Spondylolysis and Spondylolisthesis: A Case Based Discussion of Contemporary Treatment Guidelines Based on Evidence

Saturday, August 18th, 2018
Presented by the Scoliosis Research Society

Charles Crawford III, MD; John Dimar II, MD; Gregory Mundis, MD; Suken Shah, MD
Agenda

• Introduction – Charles Crawford III, MD
• Case Based Presentation of Pediatric Spondylolysis- Charles Crawford III, MD
• Case of Pediatric Low Grade Isthmic Spondylolisthesis- John Dimar II, MD
• Case of Pediatric High Grade Isthmic Spondylolisthesis- Suken Shah, MD
• Case of Adult Isthmic Spondylolisthesis- Gregory Mundis, MD
• Question and Answer
Pediatric Spondylolysis:

How do I make the diagnosis? What do I tell the parents about etiology and natural history? Should I recommend a brace? Is non-operative treatment effective? Should I recommend surgery? What is the best surgical treatment?

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Department of Orthopaedic Surgery
Disclosure

- Alphatec Spine (b,d,g); Medtronic (a); ISSG (a); Pfizer (a); Intellirod (a)
Lumbar Spondylolysis refers to a bony defect (or stress reaction) occurring in the lumbar pars interarticularis.
How do I make the diagnosis?

• Adolescent Athlete with LBP

• Lumbar pain worse with activity/extension
  • “Stork Test”

• XR, MRI, CT, SPECT, bone scan?
  • XR in office (convenient, inexpensive)
  • MRI next (effective, safe – no radiation)
  • I only get CT if failure of initial treatment
  • Rarely if ever use SPECT or bone scan
What do I tell parents/patient about etiology/natural history?

• The evidence supports an acquired etiology, as opposed to a congenital etiology.
• More common in certain families (likely due to anatomical factors)
• More common with certain activities (hyperextension sports)
• Many go undetected, short term symptoms resolve with no specific treatment; therefore, current symptoms may be aggravation of chronic spondylolysis
What is the prevalence of spondylolysis?
Are there pre-disposing factors?

• The reported prevalence ranges from 3-7% in the general population. There is an increased prevalence in specific populations secondary to familial factors (15-34% prevalence), and activity/sports related factors (7-21% prevalence). (Good evidence - consistent Level 1 studies)

• There is evidence to suggest that certain anatomic features (coronal facet orientation and less increase in interfacet distance (i.e. less of the normal increase in the coronal width of the lamina from upper lumbar to lower lumbar) are pre-disposing. (Fair evidence – consistent Level 3 studies)

• The prevalence is increased in pediatric patients presenting with low back pain (13-47%). (Fair evidence – consistent Level 2 studies)

• Most cases (90%) occur at the lowest lumbar vertebra, L5. (Good evidence - consistent Level 1 studies). Upper lumbar lesions are reported to be more commonly unilateral, and may occur over multiple levels. (Poor quality evidence – Level 4 studies)
Should I recommend a brace?

- No convincing evidence that it is better than activity modification/rest (meta-analysis)

- Pros: reminder, “placebo effect”

- Cons: inconvenient, expensive!
Is Non-Op Treatment Effective?

• YES!
• 80-90% return to sport
• Usually try for minimum of 3 months?
• Specifics are not well defined, is rest enough?
... radiographic bone healing of the pars interarticularis?

• Radiographic bony healing has been reported from 0% in chronic, bilateral lesions to 100% in early, unilateral lesions.

• The bony healing rates are higher for unilateral lesions (38%-100%) and incomplete (CT) or early (MRI or bone scan) fractures (73-87%). (Good evidence – consistent Level 1 and Level 2 studies)
... persistent bony pars defect without listhesis?

- Bilateral, chronic pars defects will not obtain bony healing in the vast majority of cases. (Good evidence – consistent Level 1 studies)
Should I recommend surgery?

- **YES!** – for symptom relief/return to sport in patients that fail non-op

- **NO!** – if asymptomatic patient
  - Untreated natural history seems to be benign for the majority of patients
What is the best surgical treatment?

• Fusion vs. Pars repair

• Multiple techniques in literature

• No clear winner

• Personal experience
Does pediatric spondylolysis lead to (and in what percentages)…
... progression to isthmic spondylolisthesis?

• There is substantial evidence that the many (43-74%) persistent, bilateral defects will progress to a Grade 1 or Grade 2 spondylolisthesis. (Good evidence – consistent Level 1 studies)
... resolution of symptoms (short vs. long term)? continued back pain? activity limitations?

• Short term symptom resolution is expected in the majority of patients. Most pediatric patients are able to continue sports activity. (Good evidence – consistent Level 1 and Level 2 studies)

• Although some patients will develop significant symptoms (both in the short and long term), the majority are able to avoid surgery with mild to moderate symptoms over the long term. (Fair evidence – consistent Level II and III studies)
Conclusions

• There is good evidence that lumbar spondylolysis is an acquired fracture of the pars interarticularis that can occur unilaterally or bilaterally.

