Degenerative Spondylolisthesis
Clinical and Imaging evolution

Jeremy Fairbank MD FRCS
Professor of Spine Surgery
University of Oxford
1976 – 2012

• Clinical evolution
• Investigation evolution
• Treatment evolution
Classification of Spondylolysis and Spondylolisthesis

LEON L. WILTSE, M.D., P. H. NEWMAN, M.D. AND IAN MACNAB, M.D.

The following classification of spondylolisthesis and spondylolysis has been derived from previous classifications published by the authors.9, 11, 24

I Dysplastic — In this type congenital abnormalities of the upper sacrum or the arch of L5 permit theolisthesis to occur.

II Isthmic — The lesion is in the pars interarticularis. Three types can be recognized. (a) Lytic-Fatigue fracture of the pars. (b) Elongated but intact pars. (c) Acute fracture.

III Degenerative — Due to long standing interarticularis either elongates or comes apart. If it elongates, it is very difficult radiologically to tell from Type II, Subtype B. If it separates, it may be impossible to tell from Type II, Subtype A, but, if exposed at operation, the abnormal relationship and subluxation of the facets will be apparent in the dysplastic type.

Fundamental to this type is that the first sacral vertebra or lowest lumbar vertebra has congenital changes of such a nature that the joint is incapable of withstanding the forward thrust of the body weight above.
The following classification of spondylolisthesis and spondylolysis has been derived from previous classifications published by the authors.9, 11, 24

I Dysplastic — In this type congenital abnormalities of the upper sacrum or the arch of L.5 permit theolisthesis to occur.

II Isthmic — The lesion is in the pars interarticularis. Three types can be recognized. (a) Lytic-Fatigue fracture of the pars. (b) Elongated but intact pars. (c) Interarticularis either elongated or split apart. If it elongates, it is very difficult radiologically to tell from Type II. If it separates, it may be indentified from Type II, Subtype A, but at operation, the abnormal reaction of subluxation of the facets will be evident in the dysplastic type.

Fundamental to this type is the fact that the sacral vertebra or lowest lumbar vertebra may have congenital changes of such a nature that the joint is incapable of withstanding the forward thrust of the body weight. The pars interarticularis is often poorly developed to begin with and is predisposed to cracking and breakage.

Often there is a wide-open slip. We have no accurate statistics as to the frequency of occurrence but many have been observed.

III Degenerative — Due to long standing intersegmental instability.

IV Traumatic — Due to fractures in other areas of the body than the pars.

V Pathological — There is generalized or localized bone disease.

DESCRIPTION AND ETIOLOGY

Dysplastic
Spinal Stenosis was described in 1954
by Henk Verbiest
A Dutch Neurosurgeon

- Difficulty with **walking** (neurogenic claudication)
- Difficulty with **standing still**
- Pain in **back and/or leg(s)**
- Once considered rare, it is now clear that this syndrome occurs frequently with advancing years.

- Verbiest recognised 2 forms
  - Developmental
  - Acquired
What sort of imaging should we use for degenerative spondylo?
...what do we want to know?

- **Xrays**
  - Standing/lying
  - Flexion/extension

- **Interventional**
  - Facet block
  - Nerve root block
  - Discography

- **MRI**
  - Supine
  - Standing???

- **CT**
the physiological upright standing posture can be reached in a different way for each person with a unique and individual pattern of spinopelvic balance and sagittal alignment..

Vialle R et al JBJS(A) 2005 87;2:260-7
Degenerative Lumbar Scoliosis: Radiographic Correlation of Lateral Rotatory Olisthesis With Neural Canal Dimensions

**Conclusions:**

- Anteroposterior olisthesis is **inversely correlated** to the dural sac anteroposterior diameter and cross-sectional area.
- Ligamentum flavum hypertrophy, posterior disc bulging, and bony overgrowth **are more likely** to contribute to stenosis irrespective of scoliosis.

