Common Missed Injuries & Mistakes in the Pediatric Orthopedic Patient

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Objectives

• Identify common missed injuries in the pediatric orthopedic patient

• Recognize specific radiographic findings that will alert the provider of a specific injury

• Formulate a plan to manage pediatric orthopedic patients

Upper Extremity

• Elbow injuries
  ➢ Medial Epicondyle fracture
  ➢ Monteggia fracture

• Forearm fractures

• Hand fractures / injuries
  ➢ Phalangeal neck fractures
  ➢ PIP fracture/dislocation
Lower Extremity

• Hip injuries
  ➢ Slipped Capital Femoral Epiphysis
  ➢ Femoral head fractures

• Compartment syndrome

• Poly-trauma Patient

Tips for examining injured child

• Assessing injured upper extremity
  – “Squeeze” test
  – Have the child reach for an object to assess finger motion

• If not working, document unable to get good exam.

Neurologic exam in 20 seconds

• “Thumbs up”
  – Radial nerve
    • Extension thumb and wrist
  – Median nerve
    • Flexion digits 2 and 3

• “OK”
  – Anterior Interosseous nerve
    • Flexion index and thumb DIP
Neurologic exam in 20 seconds

- “Scissors”
  - Ulnar nerve
    - 1st dorsal interosseous

“Squeeze” Test

- If not cooperative, then do your best to examine using passive means
  - i.e. Tendon injuries in hand/wrist
    - Push on forearm and should see flexion of digits

Elbow Injuries:

- Medial epicondyle fractures
- Monteggia fractures
Funny lateral

• DO NOT settle for bad x-rays!

Ossification Centers

Medial Epicondyle Fracture
TK - 14 y/o M, Fall

14 y/o M
Initial Injury
Post-reduction

45 deg Internal Oblique


Monteggia Fractures

• Fracture of the ulna with associated PRUJ dissociation and radio-capitellar dislocation

• Appropriate radiographs
  ➢ Dedicated elbow views
  ➢ Forearm views

Treatment

• Reduce the ulna, the radius will follow

• If warranted
  ➢ IM Nail ulna
  ➢ Do NOT pin radio-capitellar joint
  ➢ Watch for compartment syndrome

• 4 y/o fall
• Forearm deformity
Intra-OP

3 months Post-operative

This will NOT remodel
Forearm Fractures

Factors to consider:
- Age
- Angulation
- Translation
- Rotation
- Location of fracture

Forearm Shaft Fractures

Factors to consider:
- Age
- Angulation
- Translation
- Rotation
- Location of fracture

General guidelines for forearm fractures

<table>
<thead>
<tr>
<th>Age</th>
<th>Acceptable Angle</th>
<th>Acceptable Translation</th>
<th>Acceptable Rotation</th>
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</thead>
<tbody>
<tr>
<td>&lt; 9 years</td>
<td>≤ 15 - 20°</td>
<td>Bayonet</td>
<td>≤ 45°</td>
</tr>
<tr>
<td>&gt; 9 years or older with &gt; 2 years growth remaining</td>
<td>≤ 10° proximal</td>
<td>100%</td>
<td>≤ 30°</td>
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</table>
• Risk of failed closed reduction
  ➢ Age > 10 years
  ➢ Proximal 1/3 radius fractures
  ➢ Ulna fracture angle > 15°

• Failure occurs early in non-operative management

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**Motion**

• Complete displacement does NOT interfere with recovery of motion in majority of fractures
  
• Compromised motion if displacement combined with
  ➢ Angulation
  ➢ Malrotation

• Proximal forearm fracture = worse prognosis

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8 y/o Forearm fx
Phalangeal Neck Fractures

- Mechanism
  - Extension and rotational forces
  - Closing door
  - Sports-related injuries
- Border digits most common
- Middle phalanx > proximal
Radiographs

• Deformity usually in sagittal plane
  ➢ May miss on AP

• True lateral of injured digit

• Look for “bony flecks”


Classification Phalangeal Neck Fractures

• Al-Qattan
  ➢ Portends prognosis
  ➢ Guides treatment


Classification Phalangeal Neck Fractures

• Gottschalk
  ➢ Type 1 – “The Good”
  ➢ Type 2 – “The Bad”
  ➢ Type 3 – “The Ugly”

Treatment

- Diagnose early
  - Closed reduction and pin Type 2 and 3
- Watch for rotational deformity

Rotational Deformity

3 months later – “Good”
Remodeling

- Remodeling can occur
- Young pts
- Takes years
- Restricted motion

AM – “The Bad”

- 3 y/o girl, hand caught on treadmill
- Seen at OSF, initially told no fracture
- 6 weeks later, finger looks “funny”

Displaced Phalangeal Neck Fracture
3 months later

15 months later:
10° flexion PIP joint (AROM)

Treatment
EB – “The ugly”

- 3 y/o girl, granite counter fell on hand
- Evaluated by adult surgeon and splinted for 2 weeks

