How Do We Optimize Comprehensive Care in EOS?

Evaluating Height and Growth

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Disclosures

• Grants / Research Support
  • Depuy-Synthes Spine
  • Medtronic Canada
  • Joint Solutions
  • EOS Imaging

• Consultant
  • Depuy-Synthes Spine
  • Medtronic Canada
  • Apifix Ltd.
  • Wishbone Medical
Overview

• Case Based Presentation

• 3D CT Lung Volumes

• Spine Height – Normal, 18 cm rule

• Spine Length – Sagittal Spine Length (SSL)

• Spine Length – 3D (3D-TSL)

• 3D-TSL References
Case – April 2015

• 5 Y old girl
• Scoliosis
• Prader Willi Syndrome
The Volume of Lung Parenchyma as a Function of Age: A Review of 1050 Normal CT Scans of the Chest With Three-Dimensional Volumetric Reconstruction of the Pulmonary System

Sohrab Gollogly, MD,* John T. Smith, MD,† Spencer K White,‡ Sean Firth, PhD,‡ and Keith White, MD
April 2015 – TROLLEY Guided Growth
May 2016
April 2015 - October 2017

Weight
Height
Sitting Height
Arm Span

EOSQ = 88/100 (Feb 2017)
April 2018
April ‘15 – April ‘18
Normal Spine Growth

Dimeglio, JPO-B 1993
Normal Spine Growth

Dimeglio, JPO-B 1993
Normal Spine Growth
Spine Growth

Pre-Implant  Immediate Post-op  Most Recent

“Growth from Insertion”  True Growth Phase
Expected Growth:
- Age 6-10 yrs
  - $0.9 \text{ cm/yr} = 0.9 \times 3 \text{ yr} = 2.7 \text{ cm}$

Delta T1-S1

= $5.8 \text{ cm total}$

= $4.3 \text{ cm growth (159% Expected)}$
18 cm Rule

- Outcomes (8 years old)
  - T1-T12
  - % FVC

18.6 cm
84 %

Karol et al., JBJS 2008
Can Distraction-Based Surgeries Achieve Minimum 18 cm Thoracic Height for Patients with Early Onset Scoliosis?

Results – Traditional Growth Friendly

Percentage of patients that reached 18 cm

- Congenital: 48%
- Neuromuscular: 80%
- Syndromic: 86%
- Idiopathic: 68%
Rib-based Distraction Surgery Maintains Total Spine Growth

Ron El-Hawary, MD, MSc, FRCS(C),* Amer Samdani, MD,† Jennie Wade, BS, CCRP,‡ Melissa Smith, NP,‡ John A. Heftin, MD,‡ Joshua W. Klatt, MD,§ Michael G. Vitale, MD,§ John T. Smith, MD,‡ and Children’s Spine Study Group
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Kyphosis

<table>
<thead>
<tr>
<th>Lengthening Interval</th>
<th>Degrees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Implant</td>
<td>40</td>
</tr>
<tr>
<td>L1</td>
<td>50</td>
</tr>
<tr>
<td>L2-L5</td>
<td>60</td>
</tr>
<tr>
<td>L6-L10</td>
<td>70</td>
</tr>
<tr>
<td>L11-L15</td>
<td>80</td>
</tr>
</tbody>
</table>
Out of Plane Growth?
Sagittal Spine Length Measurement: A Novel Technique to Assess Growth of the Spine

Alan J. Spurway, PEng, MSc*, Chukwudi K. Chukwunyerenwa, MD, MCh, FRCS (C)\(^1\), Waleed E. Kishta, MD, PhD, FRCS (C)\(^2\), Jennifer K. Hurry, MSc, Ron El-Hawary, MD, MSc, FRCS (C)

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Spine Deformity 2016
Sagittal Spine Length Measurement: A Novel Technique to Assess Growth of the Spine

Alan J. Spurway, PEng, MSc*, Chukwudi K. Chukwunyerenwa, MD, MCh, FRCS (C)\(^1\), Waleed E. Kisha, MD, PhD, FRCS (C)\(^2\), Jennifer K. Hurry, MSc, Ron El-Hawary, MD, MSc, FRCS (C)

![Graph showing difference in spine length: SSL-SVH (mm) vs. thoracic kyphosis angle (°). Normal kyphosis and hyper kyphotic categories are indicated with asterisks. *= p<0.05.](image_url)
April ‘15 – April ‘18
Expected Growth SSL:
- Age 6-10 yrs
- Unknown

Delta T1-S1 SSL

= 6.3 cm total
= 4.3 cm growth
Three-dimensional True Spine Length: A Novel Technique for Assessing the Outcomes of Scoliosis Surgery

Alan J. Spurway, P.Eng., MASc,* Jennifer K. Hurry, P.Eng., MASc,* Luke Gauthier, MD, FRCS(C), *
Ben Orlik, MD, FRCS(C), † Chukwudi K. Chukwumyerehwa, MD, MCh, FRCS(C), *
Waleed E. Kishta, MD, PhD, FRCS(C), * and Ron El-Hawary, MD, MSc, FRCS(C) †‡

• 3D-TSL

• Biplanar, 3D Measurement Technique

• Follows the True Path of the Spine
• 3D-TSL is
  • Accurate (0.4% error)
  • Reliable (0.952 ICC)
  • Repeatable (0.944 ICC)

• 3D-TSL results in greater spine length as compared to traditional coronal plane measures.
<table>
<thead>
<tr>
<th>Date</th>
<th>Age</th>
<th>T1-T12 3D-TSL</th>
<th>T1-S1 3D-TSL</th>
</tr>
</thead>
<tbody>
<tr>
<td>April 2015</td>
<td>5 yrs</td>
<td>15.9 cm</td>
<td>25.0 cm</td>
</tr>
<tr>
<td>Pre-op</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 2015</td>
<td>5 yrs</td>
<td>16.5 cm</td>
<td>25.7 cm</td>
</tr>
<tr>
<td>Immediate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April 2018</td>
<td>8 yrs</td>
<td>19.4 cm</td>
<td>30.0 cm</td>
</tr>
</tbody>
</table>

- **Delta T1-S1 3D-TSL**
  - = 5.0 cm total
  - = 4.3 cm growth
Reference Centile Curves for 3D Spine Length in Healthy Children

Marie Beausejour PhD, Félix Thibeault MS, Paul Dallaire PhD, Ron El-Hawary MD, MS, James O. Sanders MD, Burt Yaszay MD, Behrooz A. Akbarinia MD, Marjolaine Roy-Beaudry MSc, Patrick Tohmé, Léonie Tremblay, Stefan Parent MD PhD
Conclusions

3D CT Lung Volumes

Spine height and growth has traditionally been measured utilizing coronal plane spine height measurements.

- Dimeglio’s data
Conclusions

Spine height should be measured pre-operatively and immediately post-operatively
- Initial “growth”
- Not really growth – just straightening a curve(s)

Spine height should be measured at routine intervals
- Distraction / True Growth Phase
Conclusions

Out of plane spine growth

• Spine Length – Sagittal Spine Length (SSL)
• Spine Length – 3D (3D-TSL)
• 3D-TSL References
Thank You