Sagittal Realignment Goals
Should Be Set to Ideal Proportionate Shape and Alignment
Independent of Age

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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!

- **Disadvantages of Schwab Parameters**
  - Based on HRQoL parameters, not mechanical complications
  - Do not include
    - Anteversion
    - Negative Malalignment
    - Shape and distribution of lumbar lordosis
  - 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
    - Normversion of pelvis (PT)
    - Spinopelvic mismatch (PI-LL)
Adult Spinal Deformity Surgery

- Spinopelvic alignment is known to vary for age
  - Age-adjusted alignment objectives concept
  - Less rigorous correction in elderly

  **Defining Spino-Pelvic Alignment Thresholds**
  *Should Operative Goals in Adult Spinal Deformity Surgery Account for Age?*

  **Age-Adjusted Alignment Goals Have the Potential to Reduce PJK**

  Based on patient-reported outcomes
  Biomechanics & mechanical complications not considered

- Simplified formula for age-adjusted thresholds
  - \( PT = \frac{(Age-55)}{3} + 20 \)
  - \( PI-LL = \frac{(Age-55)}{2} + 3 \)
  - \( SVA = 2\times(Age-55) + 25 \)

  **Thresholds for over and undercorrection**
  - patient age +/- 10 years

  **SRS 2016, Prague, #117**
  Under-Correction of Sagittal Deformities Based on Age-Adjusted Alignment Thresholds Leads to Worse HRQOL While Over-Correction Provides No Additional Benefit
Failure to Validate the Age-Adjusted Alignment Thresholds Concept in an Adult Spinal Deformity Database

- Mechanical complication rates were similar for:
  - PT matched and undercorrected (p>0.05)
  - PI-LL matched and overcorrected (p>0.05)
  - all age-adjusted groups in SVA (p>0.05)

- Reaching age-adjusted Schwab realignment goals:
  - in ESSG database
  - failed to improve, if not worsened,
  - clinical outcomes and
  - to prevent mechanical complications

<table>
<thead>
<tr>
<th>Categories</th>
<th>n</th>
<th>% of Mechanical Complication</th>
<th>n</th>
<th>% of Mechanical Complication</th>
<th>n</th>
<th>% of Mechanical Complication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matched</td>
<td>27/71</td>
<td>38.0 %</td>
<td>18/59</td>
<td>30.5 %</td>
<td>30/72</td>
<td>41.7 %</td>
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<tr>
<td>Over Correction</td>
<td>50/89</td>
<td>56.2 %</td>
<td>31/78</td>
<td>39.7 %</td>
<td>33/63</td>
<td>52.4 %</td>
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<tr>
<td>Under Correction</td>
<td>23/62</td>
<td>37.1 %</td>
<td>51/85</td>
<td>60.0 %</td>
<td>31/64</td>
<td>48.4 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100/222</td>
<td>45.0 %</td>
<td>100/222</td>
<td>45.0 %</td>
<td>94/199</td>
<td>47.2 %</td>
</tr>
</tbody>
</table>

p¥<0.05**<0.01**>0.05*
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
The GAP score, calculated by adding the scores for relative pelvic version, relative lumbar lordosis, lordosis distribution index, relative spinopelvic alignment, and the age factor, ranged from 0 to 13 points.

A GAP score of 0 to 2 was categorized as indicating a proportioned spinopelvic state; 3 to 6, as moderately disproportioned; and ≥7, as severely disproportioned.
Global Alignment and Proportion (GAP) Score Better Correlates to HRQoL Scores and Better Predicts Mechanical Complications Compared to SRS-Schwab Sagittal Modifiers

• Individualized PI-based analysis with GAP Score better predicted mechanical complications compared to Schwab modifiers, which uses absolute values in conjunction with previously reported population-based average thresholds

• GAP Score had better partial correlation coefficients to HRQoL scores

• when compared to PT, PI-LL and SVA (p<0.01)

Performance of the models

<table>
<thead>
<tr>
<th>Significance of the model</th>
<th>Model I with GAP score</th>
<th>Model II with PI-LL</th>
<th>Model III with PT</th>
<th>Model IV with SVA</th>
<th>Model IV with PI-LL, PT, SVA</th>
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</thead>
<tbody>
<tr>
<td>PAC</td>
<td>79.7</td>
<td>64</td>
<td>68.9</td>
<td>62.8</td>
<td>70.4</td>
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<tr>
<td>Sensitivity</td>
<td>62</td>
<td>29.9</td>
<td>73</td>
<td>41.5</td>
<td>52.1</td>
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<tr>
<td>Specificity</td>
<td>94.3</td>
<td>92.6</td>
<td>65.6</td>
<td>81.9</td>
<td>86.7</td>
</tr>
<tr>
<td>PPV</td>
<td>89.9</td>
<td>76.3</td>
<td>63.5</td>
<td>67.2</td>
<td>77.8</td>
</tr>
<tr>
<td>NPV</td>
<td>75.2</td>
<td>61.4</td>
<td>74.8</td>
<td>60.9</td>
<td>66.9</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Discrimination</th>
<th>Model I with GAP score</th>
<th>Model II with PI-LL</th>
<th>Model III with PT</th>
<th>Model IV with SVA</th>
<th>Model IV with PI-LL, PT, SVA</th>
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</thead>
<tbody>
<tr>
<td>Mechanical Complication Present</td>
<td>%00</td>
<td>%00</td>
<td>%00</td>
<td>%00</td>
<td>%00</td>
</tr>
</tbody>
</table>

GAP Score had better partial correlation coefficients to HRQoL scores when compared to PT, PI-LL and SVA (p<0.01)
Aim

• Similar to Schwab modifiers
  – normative data studies showed that
  – GAP categories change with age

• Aim of the study is to analyze
  – the effect of age
  – on mechanical complications
  – in patients reaching different post-op GAP categories

Methods

• 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

• Mechanical complication rates
  – for different age groups and
  – for post-op GAP categories
  – were compared using Chi Squared test
Results

• Analysis of the whole cohort without dividing into GAP categories – showed that mechanical complication rates were higher (p<0.001) in older age groups

• Distribution of patients that were GAP-P, GAP-MD and GAP-SD
• was different in age groups reflecting a tendency towards non-ideal correction with aging
Results

• For all age groups
  – disproportioned categories resulted with more mechanical complications (p<0.001)

• Mechanical complication rates
  – for each GAP category did not change according to age groups (p>0.05)
Conclusion

• Age-adjusted realignment goals towards less rigorous correction
  – will increase mechanical complication rates in elderly patients

• Achieving a non-ideal correction in adult spinal deformity patients
  – resulted in more mechanical complications for all ages

• Achieving individualized proportionate global sagittal alignment (GAP-P)
  – decreased mechanical complication rates for all age groups

• To prevent mechanical complications
  – Sagittal realignment goals should be set to individualized proportionate shape and alignment
  – independent of age
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