• There is good evidence that when chronic, bilateral pars defects develop, 43-74% of patients will progress to Grade 1 or Grade 2 isthmic spondylolisthesis.

• There is good evidence that unilateral, incomplete, and early lesions can obtain bony union.
Conclusions

• With or without bony union or progression to spondylolisthesis, short-term symptom resolution is the norm.

• Long-term prognosis is less clear, but there is fair evidence that the majority of patients will have lumbar symptoms comparable to the general population.

• There is fair evidence that some patients will develop significant symptoms in adulthood and will undergo surgical treatment.

• There is insufficient evidence to predict which patients will continue to do well in the long term with conservative or no treatment, and which patients will develop symptoms significant enough to warrant early surgical intervention.
17yo HS football player failed 6 months non-op
MRI = lysis with healthy disc
CT = chronic bilateral L4 spondylolysis
Direct repair with navigation and ICBG
6 month post-op CT shows union
The Pathophysiology & Treatment of & Low Grade Spondylolisthesis

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Leatherman Spine Center
Chief of Pediatrics Norton's Children’s Hospital
Clinical Professor of Orthopedic Surgery
University of Louisville
Louisville, Kentucky
Disclosure

• DePuy Synthes (b); Medtronic (b,g)
Middle Pleistocene Lower Back & Pelvis From an Aged Human Individual From the Sima de los Huesos Site, Spain


PNAS, October 26, 2010, Vol. 107, No. 43

53,000 Years Ago

45 + Year Old Neanderthal Spine + Pelvis

Pleistocene Lumbar Spine Showing a Schmörl’s Node, L5-S1 Spondylolisthesis + Bastrup Disease
Hypothesis:

- “Spondylolysis is Due to an Insufficient Distances Between Inferior Articular Facets of L4 and the Superior Facets of S1 Which Results Impingement in Lordosis”

Study:

- Analyzed Hamann-Todd Osteological Collection at the Cleveland Museum of Natural History & Compared them to 30 Age & Sex Matched Controls

Results:

- Normal Individuals Have Progressively Bigger Facets Progressively to Sacrum While Those With Spondylolysis Have Smaller Ones
- Vertebral Body Sizes Between the Groups are Not Different
- Decreased Distance Between the L4 Facet & the S1 Facet Results in Impingement
Classification

Newman & Stone Classification

Types of Spondylolisthesis

- Type I: Congenital
- Type II: Isthmic
- Type III: Traumatic
- Type IV: Degenerative
- Type V: Pathologic
- Type VI: Iatrogenic
Classification

Spondylolisthesis

3 Year Old With Rare Congenital or Dysplastic Spondylolisthesis

Courtesy of Jason Zook
L5/S1 Isthmic Spondylolisthesis

- IV: 100%
- III: 75%
- II: 50%
- I: 25%
The Natural Progression - Is That They Don’t Progress
The Natural Progression - Case in Point
Pathological Patterns of Sagittal Balance

- **Short Lumbar Lordosis**: Facet DJD, DDD, Kissing PSP, Hyper-Exten. “Nutcracker Spondylolisthesis”
- **Low Kyphosis/Lordosis**: Increased Intradiscal Pressure Leads to Early DDD & HNP
- **Normal**: Pathology Neutral
- **Hyperlordosis/Kyphosis**: Higher Incidence of Spinal Stenosis, “Isthmic Spondylolisthesis”

*Adapted From Pierre Roussouly et.al. 2005*
Spino-pelvic Sagittal Balance of Spondylolisthesis: A Review & Classification

Hubert Labelle, Jean-Marc Mac-Thiong, Pierre Roussouly


Type 1: PI < 45 (Nutcracker)
Type 2: PI - 45 to 60
Type 3: PI ≥ 60
Type 4: Balanced Pelvis
Type 5: Balanced Spine A & B
Type 6: Unbalanced Spine

Need Potential Reduction
Review of the Literature:
First of All We Know From Fredrickson's Study That An Isthmic Spondylolisthesis Rarely Need Surgery And Rarely Progress

The Natural History of Spondylolysis and Spondylolisthesis

BE Fredrickson, D Baker, WJ McHolick, HA Yuan and JP Lubicky


We performed a prospective roentgenographic study to determine the incidence of spondylolysis, spondylolisthesis, or both, in 500 unselected first-grade children from 1955 through 1957. The families of the children with spondylolysis were followed in a similar manner. The incidence of spondylolysis at the age of six years was 4.4% and increased to 6% in adulthood. The degree of spondylolisthesis was as much as 28 per cent, and progression of the olisthesis was unusual. The data support the hypothesis that the spondylolytic defect is the result of a defect in the cartilaginous anlage of a vertebra. There is a hereditary pre-disposition to the defect and a strong association with spina bifida occulta. Progression of a slip was unlikely after adolescence and the slip was never symptomatic in the population that we studied.
Diagnostic Techniques:

