MIS techniques for Sagittal Balance in Adult Spinal Deformity

NEEL ANAND, MD

Clinical Professor
Director, Spine Trauma
Minimally Invasive Spine Surgery
Spine Center, Cedars Sinai Medical Center
Los Angeles, CA

Disclosures

- Consultant – Medtronics, Nuvasive, Globus, Paradigm Spine
- Speaker - Depuy-Synthes, Stryker
- Royalties – Nuvasive, Medtronics, Globus
- SAB – Globus, Medtronics
- Editor – Gray’s Anatomy
- Stocks/Stock Options – Medtronics, Globus, Atlas Spine, Paradigm Spine, Theracell, AF cell, Bonovo

Considerations for Adult Deformity

“Conus of Economy” (Courtesy Pr J. Dubousset). Jean Dubousset introduces the concept of Conus of Economy (or Conus of Balance) where “the body can stay within this surface with a minimum of muscle action.”
TOPICS

- Who is/is not an Operative Candidate for Sagittal Realignment?
- What are the Alignment Goals in this Age Group?
- How to Decide What Rebalancing Techniques to Utilize Intraoperatively?
- What are the Results/Outcomes of Surgery in this Age Group?

ALIGNMENT OBJECTIVES

- SVA < 5 cm
- T1 Tilt < 0°
- PT < 25°
- Proportional LL = PI +/- 9°

Understanding Pelvic Parameters
### Results

• Age specific radiographic thresholds (ODI 40)

<table>
<thead>
<tr>
<th>Age group</th>
<th>Number</th>
<th>PT (deg)</th>
<th>PI-LL (deg)</th>
<th>SVA (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤45</td>
<td>218</td>
<td>15.3 ± 2.3</td>
<td>1.7 ± 3.5</td>
<td>3.3 ± 1.2</td>
</tr>
<tr>
<td>46-64</td>
<td>381</td>
<td>22.6 ± 1.5</td>
<td>12.5 ± 2.2</td>
<td>7.1 ± 0.8</td>
</tr>
<tr>
<td>65-74</td>
<td>172</td>
<td>26.2 ± 0.8</td>
<td>18 ± 1.2</td>
<td>9.0 ± 0.4</td>
</tr>
<tr>
<td>≥75</td>
<td>62</td>
<td>29.1 ± 0.8</td>
<td>22.4 ± 1.3</td>
<td>10.5 ± 0.4</td>
</tr>
</tbody>
</table>

*DECREASING LL/INCREASING + SVA WITH AGING*

*Gelb, Lenke et al SPINE 1995*
TOPICS
• Who is/is not an Operative Candidate for Sagittal Realignment?
• What are the Operative Goals in this Age Group?
• How to Decide What Corrective Techniques to Utilize Intraoperatively?
• What are the Results/Outcomes of Surgery in this Age Group?

Where do we Achieve Sagittal Correction?
• Anesthesia
• Positioning
• Facetectomies
• Interbody
  – ALIF
  – TLIF
  – Transpsoas
  – Antepsoas
• Osteotomies

Surgical factors
• Can we ignore deformity?
• Flexibility deformity
• Length of deformity
• Size of deformity
• Balance
• Fusion/fixation levels
• Previous surgery
**Investigations**

- **Whole spine x-rays** (with femoral heads) essential for highlighting sagittal and coronal balance and intersegmental deformities
  - (bending/traction views for stiffness and correctability)
- **MRI lumbar spine** – Disc degeneration, prolapse, neural compression, fixed deformity (scout view)
- **CT of fixed levels on traction/bending films**
  - (? Fused anterior column)
- **Bone Density** - If T-Score < 3 – NO MIS Surgery

**Correcting Sagittal Balance**

- **Restore C7 plumb line**
  - Goal SVA < +5cm
- **Restore spinopelvic alignment**
  - Goal PT <20 degrees
  - Goal LL = PI ± 9 degree
- **Restore coronal balance/truncal shift**
  - Goal C7 plumb = 0 to 4cm from CSVL
  - C7 plumb line within SI joints

**Now...**

- We understand the deformity
- We know what is flexible
- We know what is fixed
- We know the ideal
- We know how the lower limbs compensate
- What do we do??
- Can we achieve the ideal SAFELY
67 y/o. Progressive LBP, 80% LBP, 20% LLE pain. No improvement to care/management. VAS 8, Neurologically intact. Not working.
Alignment Goals

• PI / LL Mismatch - 34 degrees
  – Aim would be to obtain 25 - 30 degrees more lordosis
• SVA - 12 cm
  – Aim would be to bring SVA to 4 to 5 cm
• PT - 44
  – Aim would be to bring to 20 -25

