Compensatory Mechanisms & the Effect of Age on Sagittal Balance in Spondylolisthesis: An Analysis Utilizing the Pelvic Radius Technique

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<th>Stock options</th>
<th>Consultant</th>
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Few studies have investigated age & sagittal alignment

None have examined this in spondylolisthesis
Pelvic parameters:
- Pelvic incidence: 77.85
- L5 incidence: 48.53
- Pelvic tilt: 29.03
- Sacral slope: 45.81

Balance parameters:
- SSA: 134.24

Type of back:
- Type 4
- Lumber lordosis angle = 70.62°
- Thoracic kyphosis angle = 57.62°
Objectives

Age vs.

1. Spino-pelvic sagittal alignment
2. Sagittal compensation mechanisms
Methodology

- Cross-sectional observational study
- Pre-operative radiographs
- 382 consecutive surgical patients
  - Isthmic: 85
  - Degenerative: 297
Methodology

• Cross-sectional observational study

• Pre-operative radiographs

• 382 consecutive surgical patients
  o Isthmic: 85
  o Degenerative: 297

• Inclusion criteria:
  o Isthmic or degenerative spondylolisthesis
  o Failed conservative management

• Exclusion criteria:
  o History of prior surgery, trauma, tumour, infection
  o Concomitant coronal plane deformity
X-ray Measurement

- 36-inch erect films
- Manual acquisition
- Pelvic Radius Technique (Jackson et al. *Spine* 2000)
  - Pelvic lordosis (PRS1)
  - Pelvic angulation (PA)
  - Total lumbar lordosis (T12S1)
  - Total lumbo-pelvic lordosis (PRT12)
Jackson’s Pelvic Radius technique
Jackson’s Pelvic Radius technique

Pelvic lordosis (PRS1)

Pelvic Angle (PA)

Hip Axis (HA)
Jackson’s Pelvic Radius technique
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Total lumbo-pelvic lordosis or PRT12
Jackson’s Pelvic Radius technique

Pelvic angulation (PA)

Pelvic Angle (P)

Hip Axis (HA)

PR line
Statistical analysis

- Age on alignment:
  - Univariate correlations:
    - Age vs. Jackson Measures
      - All
      - Isthmic subgroup
      - Degenerative subgroup

- Age on compensation mechanisms:
  - Multivariate correlations: focal lordosis, lordosis above, total lumbar lordosis, total lumbo-pelvic lordosis and pelvic lordosis
    - All patients
    - Stratified into ages: <45 years, 45-60, >60 years

- SPSS software (version 19.0). Significance set at P < 0.05.
Results (1)

- Degenerative spondylolisthesis patients (n=297):
  - No significant correlations
Results (1)

- Degenerative spondylolisthesis patients (n=297):
  - No significant correlations

- Isthmic spondylolisthesis patients (n=85):
  - Significant correlations vs. age ($p=0.002$):
    - PRT12 ($= -0.45$)
    - Pelvic angulation ($r = 0.44$)
Results (2)

- Isthmic spondylolisthesis, younger subgroup (n=24)
  - focal lordosis at the level of the slip vs. lumbar lordosis above
    \( r = -0.58, p = 0.02 \)
• Degenerative spondylolisthesis (n=297):
  - Pelvic angulation vs. total lumbo-pelvic lordosis ($r = -0.74, P<0.001$)
Discussion
Compensation mechanisms

Normal
Discussion

Compensation mechanisms

Normal

Uncompensated
Discussion
Compensation mechanisms

Type 1 Compensation
Discussion
Compensation mechanisms

Type 2 Compensation
Pelvic retroversion
Discussion

Compensation mechanisms

Uncompensated

Type 3 Compensation
Hip & knee flexion
Conclusions

- Isthmic spondylololishesis… with age:
  - total lumbopelvic lordosis (PRT12) ↓
  - pelvic angulation (PA) ↑

- Younger patients can maintain balance:
  - ↑ lordosis at segments above focal kyphosis. *(Type 1)*

- Older patients compensate:
  - pelvic retroversion… ↑ pelvic angulation (PA). *(Type 2)*

- We postulate combined hip & knee flexion may represent a 3rd compensation mechanism *(Type 3)*, used when Type 1 & 2 mechanisms exceeded.