- **CT Scan is the Gold Standard** but has High Radiation Dose
  - Useful in Detecting a Bony Defect & Assess Bone Healing

- **MRI Accurate as CT; Useful to Detect Early Stress Reactions** of the Pars Without Fracture

- **MRI is a Good Detector of Bony Healing** after Conservative Therapy

- **15 Weeks Average Delay** Between Initial Presentation to a Health Care Provider & Referral to an Orthopedic Surgeon
  - 1 Week for Orthopedic Surgeons; 25 Weeks for Non-orthopedic Providers; 10 Weeks from Unknown Provider

- **SPECT Scan** also Available & Accurate

2. Sairyo et al., Conservative Treatment for Pediatric Lumbar Spondylolysis to Achieve Bone Healing Using a Hard Brace: What Type & How Long?, Spine 2006;31:206-11
4. Nielsen et al., Diagnosis of Spondylolysis and Spondylolisthesis is Delayed Six Months after Seeing Non-orthopedic Providers, Spine Deform. 2018 May - Jun;6(3):263-266
Conservative Treatment for Bony Healing in Pediatric Lumbar Spondylolysis

- 63 Patients, Mean Age 13.8 Years (6-17)
  - All Patients Except with Terminal Stage (pseudarthrosis) Pars Defect → Conservative Treatment Used
    - Rest; Avoidance of Sports; Use of TLSO Brace (Sairyo Model)
  - 3 Drop Outs (95.2% Follow-up Rate)
  - Diagnosed via Plain XR, CT and MRI; Monthly Follow-up with MRI

- High Healing Rates with Short Treatment Periods
- Overall Recurrence Rate 26.1% → But All Recurrences Detected as Very Early Stage, & None Had Fractures

Conservative Treatment for Bony Healing in Pediatric Lumbar Spondylolysis

Sairyo Classification (modified from Fujii et al)

- **Very Early Stage**: Stress Reaction on MRI, No Fracture Line on CT
- **Early Stage**: Visible Hairline Fracture
- **Progressive**: Obvious Fracture (gap)
- **Terminal Stage**: Pseudarthrosis

**Treatment Classification**

Pediatric Lumbar Low Grade Spondylolisthesis
Morbidity and Mortality in the Surgical Treatment of Six Hundred Five Pediatric Patients With Isthmic or Dysplastic Spondylolisthesis

Kai-Ming G. Fu, MD, PhD,* Justin S. Smith, MD, PhD,* David W. Polly, Jr., MD,† Joseph H. Perra, MD., et. Al.
Spine 2011;36:308–312

Retrospective Study SRS Data Base of 605/25,432 Pediatric Cases of Isthmic or Dysplastic Spondylolisthesis Cases
- Isthmic = 543 (90%)
- Dysplastic = 62 (10%)
- Mean Age = 15 Years
- 50% Had Neurologic Involvement
- 1% Were Revisions

Surgery
- Lumbar Fusions = 92% (518 Instru.)
- Osteotomies 39%
- Reductions = 38%

Complications
- 10.4% Overall
- Neuro Deficit = 31 (5%)
  (1 Cauda Equina)
- Infection = 12 (2%)
- Dural Tear = 8 (1.3%)
- DVT = 2 (0.3%)
- PE = 1 (0.2%)

Pediatric Isthmic & Dysplastic Spondylolisthesis is an Uncommon Disorder in Children Accounting for Only 2.4% of All Pediatric Spine Procedures in the SRS Database
Complication Rate Almost Double with Reduction

127 Patients Had Meyerding Grade Recorded: Patients with HG Spondylolisthesis (Grades 3–5) More likely than Patients with LG Spondylolisthesis (grades 1–2) To:
- Require Decompression (66% vs. 40%), P = 0.004
- Undergo Reduction (76% vs. 32%), P = 0.001
- Suffer a New Postoperative Neurologic Deficit (11.3% vs. 1.4%), P = 0.021

Low Grade Spondylolisthesis Has a Low Rate of Complications & is Rarely Done for Neurologic Symptoms Like High Grade:
- The Surgical Treatment of Pediatric Isthmic & Dysplastic Spondylolisthesis is Associated with a High Rate of Morbidity
- Patients undergoing reduction were more likely to suffer a new neurologic deficit, although most were transient
- Patients with higher grades of spondylolisthesis were more likely to suffer a new neurologic deficit with surgical treatment
CONCLUSIONS

- Spondyloysis & Low-grade Spondylolisthesis Have a Benign Prognosis & Can be Generally Managed Nonoperatively

