Aetiology and Natural history of Degenerative spondylolisthesis and scoliosis

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AO Spine Forum
22 – 23 November 2006, London

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%

Iguchi

J Spinal Disord Tech 2002

Anterolisthesis:

Posterior joint disease

Retrolisthesis:

Disc disease

Iguchi

J Spinal Disord Tech 2002

1 level

- Anterolisthesis 70%; L_{45}; F>M
- Retrolisthesis 30%; L_{23}; M=F

Iguchi

J Spinal Disord Tech 2002

2+ level

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

Possible aetiologies…….

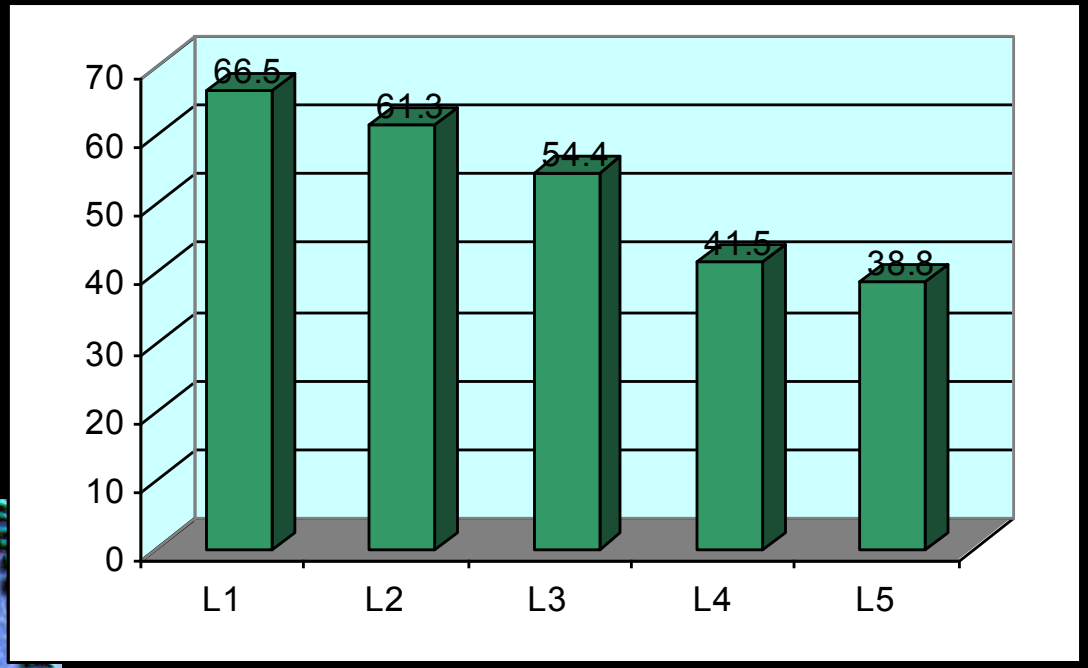
Mechanical effects

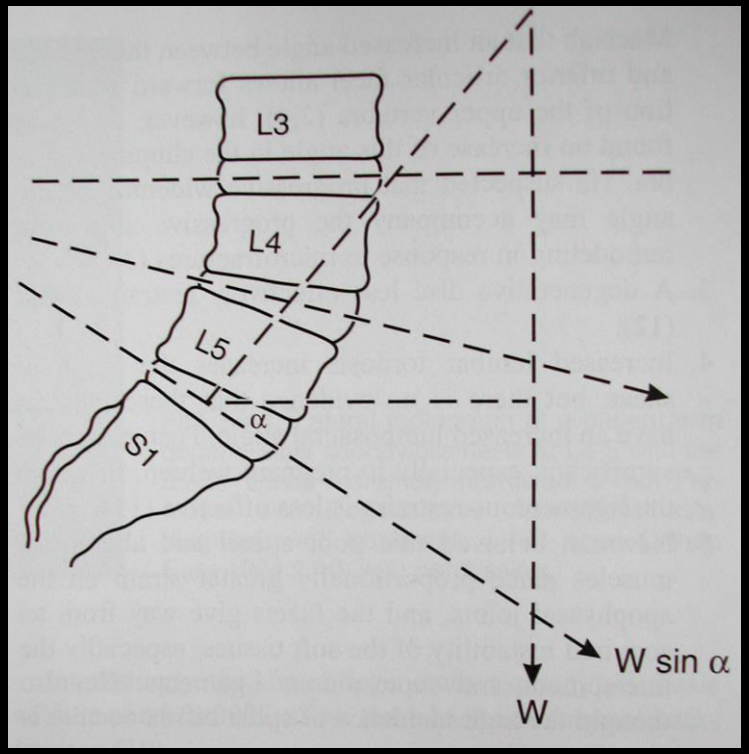
- Facet orientation
- Disc degeneration
- Osteoporosis
- Lordosis
- Muscular

