The Effect of Medical Comorbidities on subdomain scores of the Early Onset Scoliosis Questionnaire (EOSQ) Before Treatment

Brandon Ramo, Anna McClung, Chan-Hee Jo, Paul Sponseller, Firoz Miyanji, Matt Oetgen, Pediatric Spine Study Group

UT Southwestern Medical Center

PEDIATRIC SPINE STUDY GROUP

SCOTTISH RITE HOSPITAL FOR CHILDREN
Disclosures

- Brandon Ramo: Speaker’s Bureau: Nuvasive, Inc; Orthopediatrics
- Anna McClung: none
- Chan-Hee Jo: none
- Paul Sponseller: Depuy Synthes Spine: Research support and royalties
  Globus- royalties
  Orthopaedics- other support
- Firoz Miyanji: none
- Matt Oetgen: none
- PSSG: Research support: POSNA, FDA, NuVasive, DePuy Synthes Spine, Growing Spine Foundation, Children’s Spine Foundation
Background

- HRQOL 8 domains:
  - General Health
  - Pain/Discomfort
  - Pulmonary Function
  - Transfer
  - Physical Function
  - Daily Living
  - Fatigue/Energy Level
  - Emotion

- Family Burden 2 domains:
  - Parental Impact
  - Financial Impact

- Satisfaction
  - Child Satisfaction
  - Parent Satisfaction

Measuring Quality of Life in Children With Early Onset Scoliosis: Development and Initial Validation of the Early Onset Scoliosis Questionnaire

Jacqueline Corona, MD,* † Hiroko Matsumoto, MA,* †
David P. Roye, Jr, MD,* † and Michael G. Vitale, MD, MPH* †
(J Pediatr Orthop 2011;31:180–185)
Background

• First Disease Specific Patient (Parent)-Reported Outcomes Questionnaire for EOS

• **Validity**
  • **Criterion Validity (pulm) (n=10)**
  • Construct Validity (n=95)

• Reliability
  • n=15

• Responsiveness
  • n=25 pre and post-operative

• Normative Reference Data (cross-sectional)
  • 150 norms (benign orthopaedic dx’s)

Criterion Validity = measures how well one measure predicts an outcome for another measure. A test has this type of validity if it is useful for predicting performance or behavior in another situation (past, present, or future).

The Final 24-Item Early Onset Scoliosis Questionnaires (EOSQ-24): Validity, Reliability and Responsiveness

Hiroko Matsumoto, MA,*† Brendan Williams, MD,‡ Howard Y. Park, MD,§
Julie Y. Yoshimachi, BA,* Benjamin D. Roye, MD, MPH,* David P. Roye, Jr, MD,*
Behrooz A. Akbarinia, MD,¶ John E. Evans, MD,§ David Skaggs, MD,¶ John T. Smith, MD,**
and Michael G. Vitale, MD, MPH*

*(J Pediatr Orthop 2018;38:144–151)
Background

- First Disease Specific Patient (Parent)-Reported Outcomes Questionnaire for EOS

Validity
- Criterion Validity (pulm) (n=10)
- Construct Validity (n=95)

Reliability
- n=15

Responsiveness
- n=25 pre and post-operative

Normative Reference Data (cross-sectional)
- 150 norms (benign orthopaedic dx’s)

Construct Validity = the degree to which a test measures what it claims, or purports, to be measuring.

The Final 24-Item Early Onset Scoliosis Questionnaires (EOSQ-24): Validity, Reliability and Responsiveness

Hiroko Matsumoto, MA,‡ Brendan Williams, MD,‡ Howard Y. Park, MD,‡ Julie Y. Yoshimachi, BA,§ Benjamin D. Roys, MD, MPH,§ David P. Roys, Jr, MD,§ Behroz A. Akbarian, MD,¶ John Emans, MD,¶ David Skaggs, MD,¶ John T. Smith, MD,** and Michael G. Vitale, MD, MPH*

(J Pediatr Orthop 2018;38:144–151)
Background

• First Disease Specific Patient (Parent)-Reported Outcomes Questionnaire for EOS

• Validity
  • Criterion Validity (pulm) (n=10)
  • Construct Validity (n=95)

<table>
<thead>
<tr>
<th>Idiopathic</th>
<th>Congenital</th>
<th>Neuromuscular</th>
<th>Syndromic</th>
</tr>
</thead>
<tbody>
<tr>
<td>n = 29</td>
<td>n = 15</td>
<td>n = 28</td>
<td>n = 18</td>
</tr>
</tbody>
</table>

Construct Validity = the degree to which a test measures what it claims, or purports, to be measuring.