- Symptomatic Patients Who Fail Non-operative Management Should Have a Fusion In Situ Which Yields Satisfactory Long Lasting Results & is the Gold Standard

- Symptomatic Low Grade Spondylolysis at L5 or With Higher-level Defects & are Not Candidates for a Pars Repair Should be Treated with a PLSF with ICBG & Instrumentation

- Patients with Low-grade Spondylolisthesis that Remain Symptomatic Should be Treated with a Fusion in Situ

- Fusion In Situ Across One Motion Segment has Proved to be an Excellent & Safe Method for the Treatment of Low-grade Spondylolisthesis
  - Fusion Rates of 83% to 95% & Good or Excellent Results in 75% to 100% Have Been Reported in Numerous Studies
The Bimodal Peak of Surgery for Low Grade Spondylolisthesis

Presented at the SRS Annual Meeting
Dimar J, Labelle H, Roussouly P, Mac-Thiong JM et Al.

Figure 1

<table>
<thead>
<tr>
<th>Grade</th>
<th>Patients</th>
<th>Average Age of Surgery</th>
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<tbody>
<tr>
<td>I</td>
<td>40</td>
<td>32.0</td>
</tr>
<tr>
<td>II</td>
<td>57</td>
<td>32.5</td>
</tr>
<tr>
<td>III</td>
<td>62</td>
<td>21.9</td>
</tr>
<tr>
<td>IV</td>
<td>22</td>
<td>17.8</td>
</tr>
</tbody>
</table>

Figure 1A

<table>
<thead>
<tr>
<th>Cohort</th>
<th>N</th>
<th>Mean Age¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low (I/II)</td>
<td>97</td>
<td>32.3</td>
</tr>
<tr>
<td>High (III/IV)</td>
<td>84</td>
<td>20.9</td>
</tr>
</tbody>
</table>

¹p<0.001 for equality across 4 grades (ANOVA)

REVISED Figure 1: Age at Surgery by Slip Grade
Figure 1A: Age at Surgery by Slip Grade Cohort
¹p<0.001 for equality across cohorts (ANOVA)
Leverone Reports on the Reduction & Circumferential Fusion for Low-Grade Slips & Intermediate-Grade Slips in Pediatric Spondylolisthesis

- 13 Patients Treated with TLIF at L5-S1, with 5 Patients Having Additional Instrumentation to L4-L5; F/U Averaged 20.9 Months (0.5-50); Average age 13.7 Years
- 100% Fusion Rate

Table 2 Radiographic indices of spondylolisthesis at time points: preoperatively, postoperatively, and at the last follow-up

<table>
<thead>
<tr>
<th>Patient Parameter</th>
<th>Preoperative average (range)</th>
<th>Postoperative average (range)</th>
<th>Latest follow-up average (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slip percent</td>
<td>36% (10–55%)</td>
<td>19% (5–29%)</td>
<td>21% (6–28%)</td>
</tr>
<tr>
<td>Slip grade</td>
<td>2.2 (1–3)</td>
<td>1.2 (1–2)</td>
<td>1.1 (1–2)</td>
</tr>
<tr>
<td>Slip angle</td>
<td>20.4° (3°–36°)</td>
<td>20.3° (2°–39°)</td>
<td>18.5° (1°–38°)</td>
</tr>
<tr>
<td>Pelvic inclination</td>
<td>44° (25°–65°)</td>
<td>41° (20°–64°)</td>
<td>44° (27°–65°)</td>
</tr>
</tbody>
</table>

Evidence Regarding the Treatment of Pediatric Lumbar Spondylolisthesis: A Report from the Scoliosis Research Society Evidence Based Medicine Committee


Spine Deform. 2015 Jan;3(1):12-29

2016 SRS Assessment of Spondylolisthesis

Methods

- 6600 Citations
- 663 Articles Underwent Full Text Review.
- 51 Included Studies
- All Level III or IV Evidence¹

RESULTS

1. There is **Level 3 Evidence** That Instrumentation & **Reduction** **Lowers the Risk of Non-Union**
2. **Circumferential Fusion** is Superior to Posterior Only or Anterior Only Fusion.

