CORRECTION OF DEFORMITY IN ADULTS

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BACKGROUND

- The prevalence of ADS are increasing with the aging of population (ranged from 2% to 68%)

- Surgical treatment of adult spinal deformity frequently necessitates osteotomies and multilevel arthrodesis

- For this high-risk surgical group, complication rates in the literature range from 30% to 90%

Michael G. Fehlings, M.D Spine Dec 2010 / Vol. 13 / No. 6: 663-664
• What do we know about adult scoliosis?
The significant prognostic factors of progression are:

- Cobb angle > 30 °
- Grade II apex vertebra rotation
- lateral listhesis > 6 mm
- intercrest line below LIV

# Health-Related Quality of Life

## ADS Population (Cobb > 20°) vs. General Population

<table>
<thead>
<tr>
<th>SF-36 Variable</th>
<th>Maimonides Score</th>
<th>General U.S. Score</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PF</td>
<td>48.55</td>
<td>76.24</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>RP</td>
<td>35.14</td>
<td>73.66</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>BP</td>
<td>34.68</td>
<td>67.51</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>GH</td>
<td>56.58</td>
<td>64.62</td>
<td>NS</td>
</tr>
<tr>
<td>VT</td>
<td>42.59</td>
<td>60.37</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>SF</td>
<td>53.41</td>
<td>81.37</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>RE</td>
<td>58.34</td>
<td>80.26</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>MH</td>
<td>64.32</td>
<td>75.01</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

PF = Physical Functioning scale; RP = Role Physical scale; BP = Bodily Pain scale; GH = General Health scale; VT = Vitality scale; SF = Social Functioning scale; RE = Role Emotional scale; MH = Mental Health scale; NS = not significant.

N = 41; age >55 = 26; age <55 = 15.

Adult scoliosis affects patients’ self-perceived social, emotional, and general health scores by SF-36 analysis

### HRQOL, AGE & BALANCE

<table>
<thead>
<tr>
<th></th>
<th>G1 NON/OP</th>
<th>G2 NON/OP</th>
<th>G3 NON/OP</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total no. of patients</td>
<td>157/51</td>
<td>122/65</td>
<td>62/40</td>
<td>NS</td>
</tr>
<tr>
<td>Age (STD)</td>
<td>33.4/33.2</td>
<td>39.3/34.1</td>
<td>34.8/35.1</td>
<td>NS</td>
</tr>
<tr>
<td>BMI (STD)</td>
<td>24.8/25.8</td>
<td>24.9/23.0</td>
<td>25.0/25.0</td>
<td>NS</td>
</tr>
<tr>
<td>Charlson Comorbidity Index</td>
<td>0.4/0.4</td>
<td>0.3/0.1</td>
<td>0.3/0.1</td>
<td>NS</td>
</tr>
<tr>
<td>SVA (STD) mm</td>
<td>−7.9/−6.1</td>
<td>15.8/10.3</td>
<td>15.8/10.3</td>
<td>NS</td>
</tr>
<tr>
<td>PT (STD)°</td>
<td>13.1/13.9</td>
<td>15.8/15.8</td>
<td>15.8/15.8</td>
<td>NS</td>
</tr>
<tr>
<td>PI-LL mismatch (STD)°</td>
<td>−4.5/−3.8</td>
<td>−6.8/−5.9</td>
<td>−6.8/−5.9</td>
<td>NS</td>
</tr>
<tr>
<td>Maximum Cobb angle (STD),°</td>
<td>42.2/49.9</td>
<td>51.2/51.7</td>
<td>51.2/51.7</td>
<td>NS</td>
</tr>
<tr>
<td>ODI (STD)</td>
<td>17.4/24.1</td>
<td>20.6/20.2</td>
<td>20.6/20.2</td>
<td>NS</td>
</tr>
<tr>
<td>SF-36 PCS (STD)</td>
<td>46.6/42.3</td>
<td>47.2/47.6</td>
<td>38.9/37.9</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SF-36 MCS (STD)</td>
<td>49.7/49.8</td>
<td>36.3/43.8</td>
<td>31.0/37.9</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SRS-22 function (STD)</td>
<td>3.65/3.35</td>
<td>4.03/3.86</td>
<td>3.65/3.32</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SRS-22 pain (STD)</td>
<td>3.25/2.82</td>
<td>3.43/3.09</td>
<td>3.48/3.29</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SRS-22 image (STD)</td>
<td>3.61/3.34</td>
<td>3.43/3.09</td>
<td>3.48/3.29</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SRS-22 mental health (STD)</td>
<td>4.03/3.86</td>
<td>3.43/3.09</td>
<td>3.48/3.29</td>
<td>&lt;0.05 G1, G2</td>
</tr>
<tr>
<td>SRS-22 satisfaction (STD)</td>
<td>3.71/3.21</td>
<td>3.35/2.95</td>
<td>3.35/2.95</td>
<td>NS</td>
</tr>
<tr>
<td>SRS-22 total (STD)</td>
<td>3.65/3.32</td>
<td>3.48/3.29</td>
<td>3.48/3.29</td>
<td>&lt;0.05 G1, G2</td>
</tr>
</tbody>
</table>