- Degenerative scoliotic curves
  - Lateral translation is associated with rotation
    - **Increased rotary olisthesis does not** lead to decreased dural sac area
      - With increased segmental Cobb angle, foraminal cross-sectional area enlarges in the convexity and does not decrease in the concavity.
      - Presence of intervertebral rotation alone does not appear to be associated with reduced neural canal dimensions.
Degenerative Spondylolisthesis in Patients with Neurogenic Claudication Effects Functional Performance and Self-Reported Quality of Life
Spine 2009;34 (25) 2812-2817

• Methods:
  – 38 women and 39 men diagnosed with lumbar spinal stenosis and neurogenic claudication

• Imaging:
  – side-lying, lateral flexion and extension radiographs

• Assessments:
  – shuttle walking test
  – Swiss Spinal Stenosis Questionnaire
  – Short Form 36

• Conclusion
  – presence and magnitude of degenerative spondylolisthesis does NOT correlate with decreased functional capacity
    • SSSQ and SF-36 are accurate in defining the functional status of a patient.
    • Comprehensive evaluation of patients with symptomatic lumbar spinal stenosis using functional assessment and self-assessment questionnaires are helpful in determining the severity of a patient's disability
  – Plain radiographs may be valuable adjuncts for surgical decision-making, but are not useful in quantifying the degree to which a patient is impaired
Degenerative Spondylolisthesis in Patients with Neurogenic Claudication
Effects Functional Performance and Self-Reported Quality of Life
Spine 2009;34 (25) 2812-2817

• Conclusion
  – presence and magnitude of degenerative spondylolisthesis does **NOT** correlate with decreased functional capacity
    • SSSQ and SF-36 are accurate in defining the functional status of a patient.
    • Comprehensive evaluation of patients with symptomatic lumbar spinal stenosis using functional assessment and self-assessment questionnaires are helpful in determining the severity of a patient's disability
  – Plain radiographs may be valuable adjuncts for surgical decision-making, but are not useful in quantifying the degree to which a patient is impaired
Association between computed tomography–evaluated lumbar lordosis and features of spinal degeneration, evaluated in supine position

The Spine Journal 2011; 11(4):308–315

• Purpose
  – To evaluate the association of computed tomography (CT)–evaluated lumbar lordosis as well as segmental wedging of the vertebral bodies and that of the intervertebral discs with various spinal degenerative features.

• Study design
  – This cross-sectional study was a nested project to the Framingham Heart Study.

• Patient Sample
  – A random consecutive subset of 191 participants chosen from the 3,590 participants enrolled in the Framingham Heart Study who underwent multidetector CT to assess aortic calcification.

• Outcome measures
  – Intervertebral disc narrowing, facet joint osteoarthritis, spondylolysis, spondylolisthesis and spinal stenosis,
  – Density (in Hounsfield units) of multifidus and erector spinae muscles were evaluated on supine CT
  – Lordosis angle (LA)
  – Wedging of the vertebral bodies
  – Wedging of Intervertebral discs
Association between computed tomography–evaluated lumbar lordosis and features of spinal degeneration, evaluated in supine position

The Spine Journal 2011; 11(4):308–315

—Lordosis angle

- association with the presence of spondylolysis (odds ratio [95% confidence interval]: 1.08 [1.02–1.14]) and with the density of multifidus (1.06 [1.01–1.11]) as well as a marginally significant association with isthmic spondylolisthesis (1.07 [1.00–1.14]).

—Bone wedging

- showed a positive association with degenerative spondylolisthesis (1.14 [1.06–1.23])

—Disc wedging

- showed a negative association with Degenerative spondylolisthesis (0.93 [0.87–0.98])
Association between computed tomography–evaluated lumbar lordosis and features of spinal degeneration, evaluated in supine position

The Spine Journal 2011; 11(4):308–315

- My conclusion
  - CT Probably not much help
Nerve root blocks...
The Problem With Diagnostic Selective Nerve Root Blocks


• The Problem With Diagnostic Selective Nerve Root Blocks (as commonly performed and interpreted)
  – Unable to diagnose spinal pathology
  – Only role is therapeutic
Peter Nathan – a great neurologist

Kibler R, Nathan P.

