Aetiology and Natural history of Degenerative spondylolisthesis and scoliosis

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Degenerative spondylolisthesis

Spondylolisthesis with an intact neural arch

Junghanns H. Arch Orthop Unfallchir 1931
McNab I. JBJS Br, 1950
Newman PH. JBJS Br, 1963
The typical scenario

- > 50 years
- 6 x commoner in females
- 6 – 9 x commoner at L_{45} level

Rosenburg JBJS Am 1975
CORR 1976
Iguchi
J Spinal Disord Tech 2002

$n = 3,259$

- Incidence: 8.7%
- 1 level: 66%
- 2+ levels: 34%
Anterolisthesis:  
Posterior joint disease

Retrolisthesis:  
Disc disease
Iguchi
J Spinal Disord Tech 2002

1 level

- Anterolisthesis 70%; L45; F>M
- Retrolisthesis 30%; L23; M=F
Iguchi
J Spinal Disord Tech 2002

2+ level

- Anterolisthesis $L_{34, 45}$ F>M
- Retrolisthesis $L_{23}$ M>F
Possible aetiologies

Mechanical effects
- Facet orientation
- Disc degeneration
- Osteoporosis
- Lordosis
- Muscular

Systemic effects
- Generalised laxity
- Diabetes
- Oophrectomy
- Pregnancy
- Menopause
Facet and disc orientation

Facet orientation provides an effective restraint to the lumbo-sacral shear forces
Facet and disc orientation

L5 protected within the pelvic brim
L4 exposed to the shear forces
Sagittal orientation of the facet joints

Grobler Spine 1993
Boden JBJS Am 1996

Flatter sagittal facets allow for more anterior movement
Assessment of the role played by lumbar facet morphology

Grobler Spine 1993

- Digitised CT scans
- DS (26; mean age 70y; 20 F)
- Normal (15; mean age 41.3y; 10 F)
- SS (23; mean age 63.8y 7 F)
Assessment of the role played by lumbar facet morphology

Grobler Spine 1993

- L45 more sagittal facet orientation in DS compared with SS ($p < 0.01$)

- ↓ coronal dimension; ↓ area of transfer of anterior forces
Orientation of the lumbar facet joints

Boden JBJS Am 1996

- 140 subjects
- MRI studies (including 67 asymptomatic volunteers)

Facet angles:

<table>
<thead>
<tr>
<th>Asymptomatic D Spond</th>
<th>41 °</th>
<th>60 °</th>
<th>p = 0.00001</th>
</tr>
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</table>

- > 45 ° 25x chance of degen spondylolisthesis
Arthritic re-modelling theory

Love JBJS Br 1999

- Higher facet angles are due to anterior wear of the facets
- Greatest resistance to flexion is anteromedial part of facet
Arthritic re-modelling theory

Love JBJS Br 1999

- Inferior facet of L4 wears forwards
- Deforms anterior part of superior facet of L5
- Deepening of the joint by the trailing posterior edges
The orientation of the facet joints and transverse articular dimension in degenerative spondylolisthesis

Tassanawipas J Med Ass Thai Nov 2005

- MRI at L45 of 20 DS + 20 controls
- Facets > 43° (p < 0.05) in DS
Hemi-sacralised L5

- Relative immobility of the level below
- \(\uparrow\) stresses at L45
- 4x incidence of degenerative spondylolisthesis
  
  Rosenberg CORR 1976
  

Bertolotti syndrome: Chronic low back pain and asymmetrical transitional vertebra
Other factors (confounding variables!)

- Generalised laxity (65% DS; 8% controls)
  Rosenberg JBJS Am 1975

- Oophorectomy
  Imada JBJS Br 1995

- Diabetes (neuropathy; collagen X link weak)
  Frymoyer J Am Acad Orthp Surg 1994
Systemic hormonal theory

- Cartilage is a sex hormone sensitive tissue
  Rosner CORR 1986

- Oestrogen is chondrodestructive (receptor-mediated)
  Tsai Life Sci 1992
Expression of estrogen receptors in facet joints in degenerative spondylolisthesis

Ha Spine 2005

Immunohistochemical staining for estrogen receptors

Estrogen v histologic – histochemical score

\[ r = 0.78 \quad p < 0.05 \]

Fissuring in the cartilage layers
Expression of estrogen receptors in facet joints in degenerative spondylolisthesis

Ha Spine 2005

- Increased expression of the estrogen receptor correlated with facet arthritis
- Cartilage lesions higher grades in DS than SS
Influence of pregnancy on the development of degenerative spondylolisthesis