NON indicates nonoperative treatment; OP, operative treatment; G1, <50 yr; G2, 50–65 yr; G3, >65 yr; BMI, body mass index; SVA, sagittal vertical axis; PT, pelvic tilt; PI-LL, difference between pelvic incidence and lumbar lordosis; ODI, Oswestry Disability Index; SF-36 PCS, Short Form-36 physical component score; SF-36 MCS, Short Form-36 mental component score; SRS-22, Scoliosis Research Society Outcomes Score; NS, not significant STD, standard deviation.

Sagittal balance play the role in the quality of life in elderly with ASD.

Operated patients (G3) have the same amount of scoliosis, but the worst balance.

ADS of more than 15° was associated with significant modification in sagittal SPA.

Sagittal SPA to correlate with pain and disability, whereas the magnitude of the scoliotic curvature to play a minor role toward pain and disability.

Threshold values for severe disability (ODI > 40) included:
PT 22° or more
SVA 47 mm or more
CVA 4 mm or more
PI – LL 11° or more

• Efficiency of surgical treatment of patients with spinal deformities
THE RESULTS OF THE TREATMENT OF ADULTS WITH SPINAL DEFORMITIES

THE RESULTS OF THE TREATMENT OF ADULTS WITH SPINAL DEFORMITIES

Figure 5. Relationship of patient age to improvement of leg pain in adults with scoliosis after surgical treatment. Bars indicate standard deviations. *P values are from paired t tests.

Figure 3. Relationship of patient age to improvement of health status based on the SF-12 PCS in adults with scoliosis after surgical treatment. Bars indicate standard deviations. *P values are from paired t tests.

THE RESULTS OF THE TREATMENT OF ADULTS WITH SPINAL DEFORMITIES

SURGICAL MANAGEMENT

Value of correction  Rate of complication
The goal of deformity surgery is to balance spine health-related quality of life for good relief of symptoms.
SURGICAL FACTORS AFFECTING THE BALANCE OF THE SPINE IN ADULTS

- Techniques of osteotomy: Ponte or Smith-Petersen osteotomy (SPO), PSO, or pVCR.

- Biomechanics of fixation (short fusion, long fusion)

With respect to safety and efficacy, SPOs compare favorably with other osteotomy techniques.

Blood loss tends to be less with SPOs. Using at least 3 SPOs (to achieve a comparable degree of correction with a single PSO) resulted in an average blood loss of 1392 ml, versus nearly twice as much for a PSO (2617 ml).

With PSO the rate of intraoperative and postoperative neurological deficits was 11.1%, with a 2.8% rate of permanent deficits.

Bridwell KH. Spine, 2006 Open Operating Theatre
http://www.youtube.com/watch?v=EatdORXAiPc
### LONG FUSION VS. SHORT FUSION

|                                | Short fusion  
(n = 28) | Long fusion    
(n = 22) |  \(P\)-value |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of levels fused (n)</td>
<td>3.1 ± 0.9</td>
<td>6.5 ± 1.5</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age (year)</td>
<td>64.4 ± 8.1</td>
<td>66.9 ± 6.4</td>
<td>0.23</td>
</tr>
<tr>
<td>No. of comorbidities</td>
<td>1.7 ± 0.7</td>
<td>1.8 ± 0.7</td>
<td>0.66</td>
</tr>
<tr>
<td>Blood loss (ml)</td>
<td>1,671 ± 604</td>
<td>2,819 ± 1097</td>
<td>0.001</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>179 ± 56.9</td>
<td>242 ± 58</td>
<td>0.001</td>
</tr>
<tr>
<td>Hospital stay (day)</td>
<td>18.4 ± 8.3</td>
<td>23.3 ± 11.2</td>
<td>0.1</td>
</tr>
<tr>
<td>No. of decompressions</td>
<td>2.6 ± 0.9</td>
<td>2.8 ± 1.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Short fusion versus long fusion for degenerative lumbar scoliosis
Kyu-Jung Cho,1 Se-Il Suk, corresponding author2 Seung-Rim Park,1 Jin-Hyok Kim,2 Sung-Soo Kim,2 Tong-Joo Lee,1 MD,1 Jeong-Joon Lee,2 and Jong-Min Lee1
### LONG FUSION VS. SHORT FUSION

