CAN PATIENT-SPECIFIC PRE-OP PLANNING REDUCE THE INCIDENCE OF PJK

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DISCLOSURES

- **Themistocles S. Protopsaltis, MD**
  - (b) Consulting: Medicrea, Biomet, AlphaSpine
  - (a) Research Support: Zimmer Spine

- **Virginie Lafage**
  - (a) SRS, NIH, DePuy
  - (b) DePuy Spine, Johnson and Johnson
  - (b) Medicrea
  - (b) (c) Nemaris

- **Bassel G. Diebo:**
  - Nothing to disclose

- **Frank J. Schwab:**
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  - (a,b,d) Medtronic;
  - (a,b) Biomet
  - (a,b,d) K2M
  - (b,d) Medicrea
  - (a,b) Nuvasive
  - (c) Nemaris

- a. Grants/Research Support
- b. Consultant
- c. Stock/Shareholder
- d. Royalties
- e. Board member
- f. Financial support from publisher
WHAT IS PJK?

Definition,
prevalence,
and clinical impact

PJK IS THE RESULT OF ACUTE TREATMENT OF CHRONIC DISEASE

- What really happens..
  - Take an aging spine
    - Decades of deformity
    - Loss of soft tissue
      - Bones
      - Muscles
  - Realignment in 4 hours to a “much younger” spine
  - Maintenance:
    - Maybe
    - Maybe not
ECONOMICAL BURDEN OF PJK: $

- Single center experience of 457 ASD patients
- Total direct cost of PJK: 4 million dollars
- Average cost per revision for PJK: 60,000$
  - Similar between UT and LT
- Vertebroplasty to prevent?: 46,000$
- Kyphoplasty to prevent?: 82,172$

Cost effectiveness?

- Reason for revision and clinical impact:
  - Glattes et al 2005:
    - 0/21 patients required revision for PJK
  - Kim et al 2008:
    - Significance in SRS self image
  - Yagi et al 2012:
    - Significant worse ODI (p<0.001)
  - Bridwell et al 2013:
    - 1/25 patients required revision for PJK
    - No difference: ODI and SRS

- Low revision rate and comparable clinical outcomes.
- Most studies have reported no significant difference in outcomes in patients with and without PJK.

HOW BIG A DEAL IS PJK?
No real consensus on the definition in the literature

Redefining Radiographic Thresholds for Junctional Kyphosis Pathologies

ISSG – 2015:
- Try to build consensus on PJK definition by proposing more clinically relevant definition

Method:
- Analyzing 44 patients underwent revision for PJK
- Mechanisms of failure assessed:
  - Kyphosis
  - Olisthesis
- Pre-revision junctional angles were measured
- Threshold were applied to 856 ASD patients.
**REDEFINING RADIOGRAPHIC THRESHOLDS FOR JUNCTIONAL KYPHOSIS PATHOLOGIES**

- New Criteria based on pre-revision analysis:
  - *Mean PJK angle: 28°*
    - Δ 21° from baseline
  - *Mean Olisthesis: 4 mm*
    - Δ 4mm from baseline
    - If UIV<T9: olisth 2 mm
    - If UIV >T8: olisth 9 mm

- At 6 wk:
  - 34.7% met the classic criteria
  - 8.3% met the new one
  - 3% were revised for PJK

- At 1Y:
  - 37.9% met the classic criteria
  - 10.1% met the new one
  - 4.7% were revised for PJK

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**PJIK: FACTS AND THEORIES**

- Where to expect it?
  - Anywhere in the spine
  - Peds and adults

- What to blame?
  - Instruments
    - Hook, screws...
  - Gradient of stiffness
  - Stress concentration
  - Posterior arch interruption
  - Patient demographics
  - Social: smoking, drinking?