Sanderson, Fraser JBJS Br 1996

Study group:

- 949 F
- 120 M
- > 50 yrs
- Back pain > 5 yrs
Influence of pregnancy on the development of degenerative spondylolisthesis

Sanderson, Fraser JBJS Br 1996

Parous 28%
Nulliparous 16.7%
Men 7.5%

p = 0.031
p = 0.043
Influence of pregnancy on the development of degenerative spondylolisthesis

Sanderson, Fraser JBJS Br 1996

Number of pregnancies:

- Trend only (p = 0.08)

- Relaxin; flexion moment; abdominal muscles
Pathology of ligamentum flavum in degenerative lumbar disease

Okuda Spine 2004

- n = 50
- Flavum harvested en-bloc and analysed
- Clinical & imaging correlation of pathology
Pathology of ligamentum flavum in degenerative spondylolisthesis

Okuda Spine 2004

- Ossification commonly seen in higher degrees of slip
- Chondroid cells

![Image of pathology and data chart showing difference between non-ossification and ossification]
Degenerative displacement of the lumbar vertebra: A 25 year follow up study in Framingham

Kaupilla Spine 1998

- 2824 (1967 – 1968)
- 617 followed up (1992 – 1993)

- Age: 54 → 79 yrs

- Incidence: 19.7%

- 68.3%: Anterior (average slip 18%)
- 31.7%: Posterior (average slip 15%)
Effect of the slip on the canal

- Lateral recess: 2 lower facets of the upper level (with osteophytes)

- Central canal: Neural arch of upper level and poster-superior corner of the lower
Symptom patterns

- Mechanical back pain
- Radicular pain
- Neurogenic claudication
Symptom patterns: Mechanical back pain

- Posture & activities
- Referred: buttock & back of thigh
- Origin: Discogenic, Facets
- Cause: Abnormal loads through the end plate

Instability: Abnormal ‘neutral zone’ motion
Symptom patterns: radicular pain

- Nerve distribution: numbness; paresthesia; deficit; weakness

- Root in lateral recess / foramen:
  - Compression
  - Traction
  - Inflammation

L45:
- L5 in lateral recess
- L4 in foramen
Symptom patterns: Neurogenic claudication

- Stenosis: Slip + Flavum + Osteophytes
- Pain; paresthesia; weakness
- Shopping cart sign
- Differentiate from vascular claudication

Blood vessels compressed: ↑ epidural pressure
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

- 145 patients not operated (35 offered but refused)
- Minimum 10 year follow up
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

Progression:
- 34% progressed (final position of slip 15.6%)
- Angular displacement reduced over time

[Graph showing angular displacement over follow-up periods]
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

Progression:
Reduced initial disc height……less likely to progress

66 / M 13.6yr FU No change
61 / M 7.5yr FU 12 – 24 %
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

Symptoms:

- 77% Back pain improved
- 86% leg pain improved (recurred in 37%)
- 90% with ↓ disc space initially showed improvement in back pain

Restabilisation phase

Kirkaldy-Willis CORR 1982
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

**Neurology:**
- If no deficit at start ............ No deficit at 10 yrs
- 83% of those with deficits (refused op) ....progressed
- Increased deficit did not correlate with the progression
Non surgically managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

“A better clinical definition of instability is required to determine the indications for spinal fusion”

Conservative treatment: Back ± leg pain; no deficit
Direction of the slip!

- Degenerative changes unlock the facets joints

- Direction depends on:
  - Symmetry of the facets
  - Loads transmitted during this period

- Symmetrical: Sagittal translation (no rotation)

- Asymmetrical: AP + Rotatory displacement

- Lateral displacement: Rotation + scoliosis
Degenerative scoliosis

Rapid asymmetric degeneration of lumbar inter-vertebral discs, facet joints and osteoporosis
The adult scoliosis

1. ‘De Novo’

2. Previously untreated AIS

3. Secondary adult curves
   a. Oblique pelvis
   b. Metabolic diseases
Adult degenerative (de novo) scoliosis

> 60 yrs:

- Improved life expectancy
- Active senior lifestyle

- 4.4% 5th decade
- 8.6% 6th decade
- ↑↑↑ after 6th decade
Adult (degenerative; de novo) scoliosis

Tri-axial deformity:

- Axial rotation on the vertical axis
- Lateral translation towards the convexity
- Anterior translation in the sagittal axis