Systemic effects

- Generalised laxity
- Diabetes
- Oophrectomy
- Pregnancy
- Menopause

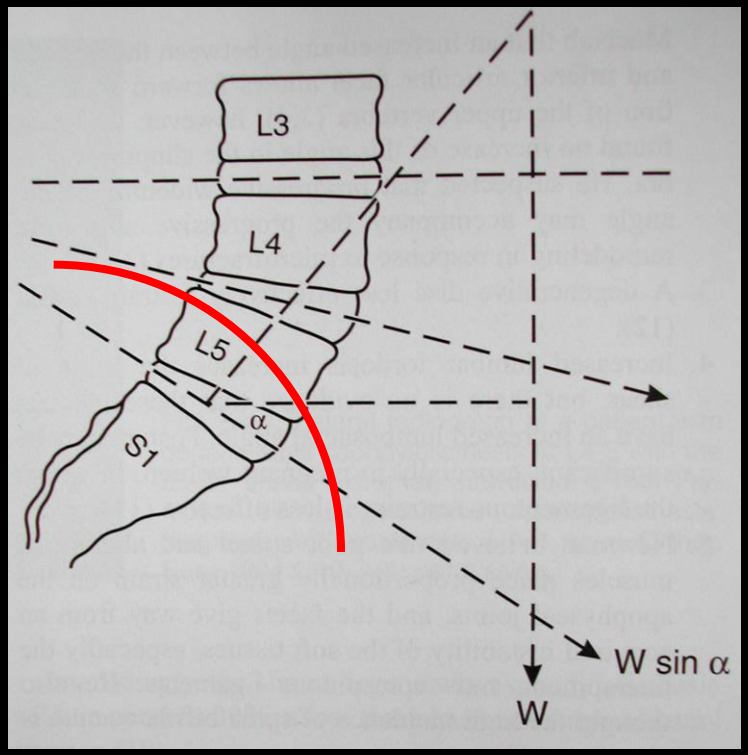
Facet and disc orientation





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

Facet and disc orientation

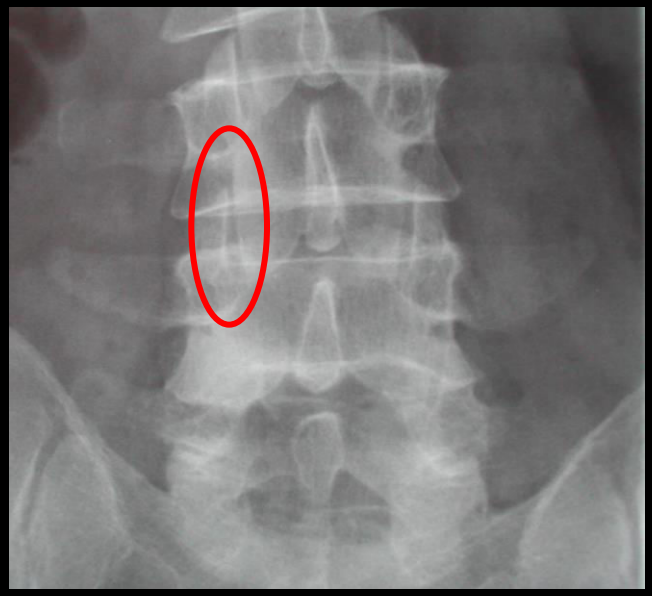


L5 protected within the pelvic brim

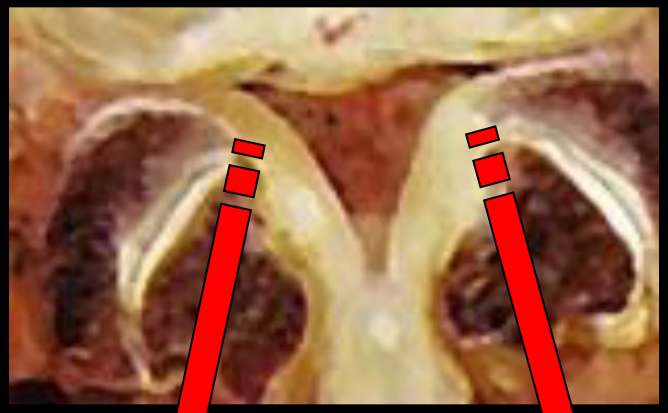
L4 exposed to the shear forces