The Final 24-Item Early Onset Scoliosis Questionnaires (EOSQ-24): Validity, Reliability and Responsiveness

Hiroko Matsumoto, MA,* Brenna Williams, MD,† Howard Y. Park, MD,‡
Julie Y. Yoshimachi, BA,* Benjamin D. Roye, MD, MPH,* David P. Roye, Jr, MD,*
Behrooz A. Akbarnia, MD,§ John Evans, MD,* David Skaggs, MD,¶ John T. Smith, MD,**
and Michael G. Vitale, MD, MPH* 

(J Pediatr Orthop 2018;38:144–151)
• Hypothesis: If the EOSQ has good construct validity, then medical co-morbidities should be a factor which is responsible for EOSQ subdomain score variation.

• Purpose: If this is true, future studies using EOSQ as an outcome will have to control for these co-morbidities when reporting outcomes.
Methods

• Retrospective comparative analysis of prospectively collected data
• Large multi-center cohort
• 610 patients who had pre-treatment EOSQ questionnaires
  • 119 congenital
  • 201 idiopathic
  • 156 neuromuscular
  • 184 syndromic
• Patients were analyzed for ambulatory status, presence of pulmonary, cardiac, renal, GI, developmental delay, and neurologic disabilities.
• EOSQ domain scores were then calculated prior to any surgical or nonoperative intervention of their EOS deformity and compared with univariate and multivariate analyses based on presence of medical comorbidities and C-EOS designation.
## Baseline Characteristics

### C-EOS Etiology

<table>
<thead>
<tr>
<th></th>
<th>All n=610</th>
<th>Congenital n=119</th>
<th>Idiopathic n=201</th>
<th>Neuromuscular n=156</th>
<th>Syndromic n=134</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at Baseline/Pre-Treatment EOSQ</td>
<td>6.1 ± 3.8</td>
<td>4.5 ± 3.2</td>
<td>6.3 ± 4.7</td>
<td>7.0 ± 2.7</td>
<td>6.2 ± 3.4</td>
</tr>
<tr>
<td>Coronal Cobb Angle</td>
<td>63 ± 25</td>
<td>56 ± 23</td>
<td>54 ± 22</td>
<td>76 ± 26</td>
<td>67 ± 23</td>
</tr>
<tr>
<td>Max Sagittal Kyphosis</td>
<td>49 ± 25</td>
<td>41 ± 19</td>
<td>41 ± 22</td>
<td>57 ± 27</td>
<td>52 ± 26</td>
</tr>
</tbody>
</table>

Neuromuscular patients were slightly older.
Neuromuscular and Syndromic Patients had slightly larger coronal and sagittal Cobbs.
Results

• Univariate and multivariate
Results - Univariate

• Tracheostomy,

• Supplemental nutrition needs, non-ambulatory status, or developmental delay led to lower EOSQ scores in all domains (General Health, Pain, Pulmonary Function, Transfers, Physical Function, Daily Living, Fatigue, Emotion, Financial Impact, Parent and Patient Satisfaction).

• Multivariate modeling was performed to identify which variables had the strongest influences within each EOSQ domain score (Table 1).

• In multivariate analysis, C-EOS etiology was consistently an independent predictor of these differences in domain scores.
Univariate Results

- Morbidities which scored lower in ALL domains
  - Developmental Delay (n = 166 vs n = 444)
  - Supplemental Nutrition (n = 86 vs n = 226)
  - Tracheostomy (n = 44 vs n = 500)
  - Ambulatory status (n = 139 vs n = 366)
Differences Based on Presence of Individual Co-Morbidities

EOSQ Domains with Developmental Delay vs Not

- General Health
- Pain Discomfort
- Pulmonary Function
- Transfer
- Physical Function
- Daily Living
- Fatigue
- Energy
- Emotion
- Parental Impact
- Financial Impact
- Child Satisfaction
- Parent Satisfaction

Non-delayed (n=444) vs Delayed (n=166)
Univariate Results

- Morbidities which scored lower in MOST domains
  - GI condition \( n=129 \text{ vs } 481 \)  
    ALL except financial impact
  - Neurologic non-spine \( n = 117 \text{ vs } 493 \)  
    ALL except financial impact
  - Pulmonary system \( n=149 \text{ vs } 486 \)  
    all domains but financial and parent satisfaction
Univariate Results

- Morbidities which scored lower in SELECT domains
  - Renal involvement (n=41 vs 569) lower in general health and transfers
  - Cardiac condition (n=92 vs 581) lower in transfer and daily living only.
Differences Based on Presence of Individual Co-Morbidities

Presence of Cardiac Disease

- General Health
- Pain Discomfort
- Pulmonary Function
- Transfer
- Physical Function
- Daily Living
- Fatigue
- Energy
- Emotion
- Parental Impact
- Financial Impact
- Child Satisfaction
- Parent Satisfaction

Legend:
- No cardiac (n=518)
- Cardiac + (n=92)
Univariate Results

• **Total number of comorbidities** showed modest inverted correlation
  - Transfer -0.408
  - Physical function -0.482
  - Daily living -0.525
  - Fatigue -0.351
  - Parental impact -0.365
  - Child Satisfaction -0.357

• **ASA class** showed inverse modest correlation with
  - Transfer -0.393
  - Physical function -0.448
  - Daily living -0.495
  - Parental impact -0.331
C-EOS Classification (next talk)

- C-EOS (Congenital, Idiopathic, Syndromic, Neuromuscular) played a role in influencing all domain scores except pain and financial impact.

