Paediatric Lower Extremity Trauma

Dale Williams
Background

- Weaker and more elastic bone with thick periosteum, therefore not as many #s, less displacement
- Peri-articular #s are able to remodel in plane of motion (usually AP plane)
- Very low rate of non-union, non-operative care usually the rule
- Physis the key to many paeds #s
Pelvic Trauma

• Rare, high energy injury, 1-3% of fractures
• Beware of associated injuries
  – Abdominal, head etc
• More elastic bone, classic double ring break may not be present
• Physeal crush injuries may occur
• Inlet/outlet, AP, Judet views ± CT scan
Classification - Torode and Zieg

• Type I, avulsion of the bony elements of the pelvis
• Type II, iliac wing fractures
• Type III, simple ring fractures, including those involving the pubic rami or disruptions of the pubic symphysis
• Type IV, ring disruption fractures, which create an unstable segment of the pelvic ring
Treatment

• Avulsions
  – Conservative, remove fragment if painful

• Stable
  – A few days-weeks of bedrest
  – Pelvic sling for symphysis diastasis

• Unstable
  – Bedrest
  – Pelvic traction, sling, spica cast
  – Ex-fix/ORIF if > 3cm SI displacement after closed reduction
Acetabular Trauma

• Can damage the triradiate cartilage
  – May lead to growth arrest
• Rim fractures may lead to superior displacement of femoral head
• CT Scan indicated to evaluate acetabular involvement and hip stability
• Prompt reduction of dislocations
<table>
<thead>
<tr>
<th>Classification (Watts) &amp; Treatment</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. small fragments most often associated with dislocation of the hip</td>
<td>1. Usually heal, occasional fragment in joint</td>
</tr>
<tr>
<td>2. linear fractures associated with pelvic fractures without displacement</td>
<td>2. Non-weight bearing with crutches</td>
</tr>
<tr>
<td>3. large linear fractures with hip joint instability (&gt;2 mm displacement)</td>
<td>3. Skeletal traction for 6-12 weeks, accurate reduction required to prevent superior migration</td>
</tr>
<tr>
<td>4. central fracture-dislocations</td>
<td>4. skeletal traction ± ORIF observation for triradiate changes for 1 year</td>
</tr>
</tbody>
</table>
Acetabular Physeal (Tri-radiate) Injuries
Hip Fractures

- Rare, <1% of paediatric fractures
- Risk of AVN, coxa vara, non-union and growth arrest necessitate aggressive management
- Risk of AVN ~ 40% for all hip fractures in children (higher in neck fractures)
  - Higher with greater displacement
A, Type I, transepiphyseal, ± dislocation from acetabulum.
B, Type II, transcervical.
C, Type III, cervicotomyrochanteric (basicervical).
D, Type IV, intertrochanteric.
Treatment

- **Type I – Transepiphysyal – 8%**
  - Poor prognosis, high AVN rate
  - Perc pinning with smooth pins ± ORIF
  - May be hidden in neonate

- **Type II – Transcervical – 46%**
  - Most frequent pattern, AVN rate related to displacement
  - CRIF with cannulated screws
  - Hematoma evacuation may ↓ AVN rate
Treatment

• Type III – Cervicotrochanteric – 34%
  – Non-displaced; traction, abduction spica cast
  – Displaced; CRIF with cannulated screws ± plate short of physis

• Type IV – Intertrochanteric – 12%
  – Best prognosis
  – Traction 2-3 weeks, spica casting 6-10 weeks
  – Closed reduction occasionally required
  – Pediatric hip screw rarely necessary
Femoral Shaft Fractures

• Subtroch, proximal, middle, and distal thirds of the shaft
• Falls, MVA’s and abuse most common causes
• 70% of #’s under age 1 caused by abuse
• High energy injury, r/o other injuries (abdomen, knee joint, other #’s)
• Watch for pathological causes (OI, ABC, NOF, EG etc.)
Location and Alignment

- **Subtroch & Prox 1/3**
  - Prox. fragment is in a flexed, ext. rotated and abducted position

- **Midshaft & Distal 1/3**
  - Usually aligned with mild ext. rotation
  - 5-10° of angulation usually acceptable, more in younger patients

