leg discrepancy in children (overgrowth)
- Accept greater angular deformity in children (remodeling)
- Intra-articular fractures have worse consequences in children because they usually involve the growth plate.

Healing

- Remodeling occurs by a combination of reabsorption & new bone formation
- Anatomic alignment is not always necessary
- Younger the child the more remodeling
- Heal with greater rapidity
- Have a remarkable capacity for remodeling
Probing of Open Wounds

Contraindicated if they are likely communicating with a fracture or a joint.
Wound must be cleansed and covered with sterile dressing until its extent can be determined under sterile conditions in the O.R.

Look for Other Signs

Clinical appearance of a pediatric stubbed great toe.
Note the subungual hematoma, representative of an open fracture.

Don’t let this happen

Toe that was not treated properly.
Patient failed to go to a clinic until 4 weeks after initial injury.

Palpation & Assessment of ROM

Examine entire extremity to detect less obvious injuries
Localized swelling & tenderness on palpation - suspect fracture
Pain on motion & limited ROM - signal scrutiny
Assessment of ROM

Involves observation of spontaneous movement
Attempts to get pt. to voluntarily move the involved part through its range & passive ROM
Watch adjacent joints both proximal & distal
Clinical findings vary

Special Populations

Trauma to the growth plate in the wrist of a gymnast from repetitive force.

Patella Fractures

M.O.I.
Direct: Most common and involves trauma to the patella secondary to a fall or motor vehicle accident. Cartilage acts as a cushion to a direct blow.
Indirect: A sudden accelerating or decelerating force on the quadriceps.
Marginal fracture: Usually medial owing to patellar subluxation or dislocation laterally.

Clinical Evaluation

Patients typically refuse to bear weight on the affected extremity.
Swelling, tenderness, and hemarthrosis, limited or absent knee extension.
Patella alta may be present with avulsion or sleeve fractures, and a palpable osseous defect.
Apprehension test may be positive and may indicate the presence of a spontaneously reduced patellar dislocation that resulted in a marginal fracture.
X-ray Findings

AP, lateral, and patellar (sunrise) views of the knee should be obtained.

Transverse fracture appreciated on lateral view of the knee.

Longitudinally oriented and marginal fractures appreciated on AP or sunrise views. It is important to distinguish this from osteochondral fracture, which may involve a large amount of articular surface.

Stellate fractures and bipartite patella are best seen on AP view. Comparison views of the opposite patella may aid in delineating a bipartite patella.

Classification

<table>
<thead>
<tr>
<th>Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transverse:</td>
<td>Complete versus incomplete</td>
</tr>
<tr>
<td>Marginal fractures:</td>
<td>Generally resulting from lateral subluxation or dislocation of the patella; may be either medial (avulsion) or lateral (direct trauma from condyle)</td>
</tr>
<tr>
<td>Sleeve fracture:</td>
<td>Unique to immature skeleton, consisting of an extensive sleeve of cartilage pulled from the osseous patella with or without an osseous fragment from the pole</td>
</tr>
</tbody>
</table>

Treatment

Non-operative: Non-displaced fractures (<3 mm) with an intact extensor mechanism.

Consists of a well-molded cylinder cast with the knee in extension.

Progressive weight bearing is permitted as tolerated. The cast is generally discontinued at 4 to 6 weeks.

Operative: Displaced fractures (>3 mm diastasis or >3 mm articular step-off); Stabilization involves use of cartilage screws, tension band technique, sutures, or screws; the retinaculum must also be repaired.

Sleeve fracture: Careful reduction of the involved pole and cartilaginous sleeve is performed with fixation and fixation. If this is missed, the result is an elongated patella with extensor lag and quadriceps weakness.

Postoperatively, the leg is maintained in a well-molded cylinder cast for 4 to 6 weeks.

Quadriceps strengthening and active ROM exercises.

Partial patellectomy for severe comminution.

Displaced fractures

More prominent swelling
More diffuse tenderness
Severe pain markedly increased on motion
Crepitance on gentle palpation
Manipulation must be kept minimal
Complications

If a bony bridge forms across the physis, the growth plate will stop growing or may start growing crookedly. This is rare. In those cases, surgery is indicated to prevent or correct deformity. Treatment varies depending on how much of the physis has stopped growing and the child's age. Techniques include removing the bony bridge and inserting fat into the that area, cutting the bone and re-aligning it, or completely stopping the growth in the rest of the physis as well as the physis in the other leg so that one leg does not grow longer than the other.

In very rare cases, surgery may consist of lengthening the bone.

Take home message

if physis is not damaged --> good remodeling potential
if physis is damaged --> risk of growth retardation

TIME TO HEAL

SHORTER TIME TO HEAL IN CHILDREN

REMEMBER

THEY ARE NOT TINY ADULTS
THANK YOU


http://pediatric-orthopedics.com/Treatments/Skeletal/Fractures/fractures.html
http://orthopedics.about.com/od/fracturesinchildren/p/typesgrowthplate.htm