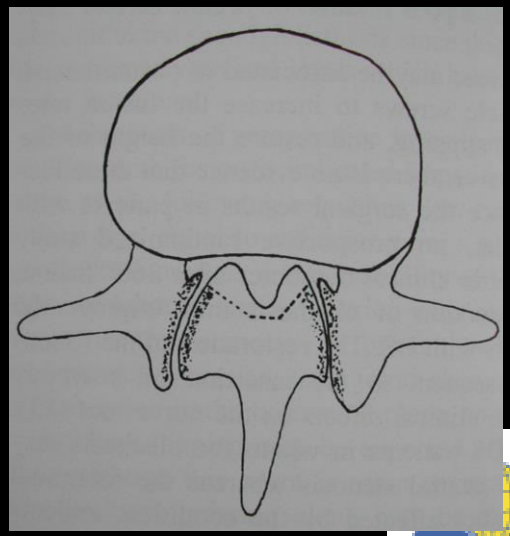
Sagittal orientation of the facet joints

Grobler Spine 1993
Boden JBJS Am 1996



Flatter sagittal facets allow for more anterior movement

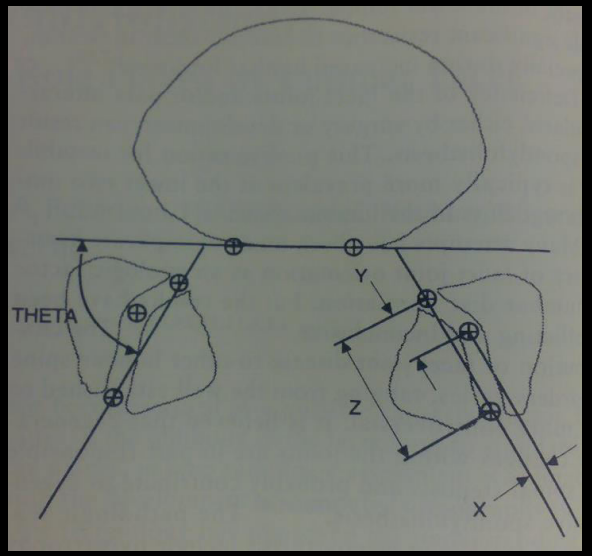


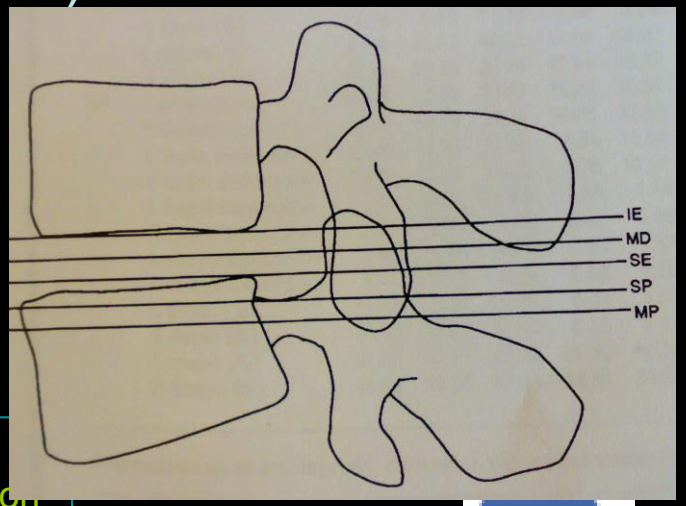


Assessment of the role played by lumbar facet morphology

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)

