Objectives

- Childhood bone fractures are common and often cause concern for patients, parents and clinicians.
- Understanding the typical timing and types of fractures is helpful when deciding who needs further evaluation for potential underlying disease.

General Principles

- Skeletal trauma accounts for 10-15% of all childhood injuries.
- Most important area of injury is “physis”.
- Physeal disruptions make about 15% of all skeletal injuries in children.
- Special considerations:
  - Pathological fractures
  - Child abuse
Fractures Are Common

- Prevalence of at least 1 fracture by 16 yrs:
  - Boys: 42%
  - Girls: 27%
- Annual incidence 1.6 – 2.1%
  - 162 to 257 per 10,000 person-years boys
  - 103 to 165 per 10,000 person-years girls
- Annual incidence has been increasing
  - Why?

Role of Calcium Deficiency and Increasing Fractures?

- Poor calcium intake might be responsible for the significant increase in the incidence of fractures in children and adolescents observed in recent years.
- Observational and interventional studies on the relationship between calcium intake and BMD gain have led to equivocal results.

Complications of Childhood Fractures

- Malalignment of the fractured bone
- Limb overgrowth
- Acute compartment syndrome
- Hospitalization each year 0.43%
- Time off school and activity-restricted days
  - 14 days for arm fracture
  - 26 days for leg fracture
Epidemiology of Childhood Fractures in Great Britain

What is most common fracture site in children?

A. Forearms
B. Clavicle
C. Tibia/fibula
D. Fingers and Toes

Where Do Children Fracture?
Fracture Site Distribution

- Forearms 45%
- Fingers 13%
- Toes 13%
- Elbow 6%
- Clavicle 5%
- Tibia/fibula 4%
- Humerus 3%

Etiologic Factors in Fractures

- Home environment accounts for 37% of all children’s fractures
- School environment accounts for 20% of children’s fractures
- Motor vehicle accidents
  - Femur fractures when pedestrian
  - Spinal and pelvic when occupant
Are Certain Children More Predisposed to Fracture?

- Many children fracture, but the majority do not. Hence, it is not the norm for healthy children to break their bones.
- Most fractures result from mild or moderate rather than severe trauma.
- A previous history of fracture increases the risk of further fractures 2- to 3-fold. 66% of all fractures occur in children and adolescents who fracture again. Fracture first at a young age (<5 years).

There is a link between bone density and childhood fractures.

A. True
B. False

A Link Between Childhood Fractures and Low BMD!

- The increase in fracture risk per SD decrease in size-adjusted BMC is similar to that for postmenopausal women and areal BMD.
- There is high degree of correlation for BMC across puberty and between mature daughters and their mothers, confirming heritability for bone mass.
- A history of fracture in childhood may point toward low peak bone mass acquisition and persistent skeletal fragility.

Meta-analysis of Case Controlled Studies of Bone Mass and Fractures in Children < 16 y

Standard Mean Difference (for bone mass in children with and without fractures)
I. Avon Prospective Study of Fracture in Children – UK

• Prospective Study of parents and children (n = 6213)
• 9.9 yrs old at baseline
• DXA (total body less head) at baseline
• Followed for 24 months

8.9% reported at least one fracture
1.4% had more than one fracture
45% were forearm fractures
More common – Males > females
– Whites > non-whites

DXA outcomes

<table>
<thead>
<tr>
<th>Model</th>
<th>OR for risk of fracture [OR (95% CI) p value]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: TBLH BMC minimally adjusted</td>
<td>1.07 (0.97, 1.19) 0.186</td>
</tr>
<tr>
<td>Model 1 additionally adjusted for height</td>
<td>1.25 (1.06, 1.48) 0.009</td>
</tr>
<tr>
<td>Model 1 additionally adjusted for weight</td>
<td>1.40 (1.16, 1.69) 0.001</td>
</tr>
<tr>
<td>Model 1 additionally adjusted for height and weight</td>
<td>1.57 (1.26, 1.96) &lt;0.001</td>
</tr>
<tr>
<td>Model 1 additionally adjusted for height, weight and TBLH BA</td>
<td>1.89 (1.18, 3.04) 0.009</td>
</tr>
</tbody>
</table>