Current Evidence on Treatment of Pediatric Lumbar Spondylolisthesis

- Asymptomatic or Minimally Symptomatic Patients Can be Observed
- Level III Evidence: Primarily High Grade Spondylolisthesis
  - For HG Spondylolisthesis Instrumentation & Reduction Lowers Risk of Nonunion
  - Circumferential Fusion Superior to Posterior-only or Anterior-only Fusion
  - Higher Slip Angle Likely to Fail Medical/interventional Treatment With High Grade Spondylolisthesis
11 YEAR OLD MALE WITH 2 MONTHS OF SEVERE LBP. REFERRED FOR EVALUATION. MRI ORDERED
L5 Spot Image Showing No Lysis or Spondylolisthesis
JDDD at L3-4 With Anterior Schmorl's Node

Left L5 Pars Increased T2 Signal

Right L5 Pars Increased T2 Signal

Axial Showing Bilateral L5 Pars Increased T2 Signal
Extension “Splinting”

Presented: 8-3-18

Treatment:
- Stop Sports
- NSAIDs
- Hard Shell LSO
- No Bending, Lifting, Twisting
- 3 Month Treatment
- Rehabilitation X 6 Weeks
- Return to Full Activity

Important Clinical Sign: Lack of Extension
14 Year Old Male who Plays Basket Ball Regularly. He Started Developing LBP that was Severe with Activity and Relieved by Rest. Denies any Neurological Issues. He Is Healthy.
Axial Cut High on Top of Pedicel Missing Most of Increased T2 Image. Some Mild Signal Change in the Facets. Showing Bilateral L5 Pars Increased T2 Signal.
Normal ROM Following LSO

Presented: 1-5-18
Final Check: 7-28-18

Treatment:
- Stop Sports
- NSAIDs
- Hard Shell LSO
- No Bending, Lifting, Twisting
- 3 Month Treatment
- Rehabilitation X 6 Weeks
- Return to Full Activity

Important Clinical Sign: Lack of Extension
14 yr./o Male Who Presents to the Office for 2nd Opinion on His Back. He has Been Treated for Almost a Year with Chronic Low Back Pain. It First Started When he is Playing Football.
Feb. 23rd, 2018 Presents with Severe LBP

L4-5 Spondylolysis Right

L4-5 Spondylolysis Left
Feb. 23rd, 2018 Presents with Severe LBP
Final Radiographs: June 12th, 2018 Asymptomatic

Grade I Spondy
With 1-2mm Listhesis
Treatment Plan

Treatment:
- Stop Sports
- NSAIDs
- Hard Shell LSO
- No Bending, Lifting, Twisting
- 3 Month Treatment
- Rehabilitation X 6 Weeks
- Return to Full Activity

Presented: 2-23-18
Final Check: 6-12-18

Results: Asymptomatic; Returned to Full Activity
Treatment Algorithm
Low Grade Spondylolisthesis

What is the Prevalence of Spondylolisthesis?

Define a Low Grade Spondylolisthesis

What is the Natural History of a LG Spondy

Clinical & Radiographic Diagnostic Testing

What Non-operative Treatments are Available

When & What Type of Surgery is Recommended

- Most Will Go On to Stabilize Till Adults
- PE, Sports, XR, MRI, CT, SPECT Scan
- NSAIDs, Braces, Avoid Sports, Rehab
- Fusion: Last Resort for Severe Pain
12 Year Old Female Here 8 Month History Low Back & Right Leg Pain (ODI - 0, Back - 0, Leg - 0). The Severe LB Pain Has Been Present for Approximately 2 Weeks after Cheer Leading. But She Has Had it Longer Intermittently. The Patient Denies Numbness, Weakness, Bowel/Bladder Incontinence. Subsequently Treated with Brace Blocks & Epidurals. Had 6 Subsequent Visits to ER Due to Severe Pain

Case Presentation

Recommendations?
Initial Onset of LBP: Jan 11th, 2017

$PI = LL + SS$

$53^\circ$

$44^\circ$
Spina Bifida Occulta

Referral To Spine from ER: August 29, 2017
MRI Done Sept. 12th, 2017
CT Scan: October 23rd, 2017
Treatment:
- Stop Sports
- NSAIDs
- Epidurals for L5 Radiculopathy
- Hard Shell LSO
- No Bending, Lifting, Twisting
- 3 Month Treatment
- Plan F/U Rehabilitation X 6 Weeks
- Plan Return to Full Activity

Results: Back Pain & Blocks Worsened Symptoms:
6 Visits to ER for Back & Leg Pain
Good Evidence Circumferential Fusion of a Spondylolisthesis (HG) Will Achieve a Fusion & Pain Relief, Long Term Results Unknown
Thank You

Pediatric Lumbar Low Grade Spondylolisthesis
Pediatric High Grade Spondylolisthesis and Spondyloptosis: Pathoetiology and Treatment

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Sidney Kimmel Medical College of Thomas Jefferson University
Disclosures

- Some implants are used off label
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- Board/Committee Positions: Scoliosis Research Society, Setting Scoliosis Straight Foundation, Pediatric Orthopaedic Society of North America
Spondylolisthesis

- Anterior slippage of vertebral body
- Incidence is 6%
  - Males higher incidence of spondylolysis (2:1)
  - Females higher risk of progression
- Usually accompanied by bilateral pars defects
- May be asymptomatic
- Progressive in growing children (10-15)
Spondylolisthesis

