Relative Lumbar Lordosis (RLL):
A new PI-based Proportional Parameter that Quantifies Lumbar Lordosis More Precisely Compared to PI-LL Concept

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Background: Sagittal Plane Analysis

- SRS-Schwab Classification – Sagittal Modifiers
  - Pelvic Tilt
    - 0: PT < 20°
    - +: PT 20-30°
    - ++: PT > 30°
  - PI minus LL
    - 0: within 10°
    - +: moderate 10-20°
    - ++: marked >20°
  - Global Alignment
    - 0: SVA < 4cm
    - +: SVA 4 to 9.5cm
    - ++: SVA > 9.5cm

- Have been used as alignment targets but addressing these does not always prevent mechanical complications

- Mechanical complication rate 31.7%

- 52.6% of them revised!

Radiographical and Implant-Related Complications in Adult Spinal-Related Deformity Surgery

Incidence, Patient Risk Factors, and Impact on Health-Related Quality of Life

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Disadvantages of Schwab Parameters

- Based on HRQoL parameters, not mechanical complications
- Do not include
  - Anteversion
  - Negative Malalignment
  - Shape and distribution of lumbar lordosis
- How to interpret in our daily practices?
  - 3 parameters X 3 options = 27 modifier types
  - The influence of each and all parameters on complication rates?
- Considering the whole spectrum of PI
  - when used as an absolute numeric value
  - in conjunction with previously reported
  - population-based average thresholds
- Schwab criteria may be insufficient or misleading
  - in quantifying
    - Normoverversion of pelvis (PT)
    - Spinopelvic mismatch (PI-LL)
Background: Sagittal Plane Analysis

There is a need for a new look into the ‘ideal’ sagittal plane

• Spinal curvatures and alignment
  – must be viewed in light of each other
  – Chain of correlations
    • PI influences SS
    • SS influences LL
    • LL influences TK
    • TK influences CL

• Pelvic incidence
  – is a (relatively) constant morphological parameter
  – that describes the ‘pelvic size’ for any given person

• PI = A signature

• All sagittal plane parameters
  – Should be evaluated
  – Proportional to PI
  – (rather than absolute numeric)
  – To assess disproportion compared with the calculated ideal
Global Alignment & Proportion: GAP Score
- New Method of Analyzing Sagittal Plane
- Offers individualized sagittal plane analysis
  - Instead of population norms & mean values
- Uses PI-based proportional radiographic parameters
  - Instead of absolute numerical values
- Denotes “normal” and “pathologic”
  - Standing sagittal alignment and shape
  - As a single score for every magnitude of pelvic incidence.

Radiographic parameters
- **RPV**: Relative Pelvic Version (Measured-Ideal SS)
- **RLL**: Relative Lumbar Lordosis (Measured-Ideal LL)
- **LDI**: Lordosis Distribution Index (L4-S1 / L1 – S1)
- **RSA**: Relative Spinopelvic Alignment (Measured-Ideal GT)
- **Age Factor**
Aim

• To compare RLL and PI-LL
  – For correlations to PI
  – Prediction of mechanical complications and
  – Correlations to HRQoL Scores
From the ESSG database
- ≥4 levels posterior fusion
- ≥2 years follow up
- 222 patients (168F, 54M) were included
- Mean age: 52.2 ± 19.3 (range 18-84)
- Mean follow-up: 28.8 ± 8.2 (24-62) months

Mechanical Complications
- PJK / PJF
- DJK
- Rod breakage
- Implant related complications
  - Screw loosening, fracture, pull out
  - Interbody, hook or set screw pull out

Methods
- RLL and PI-LL
  - Correlations to PI
  - Correlations to ODI, COMI, SRS-22 ve SF-36
  - Were analyzed by Pearson Correlations Coefficient

- In RLL subgroups for each PI-LL category
  - PI values
  - Mechanical complication rates
  - Were analyzed by one-way ANOVA, Independent samples t and Chi-square tests
Results - Dependence of RLL and PI-LL on PI

- There was a significant correlation between PI-LL and PI ($r=0.441$, $p<0.001$) threatening the use of PI-LL to quantify spinopelvic mismatch over a range of PI values.

- RLL was not correlated with PI ($r=-0.093$, $p>0.05$) being able to quantify divergence from ideal lordosis for all PI values.
Results – Mechanical Complications

- When analyzed by RLL
  - each of PI-LL ‘0’, ‘+’ and ‘++’ categories
  - were further divided into
    - 2 or 3 distinct groups of patients
      - having different PI values (p=0.000) and
      - mechanical complication rates (p<0.001)

- PI-LL groups consist of inhomogeneous groups of patients
**Results - HRQoL**

- Compared with PI-LL,
  - RLL had stronger partial correlations with
  - ODI, COMI, SF-36 PCS, MCS and all SRS-22 subdomain scores
  - at last follow-up, controlling for preoperative scores

<table>
<thead>
<tr>
<th>HRQoL Scores</th>
<th>PI-LL</th>
<th>RLL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>p</td>
</tr>
<tr>
<td>ODI</td>
<td>0.203</td>
<td>0.004</td>
</tr>
<tr>
<td>COMI</td>
<td>0.179</td>
<td>0.040</td>
</tr>
<tr>
<td>SRS-22 Subtotal</td>
<td>-0.136</td>
<td>0.052</td>
</tr>
<tr>
<td>SRS-22 Function</td>
<td>-0.115</td>
<td>0.102</td>
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<tr>
<td>SRS-22 Pain</td>
<td>-0.185</td>
<td>0.008</td>
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<tr>
<td>SRS-22 Mental Health</td>
<td>-0.069</td>
<td>0.330</td>
</tr>
<tr>
<td>SRS-22 Self Image</td>
<td>-0.050</td>
<td>0.478</td>
</tr>
<tr>
<td>SF-36 PCS</td>
<td>-0.108</td>
<td>0.129</td>
</tr>
<tr>
<td>SF-36 MCS</td>
<td>-0.125</td>
<td>0.079</td>
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</tbody>
</table>
Conclusion

• As an absolute numeric value,
  – PI-LL may be insufficient in quantifying normolordosis
  – for the whole spectrum of PI values
  – in conjunction with previously reported thresholds.

• RLL
  – offers an individualized quantification of lumbar lordosis for all PI sizes
  – predicts mechanical complications more precisely and
  – has better correlations with HRQoL scores

• Use of RLL & LDI together (Individualized magnitude & distribution of lordosis)
  – may result in better long-term HRQoL results with lower mechanical complication rates.
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