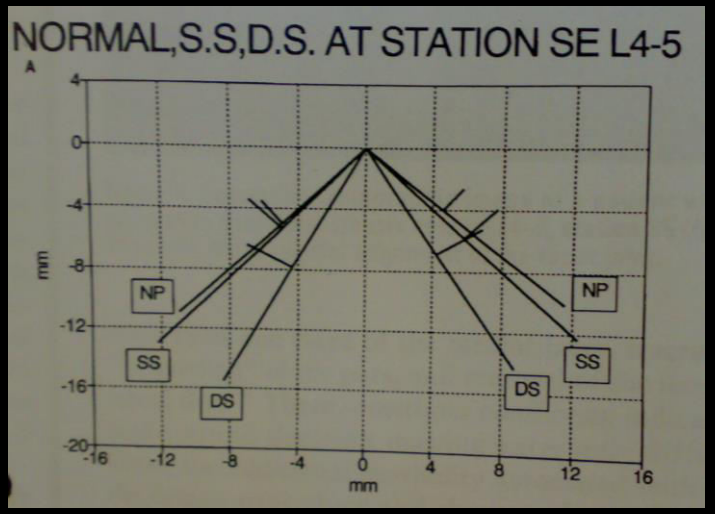




Assessment of the role played by lumbar facet morphology

Grobler Spine 1993

- L45 more sagittal facet orientation in DS compared with SS ($p < 0.01$)
- ↓ coronal dimension; ↓ area of transfer of anterior forces



Stenosis

Normal

D 'listhesis

Orientation of the lumbar facet joints

Boden JBJS Am 1996

- 140 subjects
- MRI studies (including 67 asymtomatic volunteers)
- Facet angles:

Asymptomatic	D Spond	
41 °	60 °	p = 0.00001

- > 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

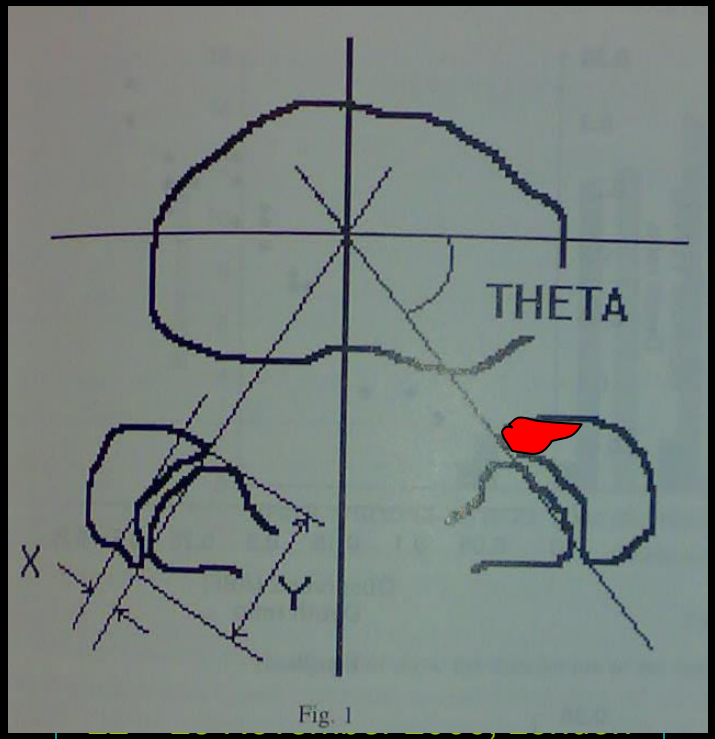


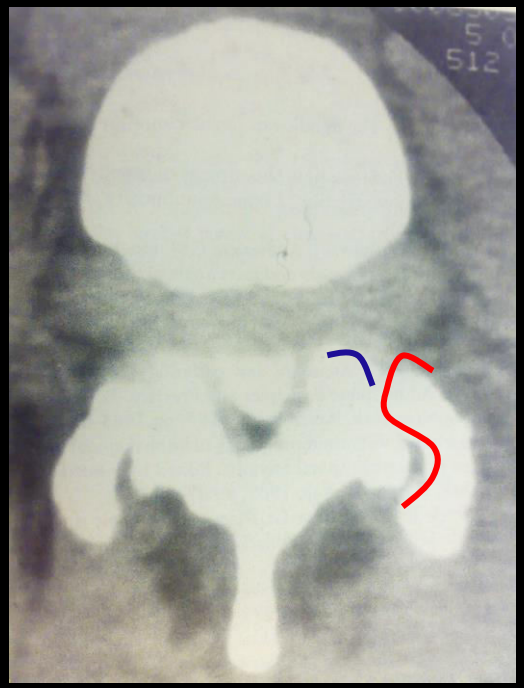
Fig. 1

The Journal of Bone & Joint Surgery (Br)
WWW.JBJS.ORG.UK

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

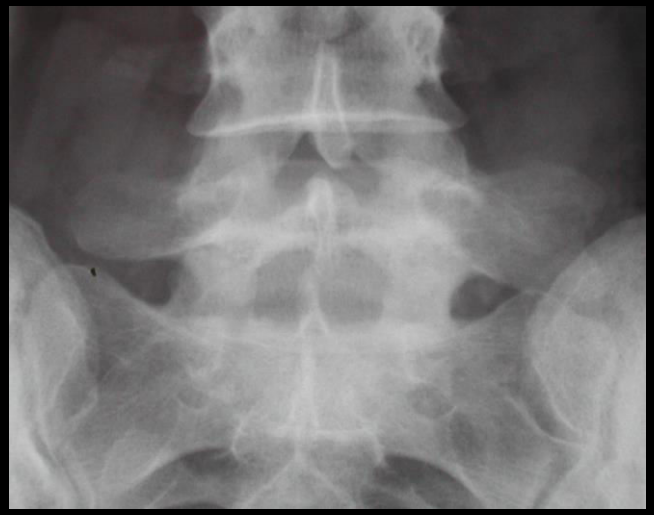


The orientation of the facet joints and transverse articular dimension in degenerative spondylolisthesis

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
- ↑ stresses at L45
- 4x incidence of degenerative spondylolisthesis

Rosenburg CORR 1976

Frymoyer JW. J Am Acad Orthop surg 1994

Bertolotti syndrome: Chronic low back pain and asymmetrical transitional vertebra

Other factors (confounding variables!)

- Generalised laxity (65% DS; 8% controls)

  Rosenburg 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

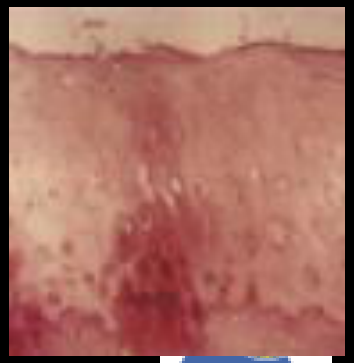
DS

Estrogen v histologic – histochemical score

r = 0.78 p < 0.05

SS

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%

p = 0.043

- ⊕ Men 7.5%

p = 0.031

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

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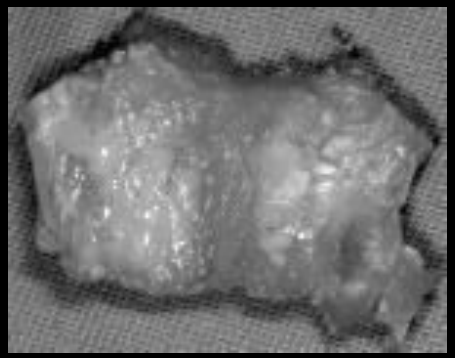
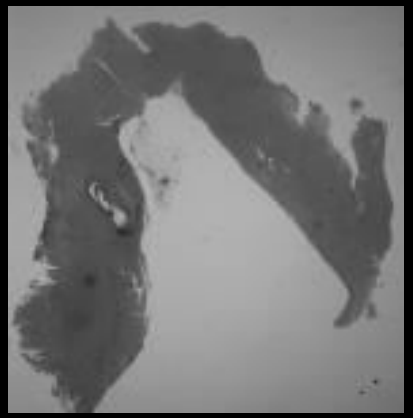
Pathology of ligamentum flavum in degenerative lumbar disease

Okuda Spine 2004

- n = 50
- Flavum harvested en-bloc and analysed
- Clinical & imaging correlation of pathology





