Timing of Conversion to Cervical Malalignment and PJK Following Surgical Correction of Adult Spinal Deformity: A 3-year Radiographic Analysis

Peter G Passias MD, Haddy Alas BS, Han Jo Kim MD, Renaud Lafage MS, Christopher P. Ames MD, Eric O. Klineberg MD, Shay Bess MD, D. Munish C Gupta MD, Paul Park MD, Breton G Line BS, Christopher I. Shaffrey MD, Justin S Smith MD, PhD, Frank J. Schwab MD, Virginie Lafage PhD, International Spine Study Group
Disclosures

• No relevant disclosures
• All disclosures can be found on http://www7.aaos.org/education/disclosure/search
Introduction

- When changes in global alignment such as hyperkyphosis or hyperlordosis of the thoracic and lumbar regions occur, the cervical spine maintains alignment with reciprocal changes
  - These changes may lead to development of cervical deformity over time
- Little is known of the timing in which reciprocal changes manifest
- PJK has been shown to occur in the early postoperative period
- Progressive PJK and radiographic deterioration with time may play a role in the rising incidence of cervical deformity (CD)
Methods: Grouping

- Patients were grouped based off timing of conversion to CD
  - Conversion within 6-weeks postoperative = Early
  - 6-weeks to 1-year = Intermediate
  - 1-year to 2-years = Late
  - 2-years to 3-years = Long-term
- Patient were then analyzed for radiographic and HRQL parameters
Results: Cohort Surgical Details

- Cohort: **266 patients were identified**
  - Mean 11.4±4.1 levels fused posteriorly
  - 69.5% underwent posterior-only approach
    - 29.7% combined approach
    - 8% anterior-only approach
  - 59.4% had interbody fusion placed
  - 61.7% had decompression
  - 68% had osteotomy
    - 21.4% with 3-column osteotomy
    - 16.2% with pedicle-subtraction osteotomy
    - 4.1% with vertebral column resection

Figure 1. Baseline and 1 year postop ASD corrective surgery.
Results: Timing of Conversion to CD

- 38 (14.3%) of the cohort met the definitions for conversion to CD by 6-weeks
  - 14 (5.3%) between 6-weeks and 1-year postop
  - 13 (4.9%) between 1-year and 2-year postop
  - 11 (4.1%) between 2-year and 3-year postop
- Overall conversion rate of 28.6%

Kaplan-Meyer curve demonstrating percent of cohort that converted to CD over the 3-year period.
## Results: Baseline Radiographic Predictors

### Baseline Radiographic Predictors for Early vs Late Conversion

<table>
<thead>
<tr>
<th></th>
<th>Early or Late?</th>
<th>Odds Ratio (OR)</th>
<th>Upper Confidence Interval (UCI)</th>
<th>Lower Confidence Interval (LCI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High C2-C7 CL</td>
<td>Late</td>
<td>1.05</td>
<td>1.004</td>
<td>1.09</td>
<td>0.033*</td>
</tr>
<tr>
<td>High C2-T3 Cobb</td>
<td>Late</td>
<td>1.05</td>
<td>1.01</td>
<td>1.09</td>
<td>0.022*</td>
</tr>
<tr>
<td>More superior apex L1-S1 LL</td>
<td>Late</td>
<td>0.35</td>
<td>0.18</td>
<td>0.69</td>
<td>0.0028*</td>
</tr>
</tbody>
</table>

### Baseline Radiographic Predictors for Conversion vs Non-conversion

<table>
<thead>
<tr>
<th></th>
<th>Conversion?</th>
<th>Odds Ratio (OR)</th>
<th>Upper Confidence Interval (UCI)</th>
<th>Lower Confidence Interval (LCI)</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>High PI-LL</td>
<td>Yes</td>
<td>1.03</td>
<td>1.007</td>
<td>1.05</td>
<td>0.010*</td>
</tr>
<tr>
<td>Lower L1-S1 lordosis</td>
<td>Yes</td>
<td>0.977</td>
<td>0.957</td>
<td>0.997</td>
<td>0.027*</td>
</tr>
<tr>
<td>Lower T4-T12 kyphosis</td>
<td>Yes</td>
<td>1.03</td>
<td>1.00</td>
<td>1.05</td>
<td>0.047*</td>
</tr>
</tbody>
</table>
Results: PJK Timing and Location

- Overall PJK rate 15.04%
- Overall rate of concurrent PJK with CD conversion was 52.6%
- Early conversion was associated with a more superior UIV

### Timing of PJK Relative to CD Conversion

<table>
<thead>
<tr>
<th></th>
<th>Pre-CD Conversion (% PJK incidence)</th>
<th>At CD Conversion (% PJK incidence)</th>
<th>Post-CD Conversion (% PJK incidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤6 weeks (Early)</td>
<td>NA</td>
<td>36.8%</td>
<td>15.8%</td>
</tr>
<tr>
<td>6w – 1Y (Intermediate)</td>
<td>71.4%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>1Y – 2Y (Late)</td>
<td>45.5%</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>2Y – 3Y (Long-term)</td>
<td>46.2%</td>
<td>7.7%</td>
<td>NA</td>
</tr>
</tbody>
</table>

### Location of PJK Relative to CD Conversion

<table>
<thead>
<tr>
<th></th>
<th>Mode UIV (% of PJK)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤6 weeks (Early)</td>
<td>T3-4 (60%)</td>
</tr>
<tr>
<td>6w – 1Y (Intermediate)</td>
<td>T10 (60%)</td>
</tr>
<tr>
<td>1Y – 2Y (Late)</td>
<td>T10 (40%)</td>
</tr>
<tr>
<td>2Y – 3Y (Long-term)</td>
<td>T10 (60%)</td>
</tr>
</tbody>
</table>
Discussion

– Few studies have looked at the interplay between ASD correction and cervical decompensation, especially over a 3 year period

– Those converting later had greater radiographic progression and higher rates of concurrent PJK demonstrating PJK’s progressive component

• ASD patients with flatter curvatures of the thoracic and lumbar spines may be prone to overcorrection and subsequent development of a CD with PJK over time.

• Our results echo the importance of avoiding under/overcorrection through the utilization of age-adjusted alignment targets and/or posterior tethering techniques
Summary

• 26.8% of patients converted from baseline cervical alignment to post-operative cervical deformity

• More patients converted within the immediate post-op period (<6-weeks), though later conversion up to 3-years was associated with radiographic progression and higher rates of PJK.
  – Predictors of CD conversion included higher baseline PI-LL and less TK and LL
  – Predictors of later (1-3 year) CD conversion included greater CL, C2-T3 angle, BMI, and CCI