• Pain
• Radicular symptoms
• Bowel or bladder impairment
• Tight hamstrings
  • Knees bent, hips flexed gait
  • Phalen-Dickson sign
  • Nerve root irritation or sacral inclination?
• Palpable stepoff, prominent SP of L5
• Scoliosis (13%-60%)
Epidemiology / Natural History

- Radiographic risk factors for progression
  - Degree of slip (Meyerding)
  - Lumbosacral kyphosis (slip angle)
  - Dome-shaped sacrum
  - Sacral inclination, pelvic incidence
  - Lack of deep-seated L5 (lacking iliolumbar ligaments)
High Grade Dysplastic Spondylolisthesis

Grade 3 or more
with lysis or elongation of pars
upper sacrum dysplastic
L5 arch poorly formed

Marchetti PC & Bartolozzi P (1997)
Classification of spondylolisthesis as a guideline for treatment. In Bridwell KH, DeWald RL (eds)
The Textbook of Spinal Surgery. 2nd edn.
Lippincott-Raven, Philadelphia, pp1211-1254
Classic Measurements

Myerding Grade or % slip

Slip Angle or lumbosacral kyphosis
Forces at Lumbosacral Junction

Axial load
Flexion forces
Rotational forces

High PI
Increased lordosis

Increasing shear forces—resisted by posterior bony hook (tension band) and intact disc
Decreased Lumbosacral Shear Resistance

failure of tension band & loss anterior column support

Segmental instability
Surgical Treatment... address pathomechanics

Goals of treatment... DeWald... *Textbook of Spinal Surgery*
1. Minimal segments fused
2. Interbody arthrodesis
3. Restore sagittal vertical axis = reduction

- Balance forces
- Restore spinopelvic balance
The Assessment and Treatment of High-Grade Lumbosacral Spondylolisthesis and Spondyloptosis in Children and Young Adults

Scott J. Schoenleber, MD
Harry L. Shufflebarger, MD
Sukin A. Shah, MD

Investigation performed at the Department of Orthopaedic Surgery, Nemours/A.I. duPont Hospital for Children, Wilmington, Delaware

» High-grade spondylolisthesis may cause substantial disability, sagittal imbalance, pain, and neurologic dysfunction.

» Imaging of spondylolisthesis should include full-length posteroanterior and lateral radiographs of the spine with attention focused on pelvic incidence, sacral slope, pelvic tilt, and slip angle.

» Indications for operative treatment in high-grade spondylolisthesis include the presence of substantial deformity, pain, stenosis, neurologic deficit, and radiographic progression.

» The optimal operative technique involves decompression, reduction, and circumferential fusion with instrumentation as this allows for restoration of sagittal balance and an improved fusion rate and has an acceptable safety profile.
Spondylolisthesis Reduction---Why?

- Direct canal decompression
- Correction of lumbosacral kyphosis—cosmesis
- Decrease tension on fusion - biomechanical advantage
- Prevent risk of acute cauda equina syndrome
- Decrease pseudarthrosis rate
- Prevent slip progression
- Improve quality of fusion
Spondylolisthesis Reduction

Posterior shortening...Posterior tension band
structural interbody graft = fulcrum for reduction and lumbosacral lordosis production
Spondylolisthesis Reduction

Creates anterior column deficit

Anterior column support
Spondylolisthesis Reduction
Shear Forces Negated

reduction -- anterior column support -- posterior tension band
Pelvic Retroversion

From Li and Hresko, JAAOS 2012
Balanced

Unbalanced

From Li and Hresko, JAAOS 2012
# New Classification of Spondylolisthesis

## New Classification of Lumbosacral Spondylolisthesis

<table>
<thead>
<tr>
<th>Slip Grade</th>
<th>Sacropelvic Balance</th>
<th>Spinopelvic Balance</th>
<th>Spondylolisthesis Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-grade (&lt;50%)</td>
<td>Low PI (&lt;45°)</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Normal PI (45°–60°)</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>High PI (≥60°)</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>High-grade (≥50%)</td>
<td>Balanced (high SS/low PT)</td>
<td>Balanced (C7 plumbline between femoral heads and sacrum)</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Unbalanced (low SS/high PT)</td>
<td>Unbalanced (C7 plumbline anterior to femoral heads or posterior to sacrum)</td>
<td>5</td>
</tr>
</tbody>
</table>

*a The spine is almost always balanced in patients with low- or high-grade spondylolisthesis with a balanced pelvis.

