Physeal Fractures and Growth Arrest

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• General
• Distal Femur
• Proximal Tibia
• Distal Tibia
• Growth Arrest
• Reconstruction
General Concepts
Physeal Fractures

• 15-30% of all childhood fractures
• Uncommon under 5 years
• Peaks at 11-12 years
Injuries Involving the Epiphyseal Plate

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• Plane of fracture on the diaphyseal side along the zone of hypertrophy

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Injuries Involving the Epiphyseal Plate

ROBERT B. SALTER and W. ROBERT HARRIS

Growth Plate Fracture

SH I distal tibia fracture in an amputated limb, 9 yo M

FIG. 3. Metaphyseal side of the fracture illustrates the rolling, hilly contour of the epiphyseal plate and the flatter plane of cleavage created by the fracture.

FIG. 4. Reconstruction of the epiphyseal side (bottom) and the metaphyseal side (top) of the fracture illustrates a bite into the metaphyseal side and the corresponding fragment on the epiphyseal side of the fracture.

Microscopic Examination of a Naturally Occurring Epiphyseal Plate Fracture

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Journal of Pediatric Orthopedics
Distal Femur
Distal Femur SH II
7 Year Old Female
Distal Femur SH I
Antegrade Pinning
Bony Anatomy

• “Undulating physis”
Bony Anatomy

26 distal femoral physes
12 bilateral
Ages 3-18 years

Liu et al, J Pediatr Orthop 2013
Bony Anatomy

Normalized Height of Undulations

- Center Peak
- Lateral Ridge
- Medial Peak

Undulation Height / Physis Height vs Age (Years)

6 Years
10 Years
16 Years

Liu et al, J Pediatr Orthop 2013
- Casting versus skeletal traction
- 7/10 lost reduction
- 9 with growth arrest
Fractures of the Distal Femoral Epiphyseal Plate

Journal of Pediatric Orthopaedics

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- 30 fractures
- 43% reductions treated with cast displaced
- None with internal fixation displaced
Traumatic injuries of the distal femoral physis. Retrospective study on 151 cases

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Department of Orthopaedics, Faculty of Medicine, University of Alexandria, Egypt


- 151 fractures
- 30/82 LLC versus 3/29 hip spica lost reduction

<table>
<thead>
<tr>
<th>Age Category</th>
<th>No angular deformity</th>
<th>Angular deformity</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant (&lt;2 years)</td>
<td>11 (100.0%)</td>
<td>0 (0.0%)</td>
<td>11 (100.0%)</td>
</tr>
<tr>
<td>Juvenile (2–&lt;11 years)</td>
<td>16 (32.7%)</td>
<td>33 (67.3%)</td>
<td>49 (100.0%)</td>
</tr>
<tr>
<td>Adolescent (&gt;11 years)</td>
<td>47 (51.6%)</td>
<td>44 (48.4%)</td>
<td>91 (100.0%)</td>
</tr>
<tr>
<td>Total</td>
<td>74 (49.0%)</td>
<td>77 (51.0%)</td>
<td>151 (100.0%)</td>
</tr>
</tbody>
</table>
34 fractures, 19 SHII
13/28 LLD 1cm
11/33 5 degree angulation
Higher incidence:
  - Displaced fractures
  - Poorly-reduced fractures
Distal Femur Physeal Fx

- **SH I**
  - Nondisplaced: cast, consider spica
  - Displaced: closed reduction under anesthesia, smooth pins

- **SH II**
  - Closed reduction and cannulated screws
  - Low threshold for open reduction

- **SH III/IV**
  - Consider percutaneous screws if non-displaced
  - Open reduction and cannulated screws otherwise
Proximal Tibia
16 yo M, attempted jump over marble table, direct blow
7 months later, basketball
Purposeful Overcorrection
Fractures of the proximal tibial epiphysis

SS Burkhart and HA Peterson

- 28 fractures
- 2 popliteal artery occlusions
Fractures of the proximal tibial epiphysis

SS Burkhart and HA Peterson

- 28 fractures
- 3 SH I, 9 II, 6 III, 8 IV, 2 V
- Sports/MVA/lawn mower
- Corrective surgery in 9 growth disturbances
14 yo M, hurdles
3 ½ months postop
Fractures of the tibial tuberosity in adolescents

JA Ogden, RB Tross and MJ Murphy


- Classification: Watson-Jones, modified by Ogden
Compartment Syndrome Complicating Tibial Tubercle Avulsion

JAMES M. PAPE, M.D., JAMES A. GOULET, M.D., AND ROBERT N. HENSINGER, M.D.

CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
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• 2 cases of compartment syndrome
• 15 fractures
• 9 preexisting Osgood Schlatter
• Type I usually can extend knee
Priority is Articular Reduction
Proximal Tibial Physeal Fx

• Proximal tibia
  – Nondisplaced: LLC, careful observation especially in type III/IV
  – Displaced: closed reduction if possible, smooth pins for type I and type II with small metaphyseal pieces, else cannulated screws

• Tibial tubercle
  – Casting for type 1A
  – ORIF for remaining types
  – Okay to cross physis with screws
  – Consider prophylactic anterior fasciotomy
Distal Tibia
12 yo male, fell dancing
Closed Reduction

ED Reduction  F/U 3 days out  Comparison View
• 124 fractures
• 12% growth arrest
• Risk factors
  – High energy
  – Initial displacement
• SH II 32% of total fractures
• 10/15 growth arrest in SH II
Tillaux Fracture

12 yo F, playing/sliding
CT Scan
Percutaneous Screws
Tibial fractures involving the ankle in children. The so-called triplane epiphyseal fracture

