Analyzing Early Onset Scoliosis in 3D: How Does Growing Rod Surgery Affect the Three Planes of Deformity?

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Introduction

• Early onset scoliosis research has been limited to 2D analyses to assess 3D deformity

• Now, technology exists to evaluate how growing rod (GR) techniques more truly affect spinal contour

• Purpose: to perform 3D radiographic analysis of patients with early onset scoliosis treated with GR surgery
Methods

Study cohort:

• Diagnosis of early onset scoliosis
• Age $\leq 10$ years at pre-operative evaluation
• Upright simultaneous biplanar radiographs (EOS Imaging, Paris, France)
• Surgery for GR placement
Methods

*Study cohort (cont.):*

- Following growing rod, patients had biplanar imaging for the duration of their treatment through
  - last follow-up appointment
  or
  - Time of final fusion
Methods

**3D Methods:**

- **Vertebral reconstructions using sterEOS® software** (EOS Imaging, Paris, France) were imported into MATLAB (Mathworks, Natick, MA)

- **Kyphosis of each vertebra:** angle between bounding endplate normals when projected into the sagittal plane

- **Cobb of each vertebra:** angle between bounding endplate normals when projected into the coronal plane
Methods

3D Methods (cont.):

• Kyphosis and Cobb were measured in:

  1) global spinal coordinate system
  2) local vertebral coordinate systems (vertebrae derotated)

  – Local Cobb angles were summed over the primary thoracic curve
  – Sagittal measurements were summed from T1 to T12 and T12 to S1
Results

• 6 patients met inclusion criteria:
  – 4 female, 2 male
  – Mean age at initial GR surgery $7.1 \pm 2.9$ years
    (range 3.3 to 10 years)
  – Etiologies:
    • Idiopathic (1 / 6)
    • Congenital (2 / 6)
    • Syndromic (1 / 6)
    • Chiari (2 / 6)
Results

- 3 patients had EOS imaging prior to initial surgery
- 3 patients had post-fusion imaging
- All patients had a minimum of 17-month follow up after initial surgery
### Results

<table>
<thead>
<tr>
<th></th>
<th>Global Thoracic Cobb (°)</th>
<th>Local Thoracic Cobb (°)</th>
<th>Global TI-12 Kyphosis (°)</th>
<th>Local TI-12 Kyphosis (°)</th>
<th>Global T12-S1 Lordosis (°)</th>
<th>Local T12-S1 Lordosis (°)</th>
<th>Apical Thoracic Vertebra Axial Rotation (°)</th>
<th>Maximum Single Vertebra Axial Rotation (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pre-op (n=3)</strong></td>
<td>68±35</td>
<td>77±38</td>
<td>53±21</td>
<td>29±28</td>
<td>57±22</td>
<td>57±19</td>
<td>22±10</td>
<td>28±12</td>
</tr>
<tr>
<td><strong>Post-op (n=6)</strong></td>
<td>54±26</td>
<td>57±27</td>
<td>47±18</td>
<td>31±29</td>
<td>53±11</td>
<td>56±9</td>
<td>19±13</td>
<td>24±9</td>
</tr>
<tr>
<td><strong>Last Follow-up (n=6)</strong></td>
<td>60±23</td>
<td>63±24</td>
<td>49±25</td>
<td>27±30</td>
<td>54±28</td>
<td>59±22</td>
<td>26±10</td>
<td>27±9</td>
</tr>
<tr>
<td><strong>Following Fusion (n=3)</strong></td>
<td>25±7</td>
<td>29±9</td>
<td>57±11</td>
<td>48±11</td>
<td>67±36</td>
<td>68±37</td>
<td>19±9</td>
<td>23±11</td>
</tr>
</tbody>
</table>

_Last Follow-up includes the last images available of ongoing GR treatment or the last images before final fusion surgery._

_Cobb and rotation are absolute values. Values are average ± std dev._
Conclusions

• As seen in 2D, there was an improvement in coronal correction following placement of GR with some gradual loss during lengthening
• Further curve correction was seen following final fusion
• In the sagittal plane, there did not appear to be any change in either thoracic kyphosis or lumbar lordosis between pre-op, immediate post-op and last follow-up
Conclusions

• Local kyphosis (each vertebral unit is derotated) demonstrated less kyphosis than that on a global sagittal x-ray suggesting a relative hypokyphosing effect of the deformity on the thoracic spine

• Worsening apical rotation was seen between pre-op and last follow-up suggesting a possible crankshaft phenomenon with GR
Acknowledgements

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