Options

• Posterior Only
  – PSO /Asymmetric?
  – Multiple SPO
  – UIV T10 or T2?
• Front and Back staged procedure
• Circumferential MIS Techniques
**Intraop Corrections**
- Facet Resection: 2-5 open disc
- SPO: 5-10 open disc
- PSO Type 3: 25-30
- Type 4: 30-40

60% Lordosis at L4-5 and L5-S1
L5-S1 ALIF: 20-25

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**Surgical Goals**
- Goal in Elderly Pt. is ALWAYS the simplest, least risky Sagittal Rebalancing Surgery
- Recognize that the Goal may not need to be “Perfect SVA Restoration” on every Older pt.
- Overcorrection of Lumbar Lordosis is detrimental - Increased PJK!
- Try and Avoid 3-CO (ie PSO/VCR) and even PCO in the elderly age group unless absolutely required (3-CO’s are for FIXED deformities)
- Factor in how any inherent Flexibility will help achieve Sagittal Restoration Goals.

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**Circumferential Minimally Invasive Surgery (cMIS)**
MIS Strategies for Adult Scoliosis

- Trans-psoas Lateral (LLIF)
- Oblique Ante-Psoas IF (OLIF)
- MIS ACR
- MIS TLIF
- MIS ALIF
- AxiaLIF
- Multilevel Percutaneous Pedicle Screws
- MIS Iliac Screws (S2-AI)
- MIS Transforaminal Osteotomies (TFO)

Limitations and ceiling effects with circumferential minimally invasive correction techniques for adult scoliosis: analysis of radiological outcomes over a 7-year experience

N. Assavangrong, M.D., M.Chr.Oritz, J. Em. M. Basso, M.D. and Balas R. Kaczerowski, M.D.
Department of Surgery and Neurosurgery, Cedars-Sinai Medical Center, Los Angeles, California

Object: Minimally invasive correction of adult scoliosis is a rapid method in popularity. Limited data exist, however, on long-term results. Several minimally invasive techniques are allowing circumferential spinal instrumentation in addition to improving surgical parameters. The study aims to quantify long-term outcomes of patients treated with various minimally invasive techniques.

Methods: Seventy patients were included in this study of 113 patients who underwent adult scoliosis correction. All patients had a Cobb angle greater than 10 degrees forward, and availability of postoperative and radiographic follow-up to 87 patients. Preoperative and postoperative Cobb angle, dextroversion, kyphosis, and scoliotic thoracic kyphosis (STK) were measured in addition to radiographic and clinical analysis. Clinical improvement was assessed using the Oswestry Disability Index (ODI) and the modified KSS.

Results: Mean preoperative VA was 87.6 ± 15.1 cm. Mean postoperative VA was 63.2 ± 14.0 cm. In terms of Cobb angle, a mean correction of 19.9° was noted, with a mean preoperative value of 19.3° (range 12.5° to 28.1°) and a mean postoperative value of 10.9° (range 5.3° to 18.4°). A scoring of Cobb angle correction was used in a patient to control the PCL or LPL. A mean of 80° was found to be achieved in the PCL or LPL. The mean of ODI improved from 40.5% to 19.8%.

Conclusions: Minimally invasive scoliosis correction is an effective method for the treatment of adult scoliosis. It is limited in terms of its ability to achieve VA correction and lateral torsion. When the preoperative VA is greater than 60 degrees and a substantial amount of lateral torsion is needed, it is determined that a minimally invasive correction may not achieve curve correction.

Sagittal Vertical Alignment

Mean Correction: 54% (p < 0.01) – 90 pts
Goal: SVA < 5 cm

Limitation – Preop SVA > 10cm
AxiaLIF

Lumbosacral Fixation

- Pseudarthroses
- Implant Failure
- Sagittal Decompensation

- Create Lordosis - Sagittal Balance

ALIF

Since 2011

- Upto then Lateral cages were 6° or 0°
- 12 and 15° lordotic cages designed
- Contouring the rod was critical
- Started doing MIS TFO for Thoracic Kyphosis

- Changed our protocol for handling sagittal balance and especially at L5-S1
- Refined Rod reduction and contouring
Analysis of Actual Segmental Lordosis with Hyperlordotic Cages

Is Segmental Lordosis Dependent on the Angle, Location, and Level of the Cage?