DR Cooperman, PG Spiegel and GS Laros

- 237 fractures, 15 triplanes
- Described two-part triplane
- Tomograms in 5 patients confirmed
- 3 with PPC, minimal deformity
- 3 had 5-10° ER deformity, rec IR in cast
Tibial fractures involving the ankle in children. The so-called triplane epiphyseal fracture

DR Cooperman, PG Spiegel and GS Laros
Tibial fractures involving the ankle in children. The so-called triplane epiphyseal fracture

DR Cooperman, PG Spiegel and GS Laros

- **Signs of two part**
  - Medial malleolus continuous with tibial shaft
  - No anterior displacement of lateral epiphysis
• 23 fractures
• 20/23 asymptomatic at 18-36 months
• 8/15 asymptomatic at 38 months to 13 years
• 2mm articular step off: poor 5/5
• Recommend CT to evaluate for stepoff
• Analyzed 184 of 237 closed fractures
• 89 **low risk** (6.7% complications)
  – SH I/II distal fibula, SH I distal tibia
  – SH III/IV with <2mm displ
• 28 **high risk** (32% complications)
  – SH III/IV with >2mm displ
  – Tilliaux, triplane
  – Comminute type V
• 66 **unpredictable** (16.7% complications): SH II distal tibia
Foot Progression Angle After Distal Tibial Physeal Fractures

Vincent C. Phan, M.D., Eric Wroten, M.D., and David A. Yngve, M.D.

Study conducted at the University of Texas Medical Branch, Galveston, Texas, U.S.A.


Injured Side

Foot progression angle (degrees)

-10  -5   0    5    10   15   20   25   30

- 2 SD

Mean

+ 2 SD

Age (years)

5  6  7  8  9  10  11  12  13  14  15

Footprints
12 year old male, trampoline
2 months postop
• Triplanes excluded
• 32 distal tibia arrests
  – 28/32 SH III/IV
  – 28/32 treated closed
• 33 acute fractures
  – 19/20 SH III/IV treated open without arrest
  – 5/9 treated closed with arrest
• Growth arrests 18 months to 4 yrs
Distal tibial physeal fractures in children that may require open reduction

TF Kling, RW Bright and RN Hensinger

Distal Tibia Physeal Fx

- **SH I/II**
  - Closed reduction and casting in IR
  - ORIF if persistent gap, deformity

- **Transitional**
  - Percutaneous/ORIF unless minimally displaced
  - Less concern of physeal arrest

- **SH IV medial malleolus**
  - ORIF unless minimally displaced
Growth Arrest
Physeal Injuries

• 1-10% of physeal fractures with growth disturbance
• Most in adolescents
• Bar can resolve on their own
• Worst sites
  – Distal femur
  – Distal tibia
  – Proximal tibia
Low Risk Growth Disturbance

- Upper extremity
- Tibial tubercle fractures
- Transitional fractures ankle
Fixator Across Physis

- Smooth is better than threaded
- Duration
- Location
- Obliquity
Distal Radius Arrest

Original Injury

Refracture
Pathoanatomy

• **Etiology**
  – Bony bridge
  – Compromised vascularity
  – Damage to germinal cells
• 7% of physis
• Peripheral injuries worse

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**Injuries Involving the Epiphyseal Plate**

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12 year old male
10 weeks postop, full ROM
2 ½ years, contralateral wrist pain
• Harris growth arrest lines
• Remodeling of fracture
• Comparison views
Diagnosis

- Recognized at a few months, up to 2 years
- Sclerotic bone bridge or blurring
- Oblique growth arrest line
- MRI/CT to clarify

Lovell and Winters, 6th Edition
Growth Disturbance Types

- **Complete**: LLD
- **Partial**
  - LLD
  - Angular deformity
  - Joint incongruity

Lovell and Winters, 6th Edition
7 yo F, Pedestrian Struck
8 weeks, free flap
Reconstruction
• Complete arrest
  – <2cm: observe
  – 2-5cm: contralateral epiphyseodesis
  – >5cm: limb lengthening
13 yo F, snowboarding
CT, Bone Age

12-13 years
Epiphyseodesis
Treatment

• Partial arrest
  – Early recognition is key
    • Completion of epiphyseodesis
    • Contralateral epiphyseodesis
  – Reconstruction
    • Osteotomy ± contralateral epiphyseodesis
    • Lengthening and deformity correction
  – Physeal bar excision
Fell one year ago, initial radiographs negative
Advanced Bone Age
Osteotomy with Contralateral Epiphyseodesis
Follow Up
3 years s/p knee injury, now knee popping
7 Months s/p Frame Placement
Follow Up
10 yo F, Trampoline Injury
Growth Disturbance

25 mm LLD, procurvatum, bone age 11-12 yrs
Correction Varus
Correction Procurvatum
8 weeks postop
4 months postop
15 yo F

- R distal femur fracture age 7
- Lost to follow up after screw removal
- 7cm LLD
Ex-fix for Lengthening
Ex-fix for Lengthening
Went into Varus
Went into Varus
Went into Varus
Follow Up
Bar Excision

- <50% of physis, better if <25%
- 2 years of growth remaining
- 2 cm growth remaining
- Earlier resection tends to do better
- Central lesions tend to do better
- Circumvent osteotomy if <20 degrees
- CT or MRI to map physis
13 Year Old Female
Growth Disturbance

Summary

• Simplest treatment
  – Early detection
  – Epiphyseodesis (unilateral/bilateral)

• Complete Arrest
  – Epiphyseodesis if time
  – Internal lengthening nails

• Partial Arrest
  – Epiphyseodesis to stop
  – Osteotomy if minimal LLD
  – Ex-fix versus internal lengthening nail
Thank You