PI = pelvic incidence, PT = pelvic tilt, SS = sacral slope


*From Mac-Thiong JM, Spine 2012*
Classification of Spinopelvic Anatomy

High grade spondylolisthesis

High SS, low PT
balanced pelvis

Low SS, high PT
retroverted pelvis
Goal of surgery

Restore spinopelvic balance

Correction of L/S kyphosis requires reduction (partial)

Maintenance of correction requires posterior inst & structural L5-S1 implant
High Grade Spondylolisthesis...  
*treatment challenge*

“Extremely demanding and potentially dangerous”


Multiple authors report
- catastrophic neurologic injury
- nerve root deficits
- non-unions
- progressive slippage
- need for revision surgery
High Grade Reduction - Results


- 25 patients
- Age 13.5 (10-16)
- Symptoms > 1 year
  - Back or leg pain
  - Postural abnormality

Neurology
- Motor deficit—11/25 10 L5 root, 1 incomplete cauda equina
- SLR < 45° in most
- All > 50% displacement L5
- 96% follow-up
- Mean follow-up 5 yrs (4-9)
Reduction for High Grade Spondylolisthesis
surgical sequence

Gill procedure & exposure L5 and S1 roots
Screw placement—reduction in L5
+/- temporary distraction
Discectomy
Sacral dome excision
Anterior graft—autogenous
Reduction—gradual with screws
Distraction
Cage placement
Compression
Postero-lateral graft
Role & Technique of Sacral Dome Resection in High Grade Spondylolisthesis

High grade spondylolisthesis

“problem of kyphosis, not translation”

- Sacral dome resection
- posterior shortening
- decreases L5 stretch
- facilitates reduction
MRI
Resolution of Sagittal Imbalance
Spondyloptosis
Spondyloptosis
Clinical Photos
Clinical Presentation

- Hyperlordosis of lumbar spine
- Lumbosacral kyphosis
- Pelvic retroversion
- Flexed hips & knees

From Li and Hresko, JAAOS 2012
Immediate Post Op
Two Year Follow Up
Sophisticated terminology defines spinopelvic relationships.

Must understand pathomechanics to design a surgical plan.
Why Reduce?

• Complete reduction is not necessary
• Lumbosacral kyphosis restoration
• Restoration of normal sagittal balance
• Improved spinopelvic balance
  • Unbalanced pelvis – benefit the most
• Fusion biomechanics
• Clinical appearance
Thank You

Nemours Spine and Scoliosis Center
www.nemours.org/spinecenter
Case of Adult Isthmic Spondylolisthesis

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Scoliosis Research Society Webinar
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Disclosures

• Nuvasive: Consulting, Royalties, Advisory Board
• K2M: Consulting, Royalties
• AlloSource: Advisory Board
• Viseon Spine: Advisory Board
• Seapsine: Advisory Board
• SOLAS: Board of Directors
• SDSF: Board of Directors
• GSO: Chief Executive Officer
Overview

• Is this the natural history of Pediatric Isthmic Spondylolisthesis?
• Is non-operative treatment effective?
• Should I recommend surgery?
• What is the best surgical treatment?
Isthmic spondylolisthesis is defined as the anterior translation of one vertebra relative to the next caudal segment as a result of an abnormality in the pars interarticularis. This slippage most commonly occurs at L5–S1 and second most commonly at L4–L5. Cross sectional study of 45-64 yo’s: Incidence was 4.6-7.7%. Among 40-80 yo symptomatic patients: Incidence was 8.2%.
Natural History

• Is it just progression from childhood?
• Etiology mulifactorial
• Multiple theories
  • Pediatric theory- pars interarticularis defect from childhood never fully healed and persisted into adulthood
  • Traumatic- An event in adulthood is linked with the development of an acute injury
  • Repeated stress on the pars; microtrauma
  • Repeated stress in light of a degenerative disc may take the pathology from spondylolysis to spondylolisthesis
• Pars defects twice as common in boys
• High grade slippage four times more common in girls
• Alaskan Eskimos with nearly 50% incidence
Is Non Operative Therapy Effective?

• Patients must be grouped into 2 groups:
  1. Back Pain predominant
  2. Leg Pain predominant
Back Pain Predominant

- NSAIDs
- Supervised Physical Therapy
  - Paraspinal
  - Abdominal
- Aerobic conditioning
  - Swimming
  - Cycling
  - Climbing
- Weight reduction
- Acupuncture
- Chiropractic care
Key Element:
- Listen to the patient
- Understand their back pain
  - Rule out other etiologic factors
  - Facet disease
  - SI joint
  - Tumor, infection etc.
- If needed continue to work up their complaints
  - MRI
  - CT
  - NM SPECT scan
  - Injections
- Maintain non operative management for 6-12 months
Leg Pain Predominant

• Similar management initially to those with back pain
• Consider adding epidural steroid injections
  • Appropriate for mono-radicular symptoms
  • Neurogenic claudication
• For diagnostic purposes selective nerve root blocks may be useful
• Can be used up to 3x per year
LEG PAIN PREDOMINENT

• When there is 6-12 weeks of radicular pain unresponsive to non surgical treatment, surgery is a reasonable alternate treatment strategy

• Other indications:
  • Neurogenic claudication
  • Other symptoms of nerve compression

• Indications to proceed with surgery quickly
  • Neurologic weakness
  • Symptomatic Severe stenosis
  • Cauda equina syndrome

Should I recommend surgery?
Should I recommend surgery?