EOSQ Domain Scores based on C-EOS Diagnosis

<table>
<thead>
<tr>
<th>Domain</th>
<th>Idiopathic (n=201)</th>
<th>Congenital (n=119)</th>
<th>Syndromic (n=134)</th>
<th>Neuromuscular (n=156)</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Health</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain Discomfort</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transfer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Physical Function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily Living</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue Energy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## Results – Multivariate Summary

### Variables affecting EOSQ Domain Scores in Multivariate Modeling

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td>(-)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-EOS</td>
<td>C &gt; S, NM</td>
<td>I &gt; S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; NM</td>
<td>C, I &gt; NM, S</td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambulatory Status</td>
<td>(+)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>C &gt; NM</td>
<td>C &gt; NM, S</td>
<td></td>
</tr>
<tr>
<td>Cardiac Condition</td>
<td></td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Condition</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental nutrition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Delay</td>
<td>(-)</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GI condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(+) implies positive correlation with subdomain score, (-) implies negative correlation with subdomain score
## Results – Multivariate Summary

### Variables affecting EOSQ Domain Scores in Multivariate Modeling

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C-EOS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>C &gt; S, NM</td>
<td>I &gt; S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; NM</td>
<td>C, I &gt; NM, S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ambulatory Status</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(+)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Cardiac Condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pulmonary Condition</strong></td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tracheostomy</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Supplemental nutrition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Developmental Delay</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>GI condition</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(+) implies positive correlation with subdomain score, (-) implies negative correlation with subdomain score
# Results – Multivariate Summary

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>(-)</td>
<td></td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-EOS</td>
<td>C &gt; S, NM</td>
<td>I &gt; S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; NM</td>
<td>C, I &gt; NM, S</td>
<td>C, I &gt; NM, S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; S</td>
<td>C &gt; NM</td>
<td>C &gt; NM</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambulatory Status</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac Condition</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Condition</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental nutrition</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Delay</td>
<td>(-)</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GI condition</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(+) implies positive correlation with subdomain score, (-) implies negative correlation with subdomain score.
### Results – Multivariate Summary

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>(-)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C-EOS</td>
<td>C &gt; S, NM</td>
<td>I &gt; S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; NM</td>
<td>C, I &gt; NM, S</td>
<td>C, I &gt; NM, S</td>
<td>C, I &gt; NM, S</td>
<td>C &gt; S</td>
<td>C &gt; NM</td>
<td>C &gt; NM, S</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ambulatory Status</td>
<td>(+)</td>
<td></td>
<td>(+)</td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td>(+)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cardiac Condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulmonary Condition</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tracheostomy</td>
<td>(-)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Supplemental nutrition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Developmental Delay</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GI condition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(+) implies positive correlation with subdomain score, (-) implies negative correlation with subdomain score.
Limitations

- Inherent to large multi-center database

- Still heterogeneity within groups:
  - Cardiac disease = small ASD not requiring treatment or multiply operated Tetralogy?
  - Pulmonary disease = asthma or vent dependence?
Conclusions

- EOS patients are a heterogeneous group and many patients have medical co-morbidities.
- Presence of co-morbidities leads to lower EOSQ scores in some domains before treatment.
- Multivariate findings indicate C-EOS etiology accounts for significant variation in EOSQ domain scores.
- EOSQ seems to have good construct validity: the presence of certain medical co-morbidities is clearly reflected in the pertinent domain scores.
Conclusions

- Hypothesis: If the EOSQ has good construct validity, then medical co-morbidities should be a factor which is responsible for EOSQ subdomain score variation
  
  Yes, Presence of co-morbidities leads to lower EOSQ scores in some domains before treatment
  This is true in both univariate and multivariate analysis
  Can conclude that the EOSQ does have good construct validity

- Purpose: If this is true, future studies using EOSQ as an outcome will have to control for these co-morbidities when reporting outcomes.
Conclusions

Multivariate findings indicated:

1) Effects of several co-morbidities influenced only a few EOSQ domains
2) C-EOS etiology accounted much of the variation in most EOSQ domain scores.

• Purpose: If this is true, future studies using EOSQ as an outcome will have to control for these co-morbidities when reporting outcomes.
Thank You