A Quantitative Method for Radiologic Assessment of Skeletal Maturity using the Distal Femur

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I have no relevant financial relationships with the manufacturer(s) of any commercial product(s) and/or provider(s) of commercial services discussed in this CME activity.

- James Sanders: stock in Abbot, Abbvie GE Healthcare
- Raymond Liu: royalties from Orthopediatrics LLC paid to institution for research fund

I do not intend to discuss an unapproved/investigative use of a commercial product/device in my presentation.
• Accurate estimation of skeletal maturity
Skeletal Maturity

- Greulich and Pyle Bone Age
  - Significant complexity
  - Time intensive
  - Comparable to chronologic age?
• Chronological Age
  – Wide variability between children

Compliments of Lori Karol
• Peak height velocity (PHV) averages at 90% of final height
• Is there a quick, quantitative and reproducible method for estimating skeletal maturity using readily available patient information?

• How does this method compare to currently used methods?
  – Chronologic Age
  – Greulich Pyle Bone Age
Distal Femoral Physis

6 Year Old Male
Peak 6.9mm Above Line

10 Year Old Female
Peak 2.8mm Above Line

13 Year Old Female
Peak 0.8mm Below Line

Liu et al. JPO, 2013
• Source: Bolton Brush Collection
• Exclusion:
  – Absence of chronologic age or Greulich and Pyle bone age at 90% of final height
  – Poor quality radiographs
• Identified chronologic age associated with 90% of final height
  – This age was marked as Time 0

<table>
<thead>
<tr>
<th>-3</th>
<th>-2</th>
<th>-1</th>
<th>0</th>
<th>+1</th>
<th>+2</th>
</tr>
</thead>
</table>

Years From 90% Growth

• 81 children (n=42 female, n=39 males) 3 years prior to Time 0 and 2 years after.
Methods

1. Physeal Length Connecting Borders = Physeal Line

2. Record length in (mm)
Methods

3. Measure Distance From Physeal Line to Central Peak

4. Record height (mm)
Central Peak Height (mm)
Physeal Line (mm)

Interclass Correlation Coefficient (n=24 radiographs) = 0.994
• **Multiple Regression Analysis**
  
  – Compare:
    
    • Chronologic Age + Gender
    • Greulich and Pyle Bone Age + Gender
    • Chronologic Age + Gender + Central Peak Value

  – Correlation between estimated age versus true 90% final height between methods
### Radiographs

<table>
<thead>
<tr>
<th></th>
<th>Males (n=39)</th>
<th>Females (n=42)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Number of Radiographs</td>
<td>195</td>
<td>194</td>
</tr>
<tr>
<td>Mean Number of Radiographs/Subject</td>
<td>4.6 ± 1.5</td>
<td>5.0 ± 0.9</td>
</tr>
<tr>
<td></td>
<td>Males (n=39)</td>
<td>Females (n=42)</td>
</tr>
<tr>
<td>--------------------------------</td>
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</tr>
<tr>
<td>Mean Age @ 90% Growth (years)</td>
<td>13.2</td>
<td>11.3</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>0.6</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Chronologic Age + Gender</td>
<td>Greulich Pyle Bone Age + Gender</td>
</tr>
<tr>
<td>--------------------------</td>
<td>--------------------------</td>
<td>---------------------------------</td>
</tr>
<tr>
<td>Correlation to True Age at 90% Growth</td>
<td>0.838</td>
<td>0.836</td>
</tr>
</tbody>
</table>
### Mean Discrepancy from True 90% Height (Years)

<table>
<thead>
<tr>
<th></th>
<th>Chronologic Age + Gender</th>
<th>Greulich Pyle Bone Age + Gender</th>
<th>Chronologic Age + Gender + Central Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mean</strong></td>
<td>0.53</td>
<td>0.64</td>
<td><strong>0.48</strong></td>
</tr>
<tr>
<td><strong>Standard Deviation</strong></td>
<td>0.40</td>
<td>0.56</td>
<td><strong>0.37</strong></td>
</tr>
</tbody>
</table>
## Results

### Percentage of Values of by 1-Year or Greater

<table>
<thead>
<tr>
<th></th>
<th>Chronologic Age + Gender</th>
<th>Greulich Pyle Bone Age + Gender</th>
<th>Chronologic Age + Gender + Central Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of Radiographs with Measurements of by &gt;1 Year</td>
<td>13%</td>
<td>12%</td>
<td>10%</td>
</tr>
</tbody>
</table>
Limitations

• Only the left femur was available for analysis

• Unknown validity to other ethnic populations

• Needs to be tested on a modern population
• Central peak value represents a valid method for predicting 90% of final height
  – Estimates are more accurate than Greulich and Pyle Bone Age
  – Less complex and time intensive

• First Purely Quantitative Method
Thank you