- Rotation up to 25° will correct spontaneously in age <13 years (goal being 10°)

- Length and alignment most important to correct

- Shortening >2 cm requires traction before casting
<table>
<thead>
<tr>
<th>Age</th>
<th>Varus/Valgus (degrees)</th>
<th>Anterior/Posterior (degrees)</th>
<th>Shortening (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth to 2 yr</td>
<td>30</td>
<td>30</td>
<td>15</td>
</tr>
<tr>
<td>2–5 yr</td>
<td>15</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>6–10 yr</td>
<td>10</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>11 yr to maturity</td>
<td>5</td>
<td>10</td>
<td>10</td>
</tr>
</tbody>
</table>
### TABLE 22-1. TREATMENT OPTIONS FOR FEMORAL SHAFT FRACTURES IN CHILDREN AND ADOLESCENTS

<table>
<thead>
<tr>
<th>Age</th>
<th>Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Birth to 24 mo</td>
<td>Pavlik harness (newborn to 6 mo)</td>
</tr>
<tr>
<td></td>
<td>Immediate spica cast</td>
</tr>
<tr>
<td></td>
<td>Traction → spica cast</td>
</tr>
<tr>
<td>24 mo to 5 yr</td>
<td>Immediate spica cast</td>
</tr>
<tr>
<td></td>
<td>Traction → spica cast</td>
</tr>
<tr>
<td></td>
<td>External fixation (rare)</td>
</tr>
<tr>
<td></td>
<td>Flexible intramedullary rod (rare)</td>
</tr>
<tr>
<td>6–11 yr</td>
<td>Traction → spica cast</td>
</tr>
<tr>
<td></td>
<td>Flexible intramedullary rod</td>
</tr>
<tr>
<td></td>
<td>Compression plate</td>
</tr>
<tr>
<td></td>
<td>External fixation</td>
</tr>
<tr>
<td>12 yr to maturity</td>
<td>Flexible intramedullary rod</td>
</tr>
<tr>
<td></td>
<td>Compression plate</td>
</tr>
<tr>
<td></td>
<td>Locked intramedullary rod</td>
</tr>
<tr>
<td></td>
<td>External fixation</td>
</tr>
</tbody>
</table>

Treatment choices are influenced by polytrauma (vs. an isolated femoral shaft fracture) or open fractures with soft tissue trauma.
Traction

• Skin or Skeletal traction
  – 0-45° line of pull to avoid N/V compromise
  – 5 lbs maximum for skin traction
  – Proximal tibial pin, avoiding growth plate
  – Distal femoral pin may be necessary for anteriorly displaced prox. femoral #’s to maintain 90-90 traction
  – Beware of Peroneal nerve palsy
  – Follow with spica casting
Operative

- **External Fixation**
  - Polytrauma, head trauma usual indications
  - Re-fracture, osteomyelitis major complications
  - Malunion, pin tract infection other complications

- **Flexible nails (Ender and Nancy Nails)**
  - Fewer complications than ex-fix with better results
  - Watch for rotation and angulation changes
  - Antegradent or retrograde insertion
Internal
diameter
(ID)

Rod size (mm) = \frac{\text{ID}}{2} \quad 0.5 \text{ mm} =
Operative

• Locked IM Nails
  – Appropriate in adolescents, low complication rate with good results
  – No antegrade nails in age < 12, higher AVN rate,
  – Minimize trochanteric dissection to limit femoral head AVN
  – Leave head proud to facilitate later removal

• Compression plating
  – Results similar to nailing, may be used with supplemental bone graft for severe comminution
  – Often used for pathological fractures
Complications

- Most fractures heal without ORIF
  - Social development often the reason for OR
- Nearly all femoral fractures result in overgrowth, usually 1 cm
- Angulation is rare with operative intervention
- Non-union is very rare, usually after open #’s or segmental defects
Supracondylar Fractures

- Classified by Salter-Harris system
- Higher rate of growth arrest than other areas
- Usually 2° to MVA or sporting injuries
- Often angulated by the pull of the gastrocs
Treatment

• SH Type I and II
  – Gentle closed reduction, spica cast
  – Close follow-up, watch for displacement
  – Age <10, up to 20° of angulation will remodel
  – Later osteotomy preferable to repeated manipulations
  – Crossed wires may be used for older patients
  – Cannulated screws for large metaphyseal spikes

• Type III and IV
  – Anatomic reduction necessary
  – ORIF with pins or cannulated screws
  – Avoid the physis!