<table>
<thead>
<tr>
<th></th>
<th>LONG FUSION</th>
<th>SHORT FUSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobb angle</td>
<td>72%</td>
<td>39%</td>
</tr>
<tr>
<td>Coronal imbalance</td>
<td>+</td>
<td>-</td>
</tr>
<tr>
<td>lateral listhesis</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>lumbar lordosis</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>sagittal imbalance</td>
<td>++</td>
<td>++</td>
</tr>
</tbody>
</table>

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### Early perioperative complications
- Long fusion: ++
- Short fusion: +

### Adjacent segment disease
- Long fusion: - +
- Short fusion: ++

### Loosening of screws
- Long fusion: + +
- Short fusion: - +

### Pseudarthrosis
- Long fusion: + +
- Short fusion: -

### PJK
- Long fusion: -
- Short fusion: ++

### Reoperation
- Long fusion: ++
- Short fusion: +
♀ 63 y.o.

ADS

type L

PI-LL++
SVA++
PT+

Pain (VAS) – 7

No neurologic deficits
♀ 63 y.o.

ADS

Fusion
Th12-S1-Al

PI-LL+
SVA 0
PT+
Pain (VAS) – 3
FACTORS AFFECTING ON PJK

- Age
- Short fusion
- hypercorrection of LL & SVA
- PSO

Fixation «IN SITU» - «PROBLEMS»

Implants failure & PJF

♀ 48

Ds: ADS LIII-IV-V-SI stenosos
VAS – 8 ASIA – D
Surg: Decompression+fixation
Complication: implants failure

Surg: PSO LIII
IMPROVE IMBALANCE

- Adult scoliosis
- L3-L4 “in situ” fixation + unilateral PLIF
- Postoperative L3 vertebral tilt of less than 5°
- Good pain relief and high satisfaction were obtained without recurrence of symptoms and major complication after 10 years
- Horizontal fixation of L3 vertebra can prevent the long-term development of unfused adult scoliosis.

Toyone T et al. Spine: 01 March 2015 - Volume 40 - Issue 5 - p 312–315
Selective fixation in ADS patients

- Minor trauma
- Correction of the deformity
- Spontaneous recovery of the body balance
- Sustained clinical outcome
- Low risk of PJK & PJF

Hongda B et al. Spine: 01 March 2015 - Volume 40 - Issue 5 - p E293–E300
Toyone T et al. Spine: 01 March 2015 - Volume 40 - Issue 5 - p 312–315
50. D.: L1-L2 stenosis. ADS.

L1 radiculopathy
VAS 5
ODI 42%
50. D.: L1-L2 stenosis. ADS.

L1 radiculopathy
VAS 5
ODI 42%
♂ 50.
3 m post.op.: Fixation L1-L2, TLIF L1-L2.
Radiographs of a 65-year-old female who had undergone L2 PSO.

A - Preoperative coronal and sagittal alignment showing a severe kyphosis.

B - Immediate postoperative sagittal alignment with negative SVA.

C - A follow-up of 1.5 years with positive SVA.
Radiographs of a 49-year-old female with ADS. T10–L4 SPOs was performed.

A - The coronal balance was well maintained preoperatively.

B - Coronal imbalance was observed immediately after operation.

C - 2 years of follow-up, coronal balance was well compensated spontaneously.

Hongda B et al. Spine: 01 March 2015 - Volume 40 - Issue 5 - p E293–E300
**IMPROVE IMBALANCE**

- The overcorrection of SVA is more often seen in the PSO group and the coronal imbalance is more likely to occur in the SPO group.

- The postoperative sagittal imbalance often spontaneously improves with time.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Improve Group (N = 15)</th>
<th>Resistant Group (N = 11)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>1</td>
<td>1</td>
<td>0.851</td>
</tr>
<tr>
<td>Female</td>
<td>14</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td><strong>LIV level</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>L5 or above</td>
<td>13</td>
<td>5</td>
<td>0.027</td>
</tr>
<tr>
<td>S1 or pelvis</td>
<td>2</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Interbody fusion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With</td>
<td>6</td>
<td>6</td>
<td>0.437</td>
</tr>
<tr>
<td>Without</td>
<td>9</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

LIV at S1 or with pelvic fixation should be regarded as potential risk factors for persistent coronal imbalance in patients with SPO.

