ELBOW: Don’t be a FOOL

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Disclosure Statement

• No financial or other conflicts of interest to report.
Goals

• Approach to the pediatric elbow: FOOL mnemonic

• Common pitfalls: Fool’s gold

• Illustrative cases
How hard is it? ER physicians...

Accuracy of Emergency Room Physicians’ Interpretation of Elbow Fractures in Children

M. Wade Shrader, MD; Mark D. Campbell, MD; David J. Jacofsky, MD

abstract

Elbow fractures in children can be difficult diagnoses for inexperienced physicians to make. The purpose of this prospective study was to determine the accuracy of radiograph interpretation of elbow fractures in children by ER physicians. The study was designed to determine the rate of missed and overtreated elbow fractures by ER physicians. The study was conducted at a tertiary care orthopedic referral center over a 6-month period and included children with elbow fractures. A total of 16 cases were included in the study. The accuracy of radiograph interpretation of elbow fractures was determined to be 53% (16/30) by ER physicians.

Materials and Methods

All consecutive children with operative elbow fractures who presented to a tertiary care orthopedic referral center over a 6-month period were included for analysis in this study. The ER physicians were from various settings, including rural, community, and pediatric hospitals. The referral sources included community and academic ER physicians, as well as pediatricians.

How hard is it? Pediatric radiologists?

**Table 1 Miss rate**

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Misses</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbows</td>
<td>475</td>
<td>18</td>
<td>3.8%</td>
</tr>
<tr>
<td>Wrist</td>
<td>261</td>
<td>8</td>
<td>3.0%</td>
</tr>
<tr>
<td>Knees</td>
<td>288</td>
<td>19</td>
<td>6.6%</td>
</tr>
<tr>
<td>Ankle</td>
<td>211</td>
<td>16</td>
<td>7.6%</td>
</tr>
<tr>
<td>Totals</td>
<td>1,235</td>
<td>61</td>
<td>4.9%</td>
</tr>
</tbody>
</table>

**Table 2 Overcall rate**

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Overcalls</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbows</td>
<td>558</td>
<td>15</td>
<td>2.7%</td>
</tr>
<tr>
<td>Wrist</td>
<td>446</td>
<td>9</td>
<td>2.0%</td>
</tr>
<tr>
<td>Knees</td>
<td>1,083</td>
<td>4</td>
<td>0.4%</td>
</tr>
<tr>
<td>Ankle</td>
<td>543</td>
<td>16</td>
<td>2.9%</td>
</tr>
<tr>
<td>Totals</td>
<td>2,630</td>
<td>44</td>
<td>1.7%</td>
</tr>
</tbody>
</table>

**Table 3 Total errors**

<table>
<thead>
<tr>
<th></th>
<th>Cases</th>
<th>Total errors</th>
<th>Error rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elbows</td>
<td>1,033</td>
<td>33</td>
<td>3.2%</td>
</tr>
<tr>
<td>Wrist</td>
<td>707</td>
<td>17</td>
<td>2.4%</td>
</tr>
<tr>
<td>Knees</td>
<td>1,371</td>
<td>23</td>
<td>1.7%</td>
</tr>
<tr>
<td>Ankle</td>
<td>754</td>
<td>32</td>
<td>4.2%</td>
</tr>
<tr>
<td>Totals</td>
<td>3,865</td>
<td>105</td>
<td>2.7%</td>
</tr>
</tbody>
</table>

Most common errors by pediatric radiologists

• Most common misses
  1. Supracondylar
  2. Olecranon/proximal ulna

• Most common overcalls
  1. Supracondylar
  2. Lateral condyle

## Most common pediatric elbow fractures

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supracondylar</td>
<td>242</td>
</tr>
<tr>
<td>Lateral condylar</td>
<td>83</td>
</tr>
<tr>
<td>Proximal ulna</td>
<td>43</td>
</tr>
<tr>
<td>Radial head/neck</td>
<td>41</td>
</tr>
<tr>
<td>Medial epicondyle</td>
<td>31</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fracture Type</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supracondylar</td>
<td>258</td>
</tr>
<tr>
<td>Radial neck</td>
<td>80</td>
</tr>
<tr>
<td>Lateral condylar</td>
<td>69</td>
</tr>
<tr>
<td>Olecranon</td>
<td>56</td>
</tr>
<tr>
<td>Medial epicondyle</td>
<td>27</td>
</tr>
</tbody>
</table>


FOOL mnemonic

• **F**: fat pads

• **O**: overt findings & outlines

• **O**: ossification centers

• **L**: lines
F: Fat pads

- Fat pad displacement: Joint Effusion ~ Fracture

- Joint effusions identified in 91.3% (422/462) of pediatric patients with elbow fractures (Emery KH et al. Pediatric Radiology 2016)
Fat pad without fracture: Occult fractures

- **Occult fracture? Suspicious.....**
  - 17% (9/54) fracture on follow up films (Donnelly LF et al. AJR 1998)
    - 78% (7/9) higher likelihood of fracture if persistent joint effusion on follow-up
  - 76% (34/45) fracture on follow up films (Skaggs DL & Mirzayon R. J Bone Joint Surg Am. 1999)
  - 23% fracture, but 100% bony injury by MRI (Al-Aubadid Z et al, J Pediatr Ortho 2002)
    - 23% (6/26) fracture, 73% (19/26) bone bruise
    - MRI did not alter the end treatment that these patients received, in agreement with other studies
  - 57% (4/7) fracture by MRI (Major & Crawford, AJR 2002)

- **Bottom line: joint effusion = high likelihood of bony injury**
  - treat with conservative management and clinical re-evaluation
O: Overt findings & Outlines

- **OVERT:**
  - Evaluate for obvious soft tissue injuries, obvious fractures and/or dislocations

- **OUTLINES:**
  - Trace outlines of each bone: subtle contour deformities
    - Distal humerus
    - Proximal radius
    - Olecranon

Most common misses
  1. Supracondylar
  2. Olecranon/proximal ulna
O: Ossification centers

- 6 centers of secondary ossification: CRITOE
L: Lines

- Anterior Humeral Line
- Radiocapitellar Line
Anterior Humeral Line
Radiocapitellar Line
Abnormal RCL
“If you obey all the rules, you miss all the fun.”

KATHARINE HEPBURN
Fool’s Gold: Pitfalls

• Proper positioning
• Young children
• Normal variants
  – CRITOE variants
  – Multiple ossification centers: trochlea, olecranon, medial epicondyle, radial head
• Fractures without fat pad
Young children: RCL

- Small epiphyses & eccentric ossification
- Metaphyseal surface of the proximal radius may not be parallel to articular surface of capitellum
- More accurate on lateral

Young children: AHL

- AHL less reliable in children < 5 years old

Pitfalls: variants of CRÎTOE: CÎRTOE
Pitfalls: variants of CRITŒŒ: CRIOTE
Pitfalls: Normal fusion vs fracture
Ossification irregularity
Pitfalls: Irregular radial neck (vs fracture)
Pitfalls: Fractures without fat pads

- Radial Neck
- Medial Epicondyle
- Olecranon tip

Joint effusions present in 91% pediatric patients with elbow fractures.
No fat pad
FOOL review

- Fat pads
- Overt findings & Outlines
- Ossification centers
- Lines
Thank you