• Type V
  – Cast and close observation
  – Contralateral epiphysiodesis may be required
Tibial Spine Avulsions

- Classified by Meyers and McKeever
- Most patients left with decreased extension and ACL laxity
- Anatomic reduction necessary
- Aspiration of tense hemarthrosis for pain control
A. Type I, avulsion fracture, nondisplaced.

B. Type II, hinged fracture, displaced but posterior rim remains intact.

C. Type III, completely displaced fracture
Treatment

• Type I and some IIIs
  – Immobilize knee in full extension (0-10°)
  – Arthroscopy may be useful to evaluate reduction
  – If reduction not anatomic, ORIF required

• Types II and III
  – Often have soft tissue reduction blocks (meniscus usually)
  – ORIF of fragment
  – Open and arthroscopic techniques described
  – Small screw for large fragments, wire or suture for smaller ones
Patella Fractures

• Exceptionally rare in children, often in near skeletal mature patients

• Post-dislocation osteochondral #’s, small peripheral #’s can occur

• Beware of ‘sleeve” #s
  – Small distal bone avulsion with large cartilaginous sleeve attached – will lead to chronic dislocations
Patella

• Bipartate patellae must be recognized
  – Rounded, corticated edges, usually superolateral
• Transverse #s more common with spastic disorders (ie cerebral palsy)
• Maintenance of the extensor mechanism paramount in treatment
• Stove-pipe cast for undisplaced #’s (4-6 wks)
• Repair displaced fractures with tension band wiring
A. Inferior pole.
B. Superior pole.
C. Transverse undisplaced midsubstance.
D. Transverse displaced midsubstance
Tibial Tuberosity Fractures

- Classified by Watson-Jones
- Anterior growth arrest and hyperextension deformity may result in younger ages
- Must be differentiated from Osgood-Schlatter’s disease
  - Acute onset, cannot walk, symptoms resolve with ORIF unlike OS disease
A. Type I, through secondary ossification center.

B. Type II, at junction of primary and secondary ossification centers.

C. Type III, across primary ossification center
Treatment

• Types I and II
  – Reduction with knee extended, casting
  – Serial lateral X-rays, quads pull may cause displacement
  – If gap is >0.5 cm after reduction → ORIF
  – Smooth wires or pin fixation, screws for larger fragments

• Type III
  – Essentially a S-H III
  – Anatomic reduction with ORIF as for I and II’s
  – Inspect meniscus
  – Any avulsed periosteal flaps should be sutured to original position
  – Cylinder cast 4-6 weeks
Osteochondral Fracture

• Usually patellar or on femoral condyles after patellar dislocation
• Suspect in stable knees with hemarthrosis
• Usually small osseous component and large cartilage component
• Resect smaller fragments, replace larger ones
• Repair medial retinaculum
The ‘Floating Knee’

• High energy injury, usually MVA
• ORIF required for at least one fracture
  – Plate fixation for younger patients, IM nail for older patients
• Poor outcomes, long term limb dysfunction
  – Average overgrowth 8.1 cm
  – Concomitant knee ligamentous injury common
Proximal Tibia Physeal Fractures

- Salter Harris classification used
- Relatively rare injury, well protected area
- Popliteal artery may be injured in type I or II fractures with posterior displacement
- Type I and II – closed reduction and cast
- Type III and IV – ORIF smooth K-wires
- Complications: compartment syndrome, nerve palsy, bony angular deformity, thrombosis
Proximal Tibia Metaphyseal Fractures

- Popliteal artery at risk again
- Undisplaced fractures in younger patients often heal with a valgus deformity
  - Unknown mechanism, probable medial physeal overgrowth
  - Close observation and comparison to other side
- Ages 3-8 at greatest risk, cast in some varus
- Large medial gaps may require open reduction to remove soft tissue
Tibial Shaft Fractures