Short curves: T11, 12 → L5, S1
Cobb < 30°
Lateral translation

- Commonest at L3-4
- \( \uparrow \) age
- \( \uparrow \) curve magnitude
- Correlates with back and leg pain

Aka: lateral spondylolisthesis; translatory shift; lateral olisthesis; lateral subluxation
Incidence of adult scoliosis

- 2.9%  
  5000 IVP's  
  Kostuik Spine 1981

- 7.5%  
  2% < 45y ...... 15% < 60y  
  Perennou Spine 1994

- 15%  
  3600 persons (electoral lists)  
  Robin Spine 1982

- 68%  
  75 elderly volunteers (70.5 y)  
  Schwab Spine 2005

- 9.47%  
  osteoporotic population  
  Pappou Spine 2006
Progression of adult scoliosis

- 2.3 ° / yr (1 – 4.8°/yr)
  Gillespy 3rd Skel Radiol 1985

- 3° / yr (200 pts; 73% progressed over 5 years)
  Pritchett Spine 1993

Progression α Age

\[ y = 4.17 + 0.27x \]
\[ r = 0.30 \]
\[ p = 0.036 \]
Changes in curvature and lordotic angle in early phases of degeneration

Murata Spine 2002

- Longitudinal radiographic measure
- 243 pts with back pain (1985 – 89)
- 47 > 10°; 10.4 yr follow up
Changes in curvature and lordotic angle in early phases of degeneration

Murata Spine 2002

- Triggered by lumbar discs at any level
- Loss of lordosis and wedging at the same level
Changes in curvature and lordotic angle in early phases of degeneration

Murata Spine 2002

Progress
- 51 yrs
- 59 yrs
- 64 yrs

Regress
- 48 yrs
- 51 yrs
- 54 yrs
Lateral rotatory olisthesis v neural canal dimensions

Ploumis Spine 2006

- Radiographic review
- 87 patients
- Mean age 69 yrs
Lateral rotatoryolisthesis v neural canal dimensions
Ploumis Spine 2006

- Lateral translation positively correlated with rotation

- ↓ central canal dimensions do not correlate with degree of rotatory olisthesis

- Foraminal area enlarged on the convexity but does not ↓ on the concavity
The adult scoliosis
Aebi ESJ 2005

Asymmetric load + Degeneration

Pain syndromes: Axial; radicular; stenosis

Rarely neurology  Never cosmesis
Clinical picture


Back pain
Buttock pain
Leg pain

5%
48%
43%
5%

AO Spine Forum
Associated canal stenosis

- 75% symptoms of spinal stenosis
- 33% did not have relief with sitting
- 48% stood forward flexed
- No root tension signs

Axial pain

Apical lumbar

L5S1
Incidence of low back pain in adult scoliosis

- Back pain 59% (≈ general population)
  Kostuik Spine 1981

- 86% Back pain (34% with rotatory olisthesis)
  Perennou Spine 1994
Characteristics of nerve root compression caused by stenosis with scoliosis

Liu J Spine 2003

- 22 pts
- Clinical + Imaging + Root blocks

L3 or L4: Foraminal or extra-foraminal on concave
Larger Cobb; translations
L5 or S1: Lateral recess on convex side
Risk factors for evolution of degenerative scoliosis

Sapkas Bull Hosp Jt Dis 1996

1. Curves > 30°

2. Grade II – III rotation

3. Secondary L4 – S1 compensatory curve

4. Apex at L23 or L34

5. Crestal line through L5

6. Translation > 6mm
Structural curves with osteoporosis

Healey  CORR 1985

- 50 pts
- Age: 69 ± 5 yr
- 47 / 50 pts with 140 # (within the curve)

Adult scoliosis is a clinical marker for osteoporosis
Discordant high BMD values

Pappou Spine 2006

- Hip BMD more reflective than lumbar spine
  Thevenon Spine 1987

- Lumbar scoliosis is a marker for osteoporosis
Prospective study of de-novo scoliosis in a community based cohort

Predictors (logistic regression):

- 20% baseline disc index
- > 5mm lateral osteophyte difference
Adult scoliosis: SF-36 and nutritional factors in elderly volunteer population

Schwab Spine 2005

75 subjects; 70.5 y; no spinal history

Mean Cobb 17°

No difference on SF 36 (Cobb > 20°)

No correlations with VAS, lymphocytes, albumin and transferrin.
Degenerative deformity pathway

- Disc degeneration
- Disc space narrowing
- Instability
  - Coronal imbalance
    - Degenerative scoliosis
  - Sagittal imbalance
    - Degenerative spondylolisthesis