Degenerative Spondylolisthesis and Scoliosis: Treatment Options

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Classification: Wiltse and Newman

Type I: Congenital (dysplastic)
Type II: Isthmic (spondylolytic)
Type III: Degenerative
Type IV: Traumatic
Type V: Pathologic
Type VI: Postsurgical (iatrogenic)

Type III: Degenerative Spondylolisthesis

- Longstanding segmental instability
  - Degeneration of disc and facets
  - Sagittal Orientation Facets
- No pars abnormality
- Disk degeneration leads to hypermobility of facet
- Nerve root compression

Figure 7-10.
Degenerative Cascade (Kirkaldy-Willis)

Degenerative Spondylolisthesis

- Appears with increasing frequency in and after the 6th decade of life
- More common in females
- Most common at L4-5
- Rarely exceeds >30% (acute neuro deficits uncommon)
- Loss of lordosis
Degenerative Spondylolisthesis
Conservative Measures

Conservative measures
– Rehabilitation (physical therapy)
– Nsaints
– Aerobic activity
– ESI

• 3-6 months of rehabilitation

Operative vs. NonOperative Treatment
<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Intervention</th>
<th>Number</th>
<th>Follow-up years</th>
<th>Primary endpoint</th>
<th>Randomization protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Möller et al. 2008</td>
<td>Posterior fusion (PLF) - non-instrumented - instrumented - 1 yr exercise program</td>
<td>77</td>
<td>2yr</td>
<td>OSS</td>
<td>Randomized</td>
</tr>
<tr>
<td>Simoni et al. 2005</td>
<td>Posterior fusion (PLF) - non-instrumented - instrumented - 1 yr exercise program</td>
<td>40</td>
<td>3yr</td>
<td>OSS</td>
<td>Randomized</td>
</tr>
<tr>
<td>Malmin et al. 2007</td>
<td>Decompression alone - Decompression/fusion with instrumentation - Exercise program/NSAIDS</td>
<td>40</td>
<td>2yr</td>
<td>OSS</td>
<td>Randomized</td>
</tr>
<tr>
<td>Carreon et al. 2008</td>
<td>Surgical (not specified) - Non-surgical (not specified)</td>
<td>288</td>
<td>3yr</td>
<td>NR</td>
<td>Meta-analysis of available RCTs</td>
</tr>
<tr>
<td>Weinstein et al. 2007, 2009</td>
<td>Decompression alone - Non-instrumented fusion - Instrumented fusion - Exercise, counseling, NSAIDS</td>
<td>20</td>
<td>4yr</td>
<td>OSS</td>
<td>Randomized</td>
</tr>
</tbody>
</table>

OSS - Oswestry Disability Index
NR - Not reported
OAR - Osteoarthritis Research Society
PLF - Posterior Lumbar Fusion
NSAIDS - Nonsteroidal Anti-Inflammatory Drugs
SPORT Study

• 4 year outcome
  – As treated analysis demonstrated the 2 year favorable outcomes for surgical treatment in terms of bothersome leg and back symptoms, overall satisfaction, and self rated progress were maintained at 4 years

Surgery vs. NonOp Care

• As a whole, the majority of the evidence supports surgery for symptomatic spondylolisthesis with regard to functional outcome and pain alleviation (especially at early time points)
Degenerative Spondylolisthesis
Surgical Treatment Options

- Decompression without fusion
- Decompression with non-instrumented fusion (posterolateral fusion)
- Decompression with instrumented fusion
  - +/- interbody device (TLIF, ALIF)
- Interspinous device

Decompression Without Fusion for Degenerative Spondylolisthesis

- Mardjetko et al (Spine 1994), meta-analysis of 11 articles from 1970 to 1993

<table>
<thead>
<tr>
<th>Results</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory</td>
<td>140 of 216 (69%)*</td>
</tr>
<tr>
<td>Unsatisfactory</td>
<td>75 of 216 (31%)*</td>
</tr>
<tr>
<td>Progressive slip</td>
<td>67 of 216 (31%)**</td>
</tr>
</tbody>
</table>