• Above knee casting usually sufficient
• Close follow-up for 2-3 weeks for any loss of alignment, cast for 8-10 weeks
  – Oblique/spiral fractures more prone to loss
• High incidence of compartment syndrome, vascular injury, open fracture
• High rate of malunion/nonunion with severe open injuries→may need ORIF and bone graft
Tibial Shaft Fractures

- $5^\circ$ of varus/valgus angulation acceptable
- $5-10^\circ$ of anterior/posterior angulation
- $50\%$ apposition
- $<1$ cm shortening
- Manipulation in OR may be necessary, often cast wedging needed in follow-up
- ORIF very rare, open #'s and spastic conditions usual indication
Toddler’s Fracture

- Spiral fracture of the tibia
  - Often missed on AP/lat projections
Distal Tibia/Ankle Fractures

- Tibia Physeal Injuries
  - SH I and II caused by abduction, ext. rotation, and plantar flexion
  - SH III and IV caused by adduction, V by compression
  - SH II the most common

- Fibula Physeal Injuries
  - Usually with tibia #s
  - Isolated #s → 3-6 weeks short leg casting

- Can also be classified by injury mechanism
Distal Tibia/Ankle Fractures

- **SH I and II**
  - Bent knee, long leg cast
  - Mild displacement will remodel age < 10
  - No varus, 5-10° valgus
  - 10° AP angulation
  - ORIF for excessive angulation
  - Single screw usually sufficient for SH II

- **SH III and IV**
  - >2 mm displacement requires ORIF
  - Do not cross physis, even with smooth pins
  - Cancellous screws parallel to physis

- **Open #’s**
  - Ex-fix, may require fusion
  - Preserve physis in fusion
Complications

• Growth arrest
  – Bony bridge formation
  – Angulation common
  – Bridge resection, osteotomy required
Triplane Fractures

- Three fragment fracture, combined SH II and III
- Caused by ext. rotation of foot
- Usually occur in older children with a partially closed physis
- Two part variant – essentially a SH IV
Management

• Adequate investigations
  – CT scan for accurate # identification

• Closed reduction
  – Internally rotate, place in long leg cast, knee @ 30°

• ORIF
  – Displacement >2mm after closed reduction
  – Medial or lateral approach, remove soft tissue, reduce fragments (may require opening other side)
  – Fix with cancellous screws
  – 8 weeks NWB
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Tillaux Fracture

• Occurs with ext. rotation in older children
  – Partial growth plate closure key to pattern
  – Tib-fib ligament avulses portion of antero-lateral epiphysis
  – Creates a SH III or IV
  – Antero-lateral approach, K-wires or small screw fixation
  – Percutaneous possible with cannulated screw
  – NWB for 6-8 weeks
Talar Fractures

• Similar algorithm of treatment to adults
  – Long leg cast 6-8 weeks
  – Posterior cannulated screws for displacement
    >3-5 mm, 5° malalignment

• Hawkins classification for neck #s

• Similar complication profile except AVN resolves with time

• Open fractures most often lawnmower related
Calcaneal Fractures

• Rare in paediatric population
• Flexible bone changes # patterns
  – >60% are extra-articular, most intra-articular are undisplaced
• Most heal without functional loss
• Open fractures, significant bone loss require OR (lawnmower again)
  – CT scan pre-op always
Tarsal Fractures

• Very rare due to foot flexibility
  – Usually from crush or severe twist injuries
• Cast 2-4 weeks after swelling subsides
• Relocation of dislocations, stabilization with K-wires as needed, as in adults
  – Preserve the 1st metatarsal physis
Metatarsal/Phalanx Fractures

• Common, usually heal uneventfully
  – Initial elevation to ↓ swelling in displaced #s
• Bulky dressing then cast as swelling permits
  – BK walker for 3-6 weeks
• Multiple displaced #s, 1st MT #s may require smooth wire fixation
  – Most often 1st and 5th pinned for stability
  – Most displaced #s will remodel
Metatarsal/Phalanx Fractures

• Stress fractures rarely occur – usually heal uneventfully

• Phalanx #s – relocate and buddy tape
  – Ensure proper rotation
  – 3-4 weeks usually sufficient

• Open # management as in adults