RELIEF OF PAIN AND PARAESTHESIAE BY NERVE BLOCK DISTAL TO A LESION.

J Neurol Neurosurg Psychiatry. 1960;23(2):91–8
• Lesions of afferent pathways may give rise to a variety of spontaneous sensations.

• When a lesion affects nerves, nerve roots, the root entry zone, or the spino-thalamic tract
  – the sensations are usually those of pain and painful pins and needles

• when it affects the posterior columns of the cord
  – the sensation is one of painless pins and needles or of tingling

• It is natural to think that the pain and paraesthesiae are due to
  – discharge of nerve fibres in or near the lesion,
  – the lesion on the afferent pathway causes these nerve fibres to fire off
In this paper ... we show that local anaesthetic injections of the afferent pathway, distal to the site of the lesion, may...

• Stop the pain or paraesthesiae
  – This effect may far outlast the duration of the anaesthesia

• Blocking a peripheral nerve supplying a large part ... (of) where the pain or paraesthesiae are felt may remove these sensations from the entire region
Outcome measures and Functional assessments

Deo S, Wanders L, Makan P, Pratt R, Virr A, Fairbank J,
Outcome measures for neurogenic claudication.
North American Spine Society; 1998; San Francisco.

Pratt R, Fairbank J, Virr A.
The Reliability of the Shuttle Walking Test, the Swiss Spinal Stenosis Questionnaire, the Oxford Spinal Stenosis Score, and the Oswestry Disability Index in the Assessment of Patients With Lumbar Spinal Stenosis.
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Questionnaires
• Walking tests
• Treadmill
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Questionnaires
  – Oswestry (ODI)
  – Zurich
  – Oxford
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Questionnaires
  – Commonly used back pain outcome are probably invalid for this population
  – Few questionnaires have been designed specifically for this complaint.
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• **Walking tests** are difficult to perform
  – Reliable distance estimation is poor
  – Walking ability is also related to speed
  – Slowing down is a frequent complaint
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Walking tests
  – Distance
    • tedious, unreliable and time consuming
  – Shuttle walking test
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

- **Treadmill,**
  - expensive
  - of doubtful reliability
  - elderly patients are worried about falling off.
  - handrails may extend walking tolerance

Use supported by study of Deen et al, *J Neurosurg* 1995; 83: 27-30
Not supported by Rainville et al 2012
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Shuttle Walking Test
  – developed originally in respiratory medicine
  – Used as an outcome measure in a back pain trials
  – none of our patients selected for surgery can manage more than 200 metres.
  – A fit adult can usually manage about 600 metres
  – The maximum of the test is 1056 Metres (12 Minutes)

Singh SJ, Morgan MDL, Scott S, Walters D, Hardman AE.
Development of a shuttle walking test of disability in patients with chronic airways obstruction.
Thorax 1992; 47: 1019-1024
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Shuttle Walking Test
  – 10M walkway
  – the subject walks up and down ('the shuttle’)
  – All instructions are standardised and given on a tape cassette.
  – The subject has to reach the end of the walkway within a specified time
  – This is dictated by a beep
  – The interval is shortened incrementally
  – The endpoint is when the subject cannot reach the end of the walkway within time
  – The number of passages of the shuttle is recorded
Shuttle Walking Test

LEVEL (minutes)

Metres walked

1  2  3  4  5  6  7  8  9  10  11  12

 Metres walked

30  70  120  180  250  330  420  520  630  750  880  1020
Shuttle Walking Test

LEVEL (minutes)