*Weighted pooled proportion
**Reported in only 9 of 11 articles

Decompression with Noninstrumented Fusion for Degenerative Spondylolisthesis

- Mardjetko et al (Spine 1994), also performed meta-analysis of decompression/noninstrumented fusions
  - Satisfactory: 90% (69%)
  - Unsatisfactory: 10% (31%)
  - Fusion: 86%
Decompression with Noninstrumented Fusion for Degenerative Spondylolisthesis

- Herkowitz, Kurz et al (JBJS 1991), prospective, randomized comparison of decompression vs. decompression/noninstrumented fusion
  - Decompression alone
    - 44% with excellent/good outcome
    - Slip increase of 2.6 mm
  - Decompression with in situ fusion
    - 96% with excellent/good outcome
    - Slip increase of 0.5 mm
    - **Pseudoarthrosis rate – 36%**
      - All with good/excellent results

<table>
<thead>
<tr>
<th>Result</th>
<th>Arthrodesis (N=25)</th>
<th>No-Arthrodesis (N=26)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>11 (44%)</td>
<td>1 (8%)</td>
</tr>
<tr>
<td>Good</td>
<td>11 (42%)</td>
<td>9 (38%)</td>
</tr>
<tr>
<td>Fair</td>
<td>1 (4%)</td>
<td>12 (40%)</td>
</tr>
<tr>
<td>Poor</td>
<td>0 (0%)</td>
<td>2 (8%)</td>
</tr>
<tr>
<td>Mean increase in slip (preoperative to postoperative)</td>
<td>0.5 mm</td>
<td>2.6 mm (P = 0.002)</td>
</tr>
</tbody>
</table>

Decompression with Instrumented Fusion for Degenerative Spondylolisthesis
Decompression with Instrumented Fusion for Degenerative Spondylolisthesis

  – Prospective, randomized study of in situ vs. instrumented fusion in 76 patients with 2 year follow-up
  – Fusion rate: 82% instrumented vs. 45% in situ
  – No significant difference in clinical outcome
    • 85% good/excellent in uninstrumented group
    • 76% good/excellent in instrumented group

Decompression with Instrumented Fusion for Degenerative Spondylolisthesis

• Kornblum et al (Spine, 2004)
• Long term follow-up of 58pts in Herkowitz, Fischgrund prospective studies randomizing pts to decompression with non-instrumented fusion.
• Mean f/u 7.7 years
• Outcome:
  – Excellent/Good 86% - solid arthrodesis
  – Excellent/Good 56% - pseudarthrosis
Decompression with Instrumented Fusion for Degenerative Spondylolisthesis

- Study showed benefit of solid arthrodesis in clinical outcome in the long term
- Prior studies showed term improvement in those with pseudarthrosis deteriorated in time.
- Study extrapolated that instrumented fusion would lead to better clinical result as a result of increased fusion rates

Instrumented Fusion

- The majority of the data supports a higher probability of achieving a fusion with an instrumented fusion, however there is no compelling evidence to suggest improved functional outcome or pain relief with the addition of instrumentation
Anterior Column Support

• May be accomplished through PLIF, TLIF, XLIF, DLIF, ALIF, IF, IF, IF
  – Theoretical advantage of maintaining disc height, anterior column support, indirect foraminal decompression, circumferential fusion, and restoration of segmental lordosis

PLIF

• Interbody fusion utilizing two interbody grafts
• May be done conventional open or minimally invasive
  – Fusion substrate is placed in the disc space
  – Distraction restores disc height, indirectly decompresses neuroforamen, restores segmental and global lordosis
PLIF vs. PLF Evidence