89% increased risk of fracture per SD decrease in TBLH BMC

II. Avon Prospective Study of Fracture in Children – UK

• Risk of fracture was significantly associated with BMD.
  - Stronger associations of low BMD with fractures after slight trauma.
  - Fractures from medium/severe trauma were associated with BMD and heavier weight.
• Risk of fracture was associated with daily vigorous physical activity independent of other factors.
Prospective Study of Fracture in Children – Australia

- 183 children
- BMD at age 8 years
- Followed for 8 years
- 63 fractures
- Upper limb fractures associated with:
  - Low BMD
  - Overweight (p=0.08)

Another risk factor: obesity!

- Bone mass is increased in heavier children.
  - But bone size relative to body size is reduced in children who fracture.
- Children with fractures not only have low BMD but also high body weight
  - Greater impact to bones on falling.

What Are Worrisome Fractures in Normal Children?

- Difficult to define “fragility fractures” in children
- **Expert opinion**: DO worry about children with:
  - One long-bone fracture of lower extremities (tibia and femur)
  - Vertebral compression fractures
  - Two or more fractures of upper extremity long bones.

Guidelines to Identify Fracture Patients for Further Evaluation

- Normal child with
  - “worrisome fractures”
  - a pathological fracture
  - hyperextensibility
  - history of renal stones
  - family history of fractures or low BMD
- Child with underlying disorder that compromises skeletal health
**Low Bone Mass Conditions**
- Genetic or metabolic bone disease
- Anorexia nervosa
- Exercise-induced amenorrhea
- Cystic fibrosis, IBD and celiac disease
- Glucocorticoid excess
- Neuromuscular disorders
- Inactivity or immobilization

**Screening Studies**
- Comprehensive metabolic panel and phosphate
- Complete blood count
- Dietary assessment
- Serum 25(OH)D and PTH
- Urine calcium, creatinine and sodium
- Bone densitometry

**Advantages and Challenges of Using DXA in Children**

**Advantages**
- Rapid, easily tolerated
- Low radiation, safe, non-invasive
- Excellent precision
- Widely available
- Axial and peripheral measurement sites

**Challenges**
- Smaller bones with open epiphyses (growth plates)
- BMD by DXA increases with age, growth and maturation
- Pediatric reference data
- Interpretation

**Bone Density Using DXA**

- Short kids have bone density by DXA that is:
  - Greater than bone density in tall kids
  - Lower than bone density in tall kids
  - No different than bone density in tall kids
Effect of Skeletal Size on DXA Areal- BMD Measures

Volumetric BMD = 1 g/cm³

<table>
<thead>
<tr>
<th>Skeletal Size</th>
<th>BMC (g)</th>
<th>Area (cm²)</th>
<th>A-BMD (g/cm³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/2 cm</td>
<td>1/8</td>
<td>1/4</td>
<td>1/2</td>
</tr>
<tr>
<td>1 cm</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2 cm</td>
<td>8</td>
<td>4</td>
<td>2</td>
</tr>
</tbody>
</table>

Adjustment Methods for Spine BMD Z-Score in Short and Tall Children

No difference between groups


In kids: Z-score not T-score!
ISCD Pediatric Official Positions: DXA Assessment in Children and Adolescents

- DXA measurement is part of the comprehensive skeletal health assessment in patients with increased risk of fracture
- Therapeutic interventions should not be instituted on the basis of a single DXA measurement
- When technically feasible all patients should have spine and TBLH BMC and areal BMD measured:
  - Prior to initiation of bone-active treatment
  - To monitor bone-active treatment in conjunction with other clinical data
- In patients with primary bone disease or potential secondary bone diseases, spine and TBLH BMC and aBMD should be measured at clinical presentation

Conclusions

- What we know:
  - Most kids who fracture do not have a severe underlying bone disorder
  - BMD correlates with fracture risk
  - DXA results should be adjusted for height Z-score
  - DXA should be reserved for kids with specific indications
- What we think we know:
  - Children with multiple fractures have an increased lifetime risk of fracture
- What we need to know:
  - How can we strengthen bones in “normal” children.

Questions?