- Realignment failure?
  - What does the literature say?
**RADIOGRAPHIC RISK FACTORS**

- Preoperative TK > 40° (T5-12)  
  - Kim et al, Spine 2007

- Incomplete restoration of lordosis
  - Overcorrection of SVA
  - Mendoza-Lattes et al, Iowa 2007

**Limitation of the literature:**

- Large change in SVA  
  - Kim et al, CORR 2012

- Large pre-op SVA  
  - Yagi et al, Spine 2011

- Poor Post-Op SVA  
  - Yagi et al, Spine 2012

- Incomplete restoration of lordosis

**IS PJK A REALIGNMENT ERROR?**

**NOVEL VIRTUAL MODELING OF THE SPINE FOLLOWING ASD SURGERY:**

- Virtual models of the spine following ASD surgery

- Method:
  - 458 patients fused to pelvis:
    - into 2 groups:
      - PJK
      - NO PJK

- @ 2yr follow up, virtual modeling combined:
  - Post-op alignment of instrumented segments
  - Pre-op alignment of unfused segments

- Compare PJK vs. no PJK after correction

PT (established formula)

Lafage R et al, 2015
NOVEL VIRTUAL MODELING OF THE SPINE FOLLOWING ASD SURGERY:

- Virtual analysis: PJK patients vs. noPJK
  - More correction: less PI-LL mismatch
    - 3.1 vs. 7.7°
    - Although they were **OLDER**
  - Less pelvic retroversion: (20 vs. 23°)
  - More posterior alignment:
    - SVA (10 vs. 24 mm)
    - TPA (15 vs. 18°)

**PJK may be a component of the compensatory mechanism for realignment failure.**
**HOW TO BETTER ALIGN OUR PATIENTS?**

Age adjusted alignment targets and Importance of planning

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**CLASSIC ALIGNMENT TARGETS: SRS-SCHWAB SAGITTAL MODIFIERS**

- Radiographic goals:
  - SVA < 50 mm
  - PI-LL < 10°
  - PT < 20°
  - TPA <20
  - Correlations with HRQOL

Current thresholds do not take into account patients’ age.
Recent work: To determine the validity of alignment objectives according to patient age.

Methods:
- Retrospective:
  - 11 centers, op & non-op
- > 700 patients:
  - stratified by age and US normal values of SF-36 PCS
- Linear regression and correlation (ODI-PCS) to establish age-specific thresholds of alignment at BL and 2Y

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Spino-pelvic mismatch (PI-LL):
- $-10^\circ$ for patients < 35 y/o
- Up to $17^\circ$ for patients > 74 y/o

Pelvic tilt (PT):
- $11^\circ$ for patients < 35 y/o
- Up to $29^\circ$ for patients > 74 y/o
Sagittal vertical axis (SVA):
- -30 mm for patients < 35 y/o
- Up to 80 mm for patients > 74 y/o

Younger patients require a more “rigorous” alignment than older patients to meet age-specific ODI / PCS

Do new targets have the potential to reduce PJK rate?

<table>
<thead>
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<th>PI-LL</th>
<th>SVA</th>
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<tbody>
<tr>
<td>&lt;35</td>
<td>11.0</td>
<td>-10.5</td>
<td>-30.5</td>
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<tr>
<td>35-44</td>
<td>15.4</td>
<td>-4.6</td>
<td>-5.5</td>
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<tr>
<td>45-54</td>
<td>18.8</td>
<td>0.5</td>
<td>15.1</td>
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<tr>
<td>55-64</td>
<td>22.0</td>
<td>5.8</td>
<td>35.8</td>
</tr>
<tr>
<td>65-74</td>
<td>25.1</td>
<td>10.5</td>
<td>54.5</td>
</tr>
<tr>
<td>≥74</td>
<td>28.8</td>
<td>17.0</td>
<td>79.3</td>
</tr>
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**Hypothesis:**
Over-correction of the sagittal plane based on age-specific threshold of ideal alignment is not a risk factor for PJK.

**Methods:**
- 697 patients
- Three groups of age
  - PJK rate increase by age
  - Sub-stratified by PJK/noPJK
- Comparison between PJK and noPJK:
  - Offset from age-specific thresholds

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**Elderly > 65yo Group Analysis: Post-op Offset from Age-Adjusted Targets**

- **PJK patients had significantly:**
  - more PI-LL correction
  - more posterior SVA
  - Trend lines = significant differences

- **When comparing to age-adjusted targets:**
  - **noPJK patients** had similar radiographic analysis to the age adjusted targets
  - **PJK patients are overcorrected**
    - PT: ~ 2°
    - PI-LL: ~10°
    - SVA: ~ 14 mm
PERSONALIZED MEDICINE

How can I be more specific when treating patients?