• No difference in pain relief, ODI outcomes or fusion in 40 retrospectively studied patients
  – Ha et al.
• No significant difference in ODI or Roland Morris scale in 60 non-randomized prospective patients
  – Dantas et al.
• Improved radiographic reduction with PLIF, better functional outcomes with PLF in RTC of 20 patients
  – Imander et al.
• Superior fusion with PLIF, no difference in clinical or function outcomes in a RTC
  – Cheng et al.
• Subgroup analysis of SPORT no difference between PLF and PLF and interbody fusion

PLF vs. PLIF

• Evidence supports improved fusion rate with PLIF
• No evidence to support improved clinical or functional benefit
ALIF

• Advantages of improved slip reduction, re-establishment of near anatomic coronal balance, and unimpeded access to the intervertebral disc space, permitting the use of larger grafts, and thus increasing the potential graft to endplate surface contact for enhanced anterior column arthrodesis

ALIF Evidence

• ALIF/instrumented PLF vs. PLF in 56 patients retrospectively analyzed
  • Similar fusion rates, less loss of slip reduction over 2 years, no difference in clinical or functional outcome
  • Suk et al.

• ALIF/non instrumented PLF vs. PLF, retrospective
  – Improved functional outcomes in ALIF group
  • Remes et al.

• ALIF vs. TLIF, retrospective
  – Improved ODI with TLIF at L4/5 and improved disc height, overall lordosis and sacral slope at L5/S1
  – Kim et al.
ALIF

• No high-level evidence to support ALIF over PLIF/TLIF or PLIF over TLIF
• Better fusion rates seen with circumferential fusion
• Moderate evidence to support improved radiographic outcome with ALIF without clinical difference

Slip Reduction

• Probably most controversial subject
• Slip reduction
  – Improved biomechanics (fusion, adjacent level dz)
  – Indirect neurological decompression
  – Correct segmental and lumbosacral kyphosis
• Increased risk
  – L5 palsey
  – Reported rates of 10-50% depending on type and degree of spondy
Slip Reduction

• Most common for reduction is interbody graft placement followed by posterior screw reduction/fixation
  – Variety of reduction screws (systems) available

Evidence

• No RCT comparing correction vs. in situ fusion
• Radiographic outcomes appear superior in pediatric patients with high-grade isthmic spondylothesis
  – No significant difference with regard to functional outcome or pain relief
  – Poussa et al.
Motion Preservation Systems

• Theoretical advantage of lower propensity for adjacent segment disease, avoidance of donor site morbidity associated with fusion

X-STOP

• Cohort analysis of IDE X-STOP trial
  – Significant improvement in ZCQ and SF-36
  – Overall clinical success of 63.4% compared to 12.9% managed conservatively
  – Recently the durability of these results has been called into questions
    • Surgical re-intervention rates as high as 58% have been reported in spondy patients
Dynesys

• Prospective multicenter trial, device found to be safe and effective for treatment of spondy
  – Stoll et al.
• Schnake et al. similar results to established protocols using PSF and decompression
  – High implant failure rate of 17% at minimum of 2 years
  – In follow-up publication with 4 year follow-up
    • No further implant failure noted

Dynesys

• Fakhil-Jerew et al., retrospective analysis of 55 patients
  – 45% re-operation rate within 2 years
Conclusions

• Results superior for operative vs. non-operative therapy for symptomatic spondylolisthesis
• Evidence supports laminectomy and uninstrumented fusion in the short term, long term data may be extrapolated to the superiority of using instrumented fusion
• Data does not support ALIF, PLIF, TLIF, etc. over PLF
• Motion preservation devices may be options, durability have been called into question as well as device failure

Degenerative Scoliosis
Degenerative Scoliosis

• De novo scoliosis
• Adults over age 40
• 1:1 male to female ratio
• Females seek medical care more commonly

Degenerative Scoliosis

• True incidence unknown
• Many patients may be asymptomatic or have only mild to moderate symptoms
• Significant co-morbidities
**Etiology**