2 weeks later:
Displaced phalangeal neck fractures

Treatment
Malunion and intra-articular step-off: Decreased motion

Proximal Interphalangeal Fracture - Dislocations

- Early diagnosis treatment
- Trying to prevent:
  - Residual pain
  - Stiffness
  - Recurrent instability
AL

• 16 y/o football player,
  ➢ “jammed middle finger into turf”
• Splinted at outside facility

2 months later

4 months later
First stage - Distraction

Second stage – Reduction / stabilization

“It’s just jammed”

- No such diagnosis as “Jam finger”
Slipped Capital Femoral Epiphysis (SCFE)

SCFE

- Knee pain in adolescent – THINK Hip
  - Obturator nerve

- Clinical exam
  - Decreased Internal Rotation
  - Unable to ambulate (Classification)

- X-rays
  - AP / Frog pelvis

14 y/o Right leg pain x 2 months
In-situ Screw fixation

AT – 13 y/o limp for 1 month

3 months Post-op
SCFE

- Labs
  - TSH, T4, T3, PTH, Calcium

- Avascular Necrosis
  - Increased risk w/ unstable slip (50%)
  - Open reduction (25 – 45%)

- Decreased motion
  - Even after surgery

Prophylactic Screw fixation

- Controversial
  - Age < 10 years
  - Hypothyroid
  - Open triradiate?
    - Combined with other criteria
  - Follow-up

Compartment Syndrome
Compartment Syndrome

- Increased pressure within an osseofascial compartment resulting in microvascular compromise
  - Leading to anoxia, ischemia
    - Cellular necrosis

Pediatrics

- Grottkau et al. 2005
  - 1% pediatric forearm compartment
  - Majority lower extremity
  - 40% seen in open fractures

Challenges in the Pediatric Patient

- Unreliable clinical exam
- Fracture pattern can be deceiving
- Difficulty communicating
Etiology

- Increased VOLUME within a confined fascial space
  - Bleeding
  - Fractures
  - Arterial injury
  - Edema
  - Pus
  - Extravasation fluids

- RESTRICTS compartment from expanding
  - Burn
  - Casting
  - Dressing (ACE bandage)
  - Tourniquet

Time Matters

- Heckman et al. 1993
  - Irreversible changes to peripheral nerves & skeletal muscle
  - After 8 hours complete ischemia

- Rorabeck & Clarke 1978
  - Duration of increased pressure matters
  - > 12 hours = permanent neuro damage

Clinical Evaluation

- Symptoms
  - “Pain” – out of proportion to injury
  - “Swelling”
  - “Numbness”

- Beware Poly-trauma patient
  - Examine entire patient
  - Contralateral extremity
Clinical Evaluation

• Signs – “The 5 Ps”
  – Pain
  – Pallor
  – Pulselessness
  – Paralysis
  – Paresthesia

  → Not as helpful!

Earliest Indicators

• Pain out of proportion to injury

• Pain with passive stretching of muscles in involved compartment

• Increasing need for pain medication
  – Especially in children

Indications for Pressure Measurement

• Patients with equivocal examination
  – Uncertainty regarding clinical exam

• Patients who cannot be examined fully
  – Unresponsive / comatose
  – Children
  – Nerve injury
  – Presence of regional anesthesia
Technique for measuring

- Multiple types of needles and systems
  - Slit catheter (long term monitoring)
  - Side port needle

- I use Stryker

Delta Pressure

- Perform fasciotomy if
  - Differential between DBP and compartment ≤ 20 mmHg
    - i.e. DBP = 45 mmHg; IC = 30 mmHg
    - ΔP = 45 – 30 = 15 mmHg (Decompress)

  - Or differential between MAP and compartment ≤ 30 mmHg

Case AT

- 14 y/o male ATV rollover
  - Two outside facilities
  - Unsplinted

- Worsening pain, swelling, pain with passive stretch (EHL), paresthesias foot
Treatment

- Open conversation with parents
  - Fasciotomy on consent
- Skeletal fixation
- Measure Compartment Pressures after fixation

Measuring pressures

[Diagram of bone with labels and arrows indicating pressure points]

[Image of surgical site with incision and pressure measurement device]
Does length of incision matter?

• Long enough

• Err on the side of longer incisions
  – Cohen et al. JBJS (Br) 1991
  – Add little to morbidity
  – Did not influence long term functional rate

Dressing and Post-op care

• Consider use of Vacuum assisted wound device

• Return to OR within 48 – 72 hours for irrigation and debridement
  – Delayed primary closure
  – Split thickness skin graft

2 months out
Poly-trauma Patient

SO

- 14 y/o girl MVC
- Right hip pain

Post-reduction in ED
CT scan Post-reduction – Femoral Head Fracture

Treatment

ORIF

3 months Post-Op

Hand X-rays
2 weeks later

Intra-Op

3 weeks post-op
Summary

• “The eye sees only what the mind is prepared to comprehend.”

• X-rays
  – Joint above and below (if warranted)
  – Don’t settle for bad x-rays

• Immobilize appropriately

• Compartment syndrome
  – Red flag – increase need for pain meds

Thank You!