1. HRQOL: HOW TO BE MORE PATIENT SPECIFIC?

Not as well defined as Radiographic Criteria

- Clinical Criteria (HRQOL)
  - How much disability is ‘acceptable’?
  - What should be the treatment Target
    - Incremental benefit?
    - Reference population?
  - How to take into account patient variability?

- Possible Approach
  - MCID
    - MCID Gained after Surgical Treatment
    - ASD versus Reference Values
    - Percentage of patients reaching MCID
2. SPINO-PELVIC MORPHOLOGY: RESPECT PATIENTS WITH EXTREME PELVIC INCIDENCE

- 230 patients
- “Ideal Alignment”
  - [Vialle 2005]
  - PT < 12deg
  - -4 < T1SPI < 1.35
- Distribution of PI-LL for
  - High Incidence
  - Average Incidence
  - Low incidence

High Pelvic Incidence

\[ LL = PI - 10^\circ \]
Ex: LL=83°

Low Pelvic Incidence

\[ LL = PI + 10^\circ \]
Ex: LL=33°

Liabaud et al, 2014

2. SPINO-PELVIC MORPHOLOGY: RESPECT PATIENTS WITH THORACIC HYPERKYPHOSIS

Theoretical LL

\[ tLL = \frac{1}{2} (PI + TK) + 10 \]

R-square > 0.55

PI and TK have similar impact on LL

Rightarrow Lordosis should account for hyperkyphosis

Case Example

\[ tLL = \frac{1}{2} (48 + 73) + 10 \]
\[ tLL = 70.5^\circ \]
### 3. Spino-pelvic morphology: Respect patients with thoracic hypokyphosis

**Thoracic reciprocal change is the big picture; PJK is subcategory**

How to ANTICIPATE reciprocal changes?

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**TK compensation pre-op: A possible alarm**

- **Method:**
  - 219 patients underwent Thoracolumbar deformity correction
  - Fused T9-L1 to pelvis only

- **Categories:**
  - Reciprocal kyphosis group:
    - $\Delta$ unfused segments < 15° and PJK angle < 15°
  - Maintained kyphosis group:
    - $\Delta$ unfused > 15° or PJK angle > 15

- **TK compensation:**
  - Calculated based on previous validate formula
Demographics:
- Similar
- Reciprocal changes group had worse SRS Appearance score

Pre-op; reciprocal changes group had:
- More PI-LL mismatch
- More thoracic compensation

<table>
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<tr>
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<th>Age</th>
<th>BMI</th>
<th>Gender%</th>
<th>PI-LL</th>
<th>SRS-Appearance</th>
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</thead>
<tbody>
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<td>Reciprocal changes</td>
<td>62</td>
<td>28</td>
<td>73</td>
<td>31</td>
<td>2.2</td>
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<tr>
<td>No reciprocal changes</td>
<td>62</td>
<td>29</td>
<td>65</td>
<td>24</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Reciprocal changes group were substratified to:
- RC with PJK
- RC without PJK

More correction/More thoracic compensation => Reciprocal changes
No differences between reciprocal changes with and without PJK
Thoracic compensation is an independent predictor of reciprocal changes in the thoracic spine following lumbar correction. Regression analysis

Impact of PI-LL correction/over correction?

Impact of patient's self image prior to surgery. SRS – appearance

Other efforts in the fight against PJK

Literature update
**Does MIS reduce the risk of PJK?**

- 68 of MIS vs. 68 of open surgery
  - Propensity matched by pre-op PI-L
  - And correction of LL
  - Investigate PJK prevalence (>10°)

- **No differences** in age, BMI, or SVA preoperatively

- Overall: MIS has better PJK rate:
  - MIS => 31.3% vs. 52.9% <= Open

- If similar # of levels fused:
  - Similar PJK rate
    - 48.1% vs. 53.8%

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**Multiple level screws?**

- Sanduist et al, 2015:
  - Multiple stabilization screw technique
  - 15 patients with 1 year follow up

- **See reference for surgical technique**

- Authors recommendation because:
  - It preserves posterior elements and soft tissue
  - Promising results with no PJK reported
**CONCLUSIONS**

- PJK is highly prevalent radiographic phenomenon with less problematic clinical impact

- Only now are we getting the data to personalize alignment:

- *Economical burden of PJK is high, but better algorithms and planning could help in containing the epidemic of PJK in near future*

What might look *ideal* for one patient is actually *ambitious* for older one.

**THANK YOU**