Hongda B et al. Spine: 01 March 2015 - Volume 40 - Issue 5 - p E293–E300
PJK and SVA CORRECTION

<table>
<thead>
<tr>
<th>Radiographical Parameters</th>
<th>no PJK n = 136</th>
<th>N vs. P</th>
<th>without revision</th>
<th>P vs. S n = 48</th>
<th>with revision</th>
<th>N vs. S P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative lumbar lordosis</td>
<td>42.1 ± 22.3</td>
<td>0.44</td>
<td>38.7 ± 27.3</td>
<td>0.005</td>
<td>54.4 ± 12.9</td>
<td>0.005</td>
</tr>
<tr>
<td>Postoperative thoracic kyphosis</td>
<td>29.1 ± 16.8</td>
<td>0.02</td>
<td>34.6 ± 12.8</td>
<td>0.63</td>
<td>37.6 ± 21.6</td>
<td>0.17</td>
</tr>
<tr>
<td>Postoperative TL kyphosis</td>
<td>2.5 ± 12.4</td>
<td>0.01</td>
<td>7.9 ± 12.3</td>
<td>0.21</td>
<td>3.8 ± 9.7</td>
<td>0.65</td>
</tr>
<tr>
<td>Pelvic incidence</td>
<td>56.4 ± 14.6</td>
<td>0.48</td>
<td>54.8 ± 12.9</td>
<td>0.44</td>
<td>58.1 ± 14.2</td>
<td>0.68</td>
</tr>
<tr>
<td>SVA change*</td>
<td>4.1 cm</td>
<td>0.4</td>
<td>4.8 cm</td>
<td>0.06</td>
<td>8.8 cm</td>
<td>0.02</td>
</tr>
<tr>
<td>Preoperative SVA</td>
<td>5.9 cm</td>
<td>0.85</td>
<td>5.7 cm</td>
<td>0.02</td>
<td>11.4 cm</td>
<td>0.03</td>
</tr>
<tr>
<td>Immediate postoperative SVA</td>
<td>4.1 cm</td>
<td>0.96</td>
<td>4.1 cm</td>
<td>0.05</td>
<td>0.8 cm</td>
<td>0.03</td>
</tr>
</tbody>
</table>

* SVA denotes sagittal vertebral axis—change is from preoperative to final postoperative image.
TL denotes thoracolumbar.
N indicates group with no proximal junctional kyphosis (PJK); P, group with PJK not needing revision surgery; S, group necessitating surgery for their PJK; TL.

- Patients with PJK requiring revision were older and had higher postoperative LL and larger SVA corrections than patients without PJK.
- Patients with an SVA correction of 4 cm with surgery did not need revision surgery whereas those with PJK requiring revisions had SVA corrections of 8 cm.
♀ 26 y.o. AIS
Fusion Th2-L5 + deformity correction -> short leg (2.5 cm)
♀ 26 y.o. AIS

Asymmetric PSO L3
♀ 55 years

Ds: AIS
Lenke: 4CN
Pain (VAS) – 5-6
Motor function normal
Hypoesthesia L3, D>S
Treatment

Fusion Th3-L5
After 3 months

Pain (VAS) – 7

Loosening of screws

L4,5
Treatment

Re-Fusion L4-L5-Al
1 month after
Rod fracture

PT 29°
SS 40°
PI 70°
LL 28°
TK 32°

LL+TK+PI ≤ 45°
= -29°
Treatment

Re-Fusion
Th3-L5-SIPS

PSO L3
Cost-effectiveness of ADS treatment

From 2002 to 2007 the number of cases of multi-level stabilization has increased if 15 times (1.3 to 19.9 per 100,000).

The number of complications associated with the risk of his life: 2.3% vs 5.6%.

The repeat hospitalizations in the first 30 days: 7.8% vs 13.0%.

Financial expenses 23,724 vs 80,888USD.
Cost-effectiveness of ADS treatment

The cost of ADS treatment:

- Pre operative exams:
  - Standard pre op + X-ray (standard + full body) + MRI + CT

- Intraoperative:
  - General anesthesia + surgery (complex & time)

- Postoperative:
  - Exams + rehabilitation
  - Complications
♀ 78 years

Ds: ADS

SRS-Schwab: Type L, PI-LL+, SVA++, PT+

Pain (VAS) – 7

No neurologic deficits
Fusion Th10-S1-Al with PMMA Th10, L2, S1 TLIF L3-4, L2-3
1 month later

Pain (VAS) – 8-9

No neurologic deficits

Osteoporotic fracture Th9
Treatment

Percutaneous vertebroplasty Th8, 9
2 month later

Pain (VAS) – 9-10

Neurologically (ASIA) – C
Treatment

Fusion up to Th3
Decompression Th8, 9
6 month later

Osteoporotic Th2 adjacent vertebral fracture.

Pain (VAS) – 9
Neurologically (ASIA) – intact
♀ 79 year-old
VCR ThII + C0-Th3-S1-Al Fusion.
Surgery plays a leading role in the treatment of ADS.

Adequate selection of patients for surgical treatment is necessary for good outcomes.

Remember of high risk of complications in the correction of ADS! Choose the correct indications for different type of surgery!

The balance of the spine plays a key role in achieving positive long-term results.

Fixation of the spine "in situ" may be performed with a slight imbalance of the body and there are contraindications to the more traumatic intervention with a high percentage of the expected complications.
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St. Petersburg, Russia

North-West Medical University named after I.I. Mechnikov
St. Petersburg, Russia