NEEL ANAND, MD
BABAK KHANDEHROO, MD
ELIM BARON, MD
SHEILA KAHWA TY, PA-C
RYAN CORRIE, MS IV
JASON COHEN, MS IV

SOMIS 2015 / ISASS 2016

A retrospective study of Circumferential MIS (cMIS) correction of Adult Scoliosis (n=57): (May 2012 to May 2015)

- All patients underwent lateral interbody fusion using lordotic cages

Demographics

- 57 patients with degenerative and Idiopathic Scoliosis
- Mean age: 66 (48-84)
- Total number of levels: 194
  - 6 degree cage: 54
  - 10 degree cage: 37
  - 12 degree cage: 93
  - 20 degree cage: 10

- All patients underwent lateral interbody fusion using lordotic cages
### Location of the Cage

Segmental Lordosis dependent on Location of the Cage in the Intervertebral Space

<table>
<thead>
<tr>
<th>Cage Angle</th>
<th>Location</th>
<th>Pre-op</th>
<th>Post-op</th>
<th>P Value</th>
<th>(Pre to Post)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 degree</td>
<td>Posterior 1/3</td>
<td>1.13</td>
<td>6.63</td>
<td>0.12</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>12 degree</td>
<td>Posterior 1/3</td>
<td>1.92</td>
<td>13.41</td>
<td>P = 0.11</td>
<td></td>
</tr>
<tr>
<td>10 degree</td>
<td>Posterior 1/3</td>
<td>1.52</td>
<td>12.09</td>
<td>13.06</td>
<td>P = 0.05*</td>
</tr>
<tr>
<td>20 degree</td>
<td>Posterior 1/3</td>
<td>5.48</td>
<td>18.09</td>
<td>12.61</td>
<td>&lt; 0.05*</td>
</tr>
</tbody>
</table>

- Placement of the cage in the posterior 3rd of the intervertebral space leads to lower segment lordosis compared to middle or anterior 3rd placement (p<0.05).
- No statistically significant difference in the segmental lordosis between the anterior 3rd and the middle 3rd positions.

### Sagittal Alignment

Segmental Lordosis dependent on Lordosis of the Cage

<table>
<thead>
<tr>
<th>Cage Angle</th>
<th>Pre-op</th>
<th>Post-op</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 degree</td>
<td>1.00</td>
<td>0.5</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>12 degree</td>
<td>5.77</td>
<td>13.8</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>10 degree</td>
<td>4.68</td>
<td>12.6</td>
<td>Insignificant</td>
</tr>
<tr>
<td>20 degree</td>
<td>4.72</td>
<td>13</td>
<td>Insignificant</td>
</tr>
</tbody>
</table>

- Lordosis of the cage did have a significant impact (p<0.05) on the amount of segmental lordosis achieved.
Hyperlordotic Cages

ALL resection and Hyperlordotic cage

<table>
<thead>
<tr>
<th>Level of the Cage</th>
<th>6 Degree Cage</th>
<th>10 Degree Cage</th>
<th>12 Degree Cage</th>
<th>20 Degree Cage</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>T12 - L1 Post Op</td>
<td>7.66</td>
<td>10.2</td>
<td>10.17</td>
<td>19.75</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>L1 - L2 Post Op</td>
<td>7.61</td>
<td>12.1</td>
<td>11.58</td>
<td>18.87</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>L2 - L3 Post Op</td>
<td>8.00</td>
<td>12.3</td>
<td>11.66</td>
<td>16.67</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>L3 - L4 Post Op</td>
<td>10.73</td>
<td>15.00</td>
<td>15.19</td>
<td>19.66</td>
<td>&lt; 0.05*</td>
</tr>
<tr>
<td>L4 - L5 Post Op</td>
<td>6.02</td>
<td>15.67</td>
<td>15.67</td>
<td>19.66</td>
<td>&lt; 0.05*</td>
</tr>
</tbody>
</table>

- 6, 10 and 12 degree cages create more segmental lordosis (p<0.05) when placed in lower lumbar intervertebral levels (L4-L5) compared to those placed in higher lumbar region (L1-L2).

Level of the Cage

Segmental Lordosis dependent on Level of the Cage

- 6, 10 and 12 degree cages create more segmental lordosis (p<0.05) when placed in lower lumbar intervertebral levels (L4-L5) compared to those placed in higher lumbar region (L1-L2).
Conclusion

- Lordosis of the cage had a significant impact on segmental lordosis achieved during lateral interbody fusion procedures.
- The achieved segmental lordosis was notably more when the cage was placed in lower lumbar intervertebral levels (L4-L5).
- Cages placed in the posterior 3rd of the intervertebral space had a significantly worse segmental lordosis compared to those placed in the anterior or middle 3rd.