- Disk degeneration more rapid than auto-stabilization
- Laxity of anterior ligamentous complex
  - Rotatory subluxations
  - Lateral listhesis
  - Spondylolisthesis
  - Vertebral tilt
  - +/- kyphosis

**Stenosis**

- Lateral recess and/or foraminal narrowing
- Subluxation of concave inferior facet impinges underlying nerve root
- Central stenosis can be seen with medial facet hypertrophy and is more severe on convex side of deformity
**Deformity**

- Usually less than 40°
- Apex located at L2 or L3
- Spondylolisthesis usually at L4 or L5 and not likely to progress past 25% to 30% slip

*McGuire; Seminars in Spine Surgery 1999*

**Risk Factors for Curve Progression**

- Curves > 30°
- Grade II and III rotation
- Unbalanced curves
- Secondary compensatory curve sharply angulated at L4-S1
- Apex at L2-3 and L3-4
- Intercrestal line through L5 vertebra
- Vertebral translation 6mm or more

*Spakas et al Bull Hosp Jt Dis 1996*
Surgical Management

- Decompression alone
- Decompression and fusion
- Decompression and fusion with instrumentation
  - Selective
  - All encompassing
- Decompression with anterior and posterior fusion
- Decompression, anterior/posterior fusion and vertebral column resection
- Anterior interbody fusion via lateral approach with indirect decompression

Posterior Procedures

- Decompression alone
- Decompression and fusion
- Osteotomies/Vertebral Body Resection
Decompression Alone

- Indications:
  - Older patient
  - Comorbidities
  - Poor bone quality
  - Isolated radiculopathy
  - Minimal back pain

Considerations for Focused Surgical Intervention in the Presence of Adult Spinal Deformity

When the sum total of patient evaluation suggests:
1) a stable deformity that does not require stabilization,
2) symptoms that are not due to the deformity itself, and
3) localizing pathology, which can be addressed surgically without curve destabilization, then limited surgical intervention, which does not address the deformity, may be indicated.

Mark Weidenbaum, MD  SPINE Volume 31, Number 19 Suppl, pp S139–S143
Considerations for Focused Surgical Intervention in the Presence of Adult Spinal Deformity

Table 1. Indications for Decompression and Segmental Fusion

<table>
<thead>
<tr>
<th>Indications</th>
<th>Decompression Only</th>
<th>Adjunct/Remote Segmental Fusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decompression needed</td>
<td>Low back pain</td>
<td>Sacroiliac pain, instability</td>
</tr>
<tr>
<td>Plain Film Findings</td>
<td>Lumbar lordosis &lt; 30°</td>
<td>Positive AP, Lateral flexion-extension tests</td>
</tr>
<tr>
<td>Global imbalance</td>
<td>Satisfactory</td>
<td>Satisfactory</td>
</tr>
</tbody>
</table>

Figure 1. Symptoms within deformity. An 80-year-old man presented with bilateral radicular pain, left greater than right, but minimal back pain. Neurologic examination was normal. Radiographs revealed a right T12-L4 spondylolisthesis of 15° and MRI revealed L2-L3 and L3-L4 stenosis. He underwent subtotal lateral decompressions at the affected levels. (A) Postoperative anteroposterior view showing 15° stenosis. (B) CT myelography showing stenosis at L2-L3. (C) Coronal view showing stenosis at L3-L4. At 22 months postoperative, he continued to have relief of radicular pain without clunk progression.