Metres walked

1  30
2  70
3  120
4  180
5  250
6  330
7  420
8  520
9  630
10 750
11 880
12 1020
Shuttle Walking Test

<table>
<thead>
<tr>
<th>LEVEL (minutes)</th>
<th>Metres walked</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>70</td>
</tr>
<tr>
<td>120</td>
<td>180</td>
</tr>
<tr>
<td>250</td>
<td>330</td>
</tr>
<tr>
<td>420</td>
<td>520</td>
</tr>
<tr>
<td>630</td>
<td>750</td>
</tr>
<tr>
<td>880</td>
<td>1020</td>
</tr>
</tbody>
</table>

LEVEL (minutes)
Shuttle Walking Test

<table>
<thead>
<tr>
<th>LEVEL (minutes)</th>
<th>Metres walked</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>70</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td></td>
</tr>
<tr>
<td>180</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td></td>
</tr>
<tr>
<td>330</td>
<td></td>
</tr>
<tr>
<td>420</td>
<td></td>
</tr>
<tr>
<td>520</td>
<td></td>
</tr>
<tr>
<td>630</td>
<td></td>
</tr>
<tr>
<td>750</td>
<td></td>
</tr>
<tr>
<td>880</td>
<td></td>
</tr>
<tr>
<td>1020</td>
<td></td>
</tr>
</tbody>
</table>
Shuttle Walking Test

Metres walked

LEVEL (minutes)
Shuttle Walking Test

LEVEL (minutes)

30 Metres walked

70

120

180

250

330

420

520

630

750

880

1020
Shuttle Walking Test

Metres walked

LEVEL (minutes)
# Shuttle Walking Test

<table>
<thead>
<tr>
<th>Level (minutes)</th>
<th>Metres walked</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>180</td>
</tr>
<tr>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td>6</td>
<td>330</td>
</tr>
<tr>
<td>7</td>
<td>420</td>
</tr>
<tr>
<td>8</td>
<td>520</td>
</tr>
<tr>
<td>9</td>
<td>630</td>
</tr>
<tr>
<td>10</td>
<td>750</td>
</tr>
<tr>
<td>11</td>
<td>880</td>
</tr>
<tr>
<td>12</td>
<td>1020</td>
</tr>
</tbody>
</table>

LEVEL (minutes)
Shuttle Walking Test

Metres walked

LEVEL (minutes)
Shuttle Walking Test

LEVEL (minutes)

1. 30 Metres walked
2. 70
3. 120
4. 180
5. 250
6. 330
7. 420
8. 520
9. 630
10. 750
11. 880
12. 1020

LEVEL (minutes)
Shuttle Walking Test

<table>
<thead>
<tr>
<th>LEVEL (minutes)</th>
<th>Metres walked</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>70</td>
</tr>
<tr>
<td>3</td>
<td>120</td>
</tr>
<tr>
<td>4</td>
<td>180</td>
</tr>
<tr>
<td>5</td>
<td>250</td>
</tr>
<tr>
<td>6</td>
<td>330</td>
</tr>
<tr>
<td>7</td>
<td>420</td>
</tr>
<tr>
<td>8</td>
<td>520</td>
</tr>
<tr>
<td>9</td>
<td>630</td>
</tr>
<tr>
<td>10</td>
<td>750</td>
</tr>
<tr>
<td>11</td>
<td>880</td>
</tr>
<tr>
<td>12</td>
<td>1020</td>
</tr>
</tbody>
</table>
Shuttle Walking Test

Metres walked

LEVEL (minutes)
Shuttle Walking Test

1  Metres walked
2  70
3  120
4  180
5  250
6  330
7  420
8  520
9  630
10 750
11 880
12 1020

LEVEL (minutes)
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• The purpose of this study was to evaluate

3 questionnaires:

  • Oswestry Disability Index
  • Zurich
  • Oxford

and the

  • Shuttle Walking Test
Test populations

- 17 controls
- 59 miscellaneous SS patients
- 29 SS patients examined 1 week apart
- 17 patients pre- and 13-21 (mean 18) months post-surgery
Shuttle Walking Test - 17 controls (mean age 64yrs)

Metres walked

1 2 3 4 5 6 7 8 9 10 11 12

LEVEL (minutes)

1 2 3 4 5 6 7 8 9 10 11 12

30 70 120 180 250 330 420 520 630 750 880 1020

**482 metres** = mean normal walking distance

Range = 210 metres - 920 metres
Shuttle Walking Test - 61 neurogenic claudication patients

Metres walked

1. 130 metres = mean normal walking distance
2. Range = 0 metres - 620 metres
Shuttle Walking Test - 17 pre-op patients

Metres walked

1 2 3 4 5 6 7 8 9 10 11 12

30 70 120 180 250 330 420 520 630 750 880 1020

LEVEL (minutes)

65 metres = mean normal walking distance
SD = 52 metres
Shuttle Walking Test - 17 post-op patients

Metres walked

1 2 3 4 5 6 7 8 9 10 11 12

30 70 120 180 250 330 420 520 630 750 880 1020

202 metres = mean normal walking distance
SD = 85 metres

LEVEL (minutes)
Shuttle Walking Test - 17 post-op patients

202 metres = mean normal walking distance

482 metres = mean normal walking distance
Mean + SD of pre- (●) and post- (○) operation (n=17)
Mean + SD of pre- (●) and post- (○) operation (n=17)
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Conclusions
  – No absolute measure of outcome
  – All 3 questionnaires correlated well with Shuttle Walking
  – After surgical treatment
  – None show evidence of a large change
  – None approach "normality"
OUTCOME MEASURES FOR NEUROGENIC CLAUDICATION

• Conclusions (Continued)
  – Quite large changes are needed to detect significant improvement
  – Scores were consistent with the clinical severity and the surgical outcome
  – Further work is needed to identify the optimum outcome measure in this group of patients
  – We could not reject any measure as unreliable

The tape of the shuttle test can be obtained from: Pulmonary Rehab Co-ordinator, Respiratory Medicine, The Glenfield Hospital, Groby Road, Leicester LE3 9QP, UK (Phone +44 116 287 1471 ext 3181)
Conclusions

• Does not look as though there is much gain from special investigations/imaging beyond standard MR
• Treatment of this condition does not usually restore lost youth
• That it is more likely to reduce but not cure symptoms
Surgical versus Nonsurgical Treatment for Lumbar Degenerative Spondylolisthesis


METHODS

• Surgical candidates from 13 centers in 11 U.S. states
  – >12 weeks of symptoms
  – degenerative spondylolisthesis

• Either randomized cohort or an observational cohort.

TREATMENT

– standard decompressive laminectomy (with or without fusion)
  or
– usual nonsurgical care

• **Primary outcome measures**
  – (SF-36) bodily pain and physical function scores
  – Oswestry Disability Index

• Follow-up 6 weeks, 3 months, 6 months, 1 year, and 2 years.
Surgical versus Nonsurgical Treatment for Lumbar Degenerative Spondylolisthesis


• Randomized cohort 304
• Observational cohort 303
  — 1 year crossover rates
    • Randomized cohort
      » ~40% in each direction
    • Observational cohort
      » 17% crossover to surgery
      » 3% crossover to nonsurgical care

• The intention-to-treat analysis for the randomized cohort showed no statistically significant effects for the primary outcomes.

• The as-treated analysis for both cohorts combined showed a significant advantage for surgery at 3 months that increased at 1 year and diminished only slightly at 2 years.

• The treatment effects at 2 years were
  — 18.1 for bodily pain (95% CI, 14.5 to 21.7)
  — 18.3 for physical function (95% CI, 14.6 to 21.9)
  — −16.7 for the ODI(95% CI, −19.5 to −13.9)