PREDOMINENT BACK PAIN

• More controversial if back pain alone is complaint
• After thorough non op course surgery can be considered
SURGICAL DECISIONS:

1. Decompression alone?
2. Instrumented fusion?
3. Addition of Interbody as anterior column support?
4. Is a decompression even needed?
5. Is a reduction warranted
When is decompression alone a reasonable option?
- In the setting of isolated leg pain, and...
- No evidence of radiographic dynamic instability
- Only low grade should be considered for this approach
- Muscle sparing is key if this approach is adopted.

Herkowitz et al
- Prospective series of matched patients...at 2 years:
  - 96% in fusion group had good to excellent results
  - 46% in non fusion
  - Laminectomies were performed not laminoforaminotomies
Fusion

• Most patients will complain of either clinical instability (change in symptoms with change in position) or demonstrate radiographic instability.

• If fusion is chosen the only clear data that currently exists is that instrumented fusion outperforms non-instrumented fusion.

• Decisions for surgical approach to fusion:
  1. Posterior instrumented fusion (PIF)
  2. Transforaminal lumbar interbody fusion (TLIF)
  3. Anterior lumbar interbody fusion with PIF (APIF)
  4. Lateral lumbar interbody fusion with PIF (LPIF)
POSTERIOR INSTRUMENTED FUSION

- Midline approach
- Pedicle screw fixation
- Typically accompanied by decompression with laminectomy and foraminotomy to address the stenosis symptoms

- Data is very favorable with short to mid term follow up (2-3 years)
  - Good durability over time
  - Only applicable for low grade spondylolisthesis
  - Most studies do not evaluate segmental sagittal parameters
  - Performs equal to posterior fusion with interbody
Addition of Interbody as anterior column support?

- The choice of interbody in the literature does not matter
- Can choose anterior approach for interbody fusion.
  - Can be traditional ALIF
  - Mini-open supine ALIF
  - Lateral ALIF
- BENEFITS
  - Large graft
  - Can control lordosis correction
  - Indirect foraminal decompression is excellent
- DOWNSIDES
  - Additional approach
  - Adds a new subset of complications
  - May take longer
• **BENEFIT:**
  - Single approach
  - Direct decompression of the side that is affected most
  - Fusion rates are good

• **DOWNSIDES:**
  - Segmental sagittal alignment more likely to suffer
  - Smaller implant with limited load sharing capability
  - Requires visualizing neurologic elements ➔ Direct injury to nerves, retraction of nerves, durotomy etc.
• BENEFITS:
  • MIS approach
  • Can approach antepsoas or transpsoas
  • Large implants that cover the apophyseal ring
  • Segmental sagittal alignment
  • Indirect decompression
  • Single position surgery (can place screws from single positioning.

• DOWNSIDES
  • Still technically demanding procedure, particularly in the setting of spondylolisthesis at L4-5 where the anatomic corridor is narrow
  • Potential neurologic complications
  • Navigating vascular structures when necessary
Is Decompression even Needed

- 2 Schools of thought

1. If there is preoperative neurology there is an obligation to visualize the neurologic elements, perform a decompression so that the surgeon is certain that there is no residual stenosis.

2. If patients have clinically dynamic symptoms/instability (radicular pain or neurogenic claudication that is positional or activity level that lessens/resolves with rest) then they are candidates for indirect decompression regardless of the advanced imaging findings.
Is a Reduction Warranted

• For low grade spondylolisthesis:
  • Data is very strong in support of no long term clinical benefit to reducing low grade spondy
  • Studies are limited:
    • Limited sagittal plane considerations
    • Follow up generally limited to 2-3 years
    • Most studies evaluate reduction by change in grade not in improvement of slip angle.

• High grade spondylolisthesis
  • Reduction recommended
  • Caution with reduction >50%
    • Incidence of new neurology increases
Conclusion

1. Etiology is multifactorial
2. Non operative management in adults result in successful management of 85% of patients
3. Surgery should be limited to patient with refractory pain and disability with leg symptoms being the predominant complaint
4. Decompression has limited utility in isthmic spondylolisthesis.
5. Instrumented fusion perform superior to non-instrumented in low grade spondy
6. The addition of interbody fusion does not necessarily yield better short – intermediate results
7. Choice of interbody is up to the surgeon
8. Indirect decompression can be considered in select cases
9. Reduction of spondylolisthesis is unnecessary in low grade and limited to 50% in high grade.
Question and Answer

Presented by the Scoliosis Research Society