Mark Weidenbaum, MD SPINE Volume 31, Number 19 Suppl, pp S139–S143

Focal Decompression

- Techniques
  - Laminectomy
  - Laminotomies
  - MIS
Focal Decompression

- Laminotomies ("port hole", foraminotomies, selective nerve root decompression)
  - Usually midline incision,
  - Microscope
- Bilateral decompression through a unilateral approach
  - Tube retractor, microscopic
  - Microendoscopic

Bilateral decompression through a unilateral approach

- Khoo/Fessler Neurosurgery 2002
- Ikuta, J Neurosurg Spine 2005
  Outcome results similar to laminectomy
- Podichetty et al J. Spinal Disord Tech
  - 4.5 % durotomy rate (220 patients)
Focal Decompression

• Focal decompression may be successful in carefully selected patients
  – Isolated radiculopathy
  – Confirmatory NRB
  – Curves $< 20^\circ$
  – Lateral listhesis $< 2mm$
  – Autostabilization

Focal decompression

• Is it effective?
  – Often difficult to adequately decompress lateral recess without compromising facet
  – Subsequent instability
Posterior Decompression and Fusion

• Patients with stenosis and subluxations with reasonable sagittal and coronal balance
• No data on instrumented vs. noninstrumented fusions however extrapolation of data from degenerative spondylolisthesis suggests instrumentation will increase fusion rates with more durable results

Herkowitz et al JBIS(A) 1991
Herkowitz et al 2005

Selective Posterior Fixation
Clinical Outcome for Limited Transforaminal Lumbar Interbody Fusion (TLIF) in Patients with Adult Scoliosis
Lavelle, Evanchick, Orr

• 40 pts with single level fusion using TLIF
• Min 1 yr f/u
• Improved curve Avg 7 degrees
• Pain score improved AVG 3.6 on 10 pt scale
• Only 1 pt needed further surgery for deformity progression
• Avg progression 0.7 degrees

Posterior Fusion of Entire Curve
Posterior Decompression and Fusion

- Instrumentation allows for correction of deformity
- Bone quality can affect the ability to use instrumentation

Simmons ED, Simmons EH: Spinal stenosis with scoliosis. Spine 1992

- 40 patients with degenerative scoliosis and stenosis
- Decompression, segmental stabilization and arthrodesis
- Pain improvement in 93% of patients
- Average curve correction 19°

- 27 patients
- Decompression and fusion with instrumentation
- 86% satisfactory result
- 50% curve correction
- Correction of lumbar kyphosis correlated with improvement in back pain


- 40 patients surgically treated for degenerative scoliosis
- 30 patients available for follow up (mean 59.5 months)
- Results: 43.3% excellent, 53.3% good, 3.3% satisfactory
- Scoliosis corrected from 18.7° to 7.6°
- Lordosis increased from 37° to 41.5°
Instrumented posterior lumbar interbody fusion for patients with degenerative lumbar scoliosis

Wu et al. J Spinal Disorders; July 2008

• Retrospective review
• 26 patients
• 2 year f/u
• ODI improved from 58.0 to 25.8 (p<0.001)
• 76.9% patient satisfaction

Combined Procedures
Decompression with Anterior and Posterior Fusion

- Patients who are severely unbalanced in sagittal plane
- Marked rotatory subluxation
- Revision surgery
- Long fusion constructs +/- fusion to the sacrum

Lumbar degenerative scoliosis: outcomes of combined anterior and posterior pelvis surgery with minimum 2 year follow up.
Khan et. al. Orthopedics; April 2009

- 14 patients with mean f/u 44 months
- Highest post-op scores in patients with maximal curve correction
- Outcomes correlated strongly with pain relief; weakly with function
Anterior Interbody Fusion via Lateral Approach with Indirect Decompression

• Evolving minimally invasive (minimal access) technique
• Early results promising
• Stand alone?
• Indications/contraindications?
Minimally invasive anterolateral approaches for the treatment of back pain and degenerative lumbar scoliosis
Benglis et. al. Neurosurgery, 2008

• 4 patients
• 10 month f/u
• 1 patient had additional posterior instrumentation
• Deformity improved from 28.5 degrees to 18.3 degrees.

Approach to Surgery for Stenosis in Adult Deformity

• In younger healthier pt generally opt to treat the entire deformity
• If out of balance then either treat entire deformity or do not operate
• If older and balanced look to see if focal problem
• Decompression only????
• Focal fusion
• Intraspinous spacers may be a salvage
THANK YOU