Radiology of Pediatric Fractures

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Overview

- Osteology
- Salter-Harris Fractures
- Greenstick Fractures
- Torus Fractures
Longitudinal Bone Growth

- The physis is divided into metaphyseal and epiphyseal sections.
- Mitosis of chondrocytes in the epiphyseal section and growth in the metaphyseal section leads to longitudinal growth.
- The resting and proliferating zones contain high amounts of chondroitin sulfate, which imparts strength.
- The hypertrophing zone lacks chondroitin sulfate or calcium and is the weakest layer - this is the site of physeal fractures.

Modified from: http://www.unu.edu/Unupress/food2/UID06E/uid06e0u.htm
Kids bones are special

- Epiphyseal growth plates in children have not completely ossified.

- The periostium in children is thicker, more metabolically active, less easily torn, and more easily stripped from the bone.
Endplate Closure

- Prior to endplate closure, there is a balance between chondrocyte proliferation and bone mineralization.
- Once proliferation slows and ceases, mineralization can be completed.
- Endplate closure occurs when mineralization crossed into the epiphysis.
Salter-Harris (SH) Overview

- Developed 5 level classification system in 1963.
- Fracture involving injury to the physis of long bones before complete closure occurs.
- 35% of all skeletal injuries in children.
- 75% of cases occur in kids between 10-15 years.
- Most common sites: wrist 50%, ankle 30%.
- The growth plate is 2-5 times weaker than joint capsule or ligaments.
Type I

- Line of cleavage confined to the physis.
- Accounts for 6% of cases.
- Most commonly occurs in the phalanges.
- Growth disturbance uncommon because germinal layer and vessels not disturbed.
- Excellent prognosis, treat with closed reduction and immobilization.
- Patients often treated if no overt signs of fracture, but there is soft tissue swelling or patient is symptomatic.
Type I continued

- Best identified by comparing to normal joint and looking for widening of the physis.

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Type II

- Fracture line through the physis and extends through margin of metaphysis - “corner sign”
- Most common type (75% of cases)
- Distal radius most common site
- Minimal shortening, good outcomes.
- Treat with closed reduction and immobilization.
Type III

- Fracture runs through epiphysis then horizontally through physis.
- Accounts for 8% of cases.
- Typically seen after partial epiphyseal plate closure in tibia and distal femur.
- Some deformity, but most problems arise from fracture entry into joint space.
- Treat with closed reduction and immobilization, occasional ORIF.
Type IV

- Vertically oriented fracture through epiphysis, physis, and metaphysis.
- 10% of injuries.
- Most commonly in distal femur and distal tibia.
- Requires surgical repair, and often causes disability and joint deformity from damage to germinal layer and epiphyseal blood supply.
Type V

• Crush injury of physis typically from axial loading, no injury to epiphysis or metaphysis.
• Accounts for <1% of cases.
• Immediate radiographs show no abnormality other than soft tissue swelling, later studies demonstrate abnormal bone growth.
• Associated with growth arrest and formation of bone bridges requiring surgical repair.

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Rare Types

- VI - Injury to perichondrial structures
- VII - Isolated injury to epiphyseal plate
- VIII - Isolated injury to metaphysis
- IX - Injury to periosteum
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\(^1\).
- US - Limited use in assessing fractures near joints\(^2\).
- MRI - Sensitive detection of fractures when plain films equivocal and evaluation of physis damage.

\(^1\)Brown, SD, et al., Analysis of 51 tibial triplane fractures using CT with multiplanar reconstruction. AJR (2004) 183: 1489-95
Case I

• 15 year old male presents to the ED after falling onto his right ankle while wrestling.
• He is unable to bear weight on his right ankle, denies any loss of sensation, and has normal peripheral pulses.
• Differential Diagnosis Includes:
  – Ankle sprain
  – Fracture
• Best first evaluated with plain film including AP and lateral spanning the joint above and below the expected fracture.
Case I: Plain Film Radiography

Minimally laterally displaced distal tibia fracture in a Salter-Harris IV fashion.
Case I Evaluation

- Salter-Harris IV fractures often require surgical fixation.
- In this patient, a decision to perform a CT was made to better evaluate the extent of the fracture and plan possible surgical repair.
Since tibial fragment displaced >2mm and fragment could not be reduced closed, decision made to surgically repair.

Confirmed SH-IV fracture through metaphysis, physis, and epiphysis.
Case I: Treatment

A screw was placed through displaced fragment and the patient was casted.

3 months later, cast removed, good fracture healing. Patient did well.
Complications of SH Fractures: Case Ia

12 year old boy with a triplane fracture:
- SH-II of medial tibial
- SH-III of lateral epiphysis

Patient still has occasional pain 7 months after injury.

Orthopedic surgeons requested a CT to evaluate patient for epiphyseal plate damage.
Case Ia: Bone Bridge Formation

- When area of growth arrest less than 50%, then outcomes are good with surgical intervention\(^1\).


Patient currently has no signs of growth arrest, he will be closely followed. No surgery planned at this time.
Use of MRI in Salter Harris Evaluation

• Not widely used, however, powerful when plain films equivocal as in one study, radiographs detected 9/14 cases while MRI detected 14/14 cases, this improved sensitivity led to a change in management in 5/14 patients.¹

• Also used to evaluate damage to physis.

Case II

• A 13 year old male presents to the ED with wrist pain after falling off bicycle onto outstretched hand.
• PE reveals deformity of forearm proximal to right wrist, normal distal pulses.
• Radiographs were taken to evaluate patient.
Incomplete Greenstick fracture of distal radius with palmar angulation. Patient was casted and recovered well.
Greenstick Fracture

- Derived from “green” tree branches that bend, but do not completely break.
- Commonly results from a twisting motion on an outstretched hand.
- The genuine greenstick fracture involves disruption of cortex and periostium on convex side of fracture.
- Due to the strength of the periostium and incomplete mineralization of bone.
Treatment/Prognosis

- Often very easy to reduce and immobilize in a cast.
- Some fractures require completion of the fracture prior to reduction and immobilization.
- The prognosis is also very good for these types of fractures.
- May be complicated by recurrent deformity while casted.
Case III

- 14 year old male presents to the ED after falling onto his left forearm while snowboarding.
- Pain is localized to the forearm, denies any loss of sensation.
- Plain films were ordered.
Case III: Plain Films

Non-displaced torus fracture through distal metaphysis of L radius

Patient was casted and recovered well.
Torus Fracture

- Torus derived from Latin (*tori*), which means a swelling or protuberance.
- A buckling of the cortex on the compression side, typically 2-3cm from physis.
- Stable, non-displaced fracture, treat with casting.
- Important radiologic distinction between torus and greenstick since risk of recurrent deformation in cast higher in patients with greenstick fractures.
Summary

- Pediatric bones are immature with incomplete growth plate closure and a strong periosteum.
- Salter-Harris fractures are common fractures in children and classification of the type of fracture has important implications on treatment and outcome.
- Plain films are the standard of care for SH fractures, while CT and MRI may be necessary in more complicated cases.
- Torus and Greenstick fractures are “incomplete” fractures unique to children.
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