Lordotic Cages - Segmental Lordosis per level

<table>
<thead>
<tr>
<th>6 Degree Cage</th>
<th>n=48</th>
<th>T12-L1(n=10)</th>
<th>L1-L2(n=16)</th>
<th>L2-L3(n=13)</th>
<th>L3-L4(n=6)</th>
<th>L4-L5(n=4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Pre-op 1.25</td>
<td>7.61</td>
<td>8.00</td>
<td>10.73</td>
<td>6.92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min -11.89</td>
<td>4.42</td>
<td>5.59</td>
<td>5.96</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max 7.38</td>
<td>11.04</td>
<td>14.40</td>
<td>17.68</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD 6.22</td>
<td>1.85</td>
<td>2.59</td>
<td>4.64</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>12 Degree Cage</th>
<th>n=84</th>
<th>L1-L2(n=3)</th>
<th>L2-L3(n=17)</th>
<th>L3-L4(n=32)</th>
<th>L4-L5(n=32)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean 10.80</td>
<td>12.35</td>
<td>12.67</td>
<td>15.67</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Min 4.59</td>
<td>7.30</td>
<td>6.60</td>
<td>7.80</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max 19.75</td>
<td>18.87</td>
<td>19.56</td>
<td>25.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD 5.58</td>
<td>2.72</td>
<td>2.81</td>
<td>3.27</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pre-op Planning

- 20 - 25 degrees at L5-S1 with an ALIF.
- 15 - 20 degrees at L4-5 with a 12° hyperlordotic lateral cage.
- 10 - 15 degrees at L3-4, L2-3 and L1-2 with an hyperlordotic lateral cage.
- 2-5 degrees at T12-L1 with a normolordotic lateral cage.

- I WOULD NOT DO AN ALL RESECTION/ACR FOR THIS CASE.
Surgical Protocol

• 1st Stage – MIS Lateral and L5-S1 ALIF
  • Patients walk after 1st stage
  • Re-assess any need for decompression
  • Re-assess Sagittal/Coronal alignment

• 2nd Stage (3 days later) – Percutaneous Screws and MIS Post Fusion at non-interbody levels

Today

- Intradiscal Release and Osteotomies
- Hyperlordotic Lateral Cages (12°)
- ALL release not needed in Virgin Scoliosis
- Staged reassessment of Interim Xray
- Aggressive Rod Contouring and Reduction Techniques
Principles of ACR™ Technique

1. Complete release (ALL & annulus; any posterior?)
2. Proper cage position & size
3. Cage fixation & screw
4. Posterior SPO ?? And Compression based on goal needed

68 yr Teacher
Severe progressive Deg Scoliosis
SVA = 110cm
PT = 40
PI = 46
LL = -5
Anterior Column Realignment (ACR™): Minimum 2 Year Follow-up of Clinical and Radiographic Outcomes

Drew Brown IV, M.D., Ali Bagheri, M.D., Navid Arandi BS
Robert Eastlack, M.D., Greg Mundis, M.D., Stacie Nguyen, MPH, Ramin Bagheri, M.D., Behrooz A. Akbarnia, M.D.

San Diego Spine Foundation

IMAST 2014 – Valencia, Spain, July 16-19, 2014

17 consecutive patients over 7 years
12 previous surgery
12 were for adjacent segment disease
15 had associated SPO
8 pts had 10 complications

Segmental lordosis: +9° to -19° to -26°
Lumbar Lordosis: -16° to -38° to -45°
Pelvic Tilt: 34° to 24°
Discussion Summary

LL, PI/LL mismatch, & T1SPI were significantly improved at post-op and maintained at 2 years

Average MSA / IDA correction in this series was 21°, compares favorably with PSO

Improved pain and disability outcomes at 2 years

Strategies for Minimally Invasive Reconstruction of the Anterior Column: Improving Sagittal Balance with Anterior Column Release

J.B.Billys ISASS, San Diego 2015

• 17 pts, ALL release
• 15, 20 and 30 degree implants

• Mean segmental Lordosis = increased 16°
• Global Lordosis = Increased 25°

• No complications

Conclusion - ALL Release/ACR Techniques

• Excellent alternative to PSO
• Highly Selected Patients
• Should be considered in conjunction with SPO
• Best for Focal Kyphotic Deformities
• Best Adjacent Segment Kyphoses

• 90 to 95% of De Novo Scoliosis patients DO NOT NEED IT!!!
Optimal Balance

- Individual for Each Patient
- Should not be a NUMBERS GAME!!!!
- Calculate your Goals pre op
- Understand Pelvic Parameters
- Understand Procedural ability to correct
- Application of appropriate Strategies
- Avoid 3 CO in the elderly as much as possible
- Reserve ACR for Distal Lumbar Fused patients with PJK

Thank you