IDENTIFYING THORACIC COMPENSATION AND PREDICTING RECIPROCAL THORACIC KYPHOSIS AND PJK

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Adult Spinal Deformity driver:
- Loss of lumbar lordosis
- Quantified by spino-pelvic mismatch: PI-LL
  - Schwab et al 2010.

Compensatory Mechanisms established:
- Pelvic retroversion
  - Duval-Beaupere et al
- Knee flexion
  - Itoi, Obeid et al
- Pelvic Shift (translation)
  - Schwab et al

These mechanisms of compensation are below the lumbar spine. What’s happen above?
Reciprocal change in Thoracic spine
- Favorable or unfavorable,
  - Lafage & al. Spine 2012

Relationship between Lordosis and Kyphosis
- Proportion between curvatures
  - Legaye and al. Rachis 1993
  - Ames and al. Spine 2013
- Mathematical proportion between LL and TK
  - Schwab and al. NASS 2014

Does PJK influence the reciprocal change in the thoracic spine?
- Part of the thoracic compensation
  - Lafage and al. IMAST 2015

Theoretical LL
\[ tLL = \frac{1}{2}(PI + TK) + 10 \]
R-square > 0.55
Pi and TK have similar impact on LL

Case Example
\[ tLL = \frac{1}{2}(48 + 73) + 10 \]
tLL = 70.5deg
(22deg more than PI)
Comparison of demographic, surgical and radiographic parameters between patient with and without a reciprocal change into the unfused segment of the thoracic kyphosis

Identify predictor of a possible change into the thoracic spine
Retrospective review of ASD patients

- Age > 18
- Sagittal Deformity and/or PSO

Inclusion criteria for the study

- 6 weeks and 1 year X-rays
- Fusion to the pelvis
- UIV between T9-L1

Data collection included

- Demographic data
  - age, gender, BMI
- Surgical data
  - UIV / LIV, use of 3CO, op. time, EBL
- Baseline, 6 weeks and 1 year radiograph

Radiographic parameters

- Pelvic parameters:
  - PI and PT
- Regional parameters:
  - L1-S1 lordosis (LL), PI-LL
  - T4-T12 kyphosis (TK)
- Global parameters:
  - SVA
  - T1-Pelvic-Angle (TPA)
- Focal parameters:
  - Angle between UIV and UIV+2 (PJK angle)

Thoracic Spine analyzed based by segment:
- Unfused (T4 to UIV), Fused (UIV to T12)
Theoretical TK (tTK) computed using three published formulas:

- LL = ½ (PI + TK) + 10 \( \Rightarrow \) TK = (LL - 10) * 2 – PI, *Schwab et al 2014|NASS*

In order to calculate TK: LL was substituted based on “PI-LL = 10” formula of *Schwab et al 2010* with respect to PI value as the following:

- Patients with PI > 70 \( \Rightarrow \) LL = PI - 10
- Patients with PI (40-70) \( \Rightarrow \) LL = PI
- Patients with PI < 40 \( \Rightarrow \) LL = PI+10

**METHODS**

- Stratification into two group
  
  - **Reciprocal TK (RK):** change on unfused TK ≥ 15
  - **Maintained TK (MK):** change on the unfused TK < 15
Comparison between patients with and without reciprocal change
- Baseline demographic parameters
- Surgical information
- Change / post operative parameters

Prediction of reciprocal change
- Logistical regression

Sub-stratification RK
- patient with / without radiographic PJK (Glattes and al. Spine 2005)
Demographic
- 219 patients included
- Mean Age: 62.6 yo (±10.3)
- BMI: 28.6kg/m² (±6.0)

Baseline alignment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>SD</th>
</tr>
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<tbody>
<tr>
<td>PT</td>
<td>27.6°</td>
<td>10.2</td>
</tr>
<tr>
<td>PI</td>
<td>57.1°</td>
<td>13.5</td>
</tr>
<tr>
<td>PI-LL</td>
<td>27.4°</td>
<td>20.0</td>
</tr>
<tr>
<td>TK</td>
<td>26.1°</td>
<td>16.8</td>
</tr>
<tr>
<td>SVA</td>
<td>9.7cm</td>
<td>8.0</td>
</tr>
<tr>
<td>TPA</td>
<td>28.6°</td>
<td>12.8</td>
</tr>
<tr>
<td>tTK</td>
<td>51.3°</td>
<td>10.6</td>
</tr>
</tbody>
</table>

Surgical:
- 101 (46%) underwent 3CO
  - 38 at L3 (38%)
  - 35 at L4 (35%)

Demographic comparison between the groups:
- Comparable age, BMI and gender distribution
- Comparable % of revision and utilization of 3CO

Reciprocal TK (RK): change on unfused TK ≥ 15
Maintained TK (MK): change on the unfused TK < 15
The two groups had comparable:
- SVA, PT, PI and TPA

Patients who sustained reciprocal kyphosis (RK) had:
- Significantly more thoracic compensation (hypokyphosis)
- More PI-LL mismatch
- Worse SRS-appearance: 2.2 vs. 2.5, p=0.005

Logistical regression to patients with reciprocal changes (yes/no):
- Thoracic compensation preoperatively (cTK) was the only predictor
Patients with and without reciprocal changes had comparable post-operative alignment
- SVA, PT, PI-LL

Sub-stratifying patients into:
- Reciprocal changes + PJK (n = 76)
- Reciprocal changes w/o PJK (n=39)

No differences in thoracic compensation, PI-LL correction, post-operative alignment
Change in thoracic kyphosis occur when patient underwent realignment

This change can be predicted in a specific setting
- Patient fused to the pelvis
- High compensation preoperative in the thoracic spine

No significant difference on post operative alignment between patient with and without reciprocal change
- Change on the unfused spine to “normalized” final alignment

Sub-stratification of patient with reciprocal change into with and without a radiographic PJK revealed no significant differences
- PJK as a part of the compensation mechanism / reciprocal change?

Preoperative thoracic compensation need to be incorporated into the preoperative planning in order to reach objectives of alignment
- **Renaud Lafage, MS** – No Relationships
- **Themistocles S. Protopsaltis, MD** – Medicrea (b); Zimmer Spine (a)
- **Bassel Diebo, MD** – No Relationships
- **Justin Smith, MD, PHD** – Biomet (b,g); Cerapedics (f); DePuy Synthes (a,b); Globus Medical (b); Medtronic (b); NuVasive (b)
- **Eric Klineberg, MD** – AOSpine (a); DePuy Synthes (a,d)
- **Doug Burton, MD** – DePuy Synthes (a,b,g)
- **Christopher P. Ames, MD** – Biomet (g); DePuy Synthes (a); Globus Medical (d); Medtronic (b); Stryker Spine (b,g)
- **Shay Bess, MD** – Allosource (e); DePuy Synthes (a); Innovasis (a); K2M (a); NuVasive (b); Pioneer (g)
- **Frank Schwab, MD** – AOSpine (a); Biomet (b); DePuy Synthes (a,b); K2M (b,g); Medicrea (b); Medtronic (a,b,g); Nemaris Inc. (e); NuVasive (g)
- **ISSG** – DePuy Synthes (a); Innovasis (a); Medtronic (a); Stryker Spine (a)

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