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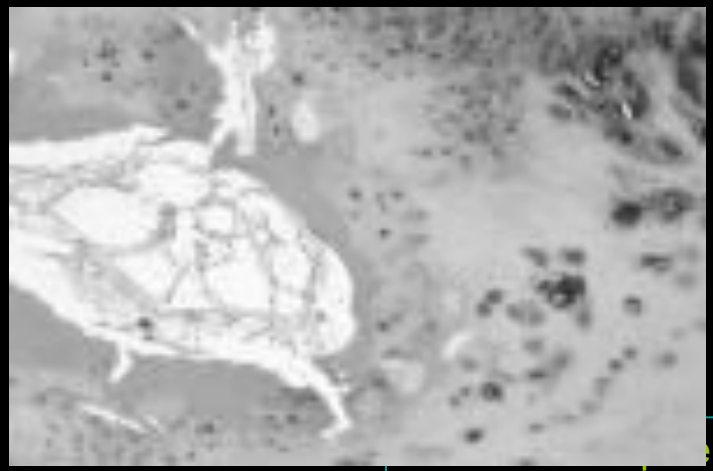
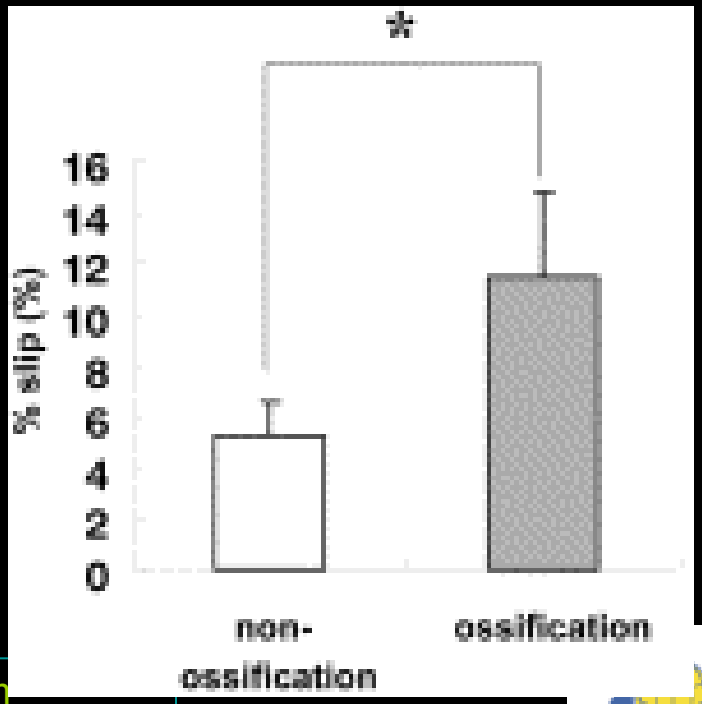
Pathology of ligamentum flavum in degenerative spondylolisthesis

Okuda Spine 2004

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





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)

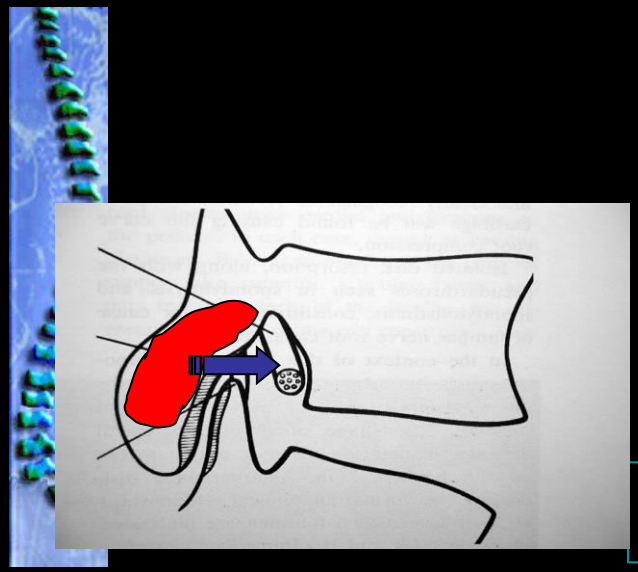
- Age: 54 → 79 yrs

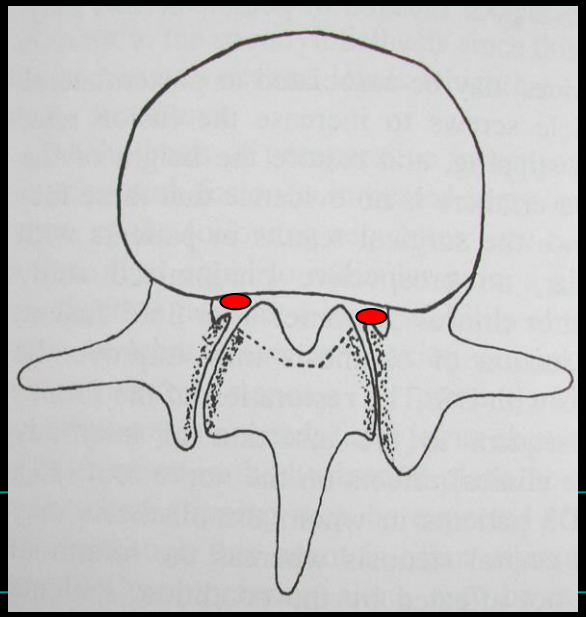
- Incidence: 19.7%

- 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





Supine

Erect

Sit flexion

Sit neutral

Sit extension

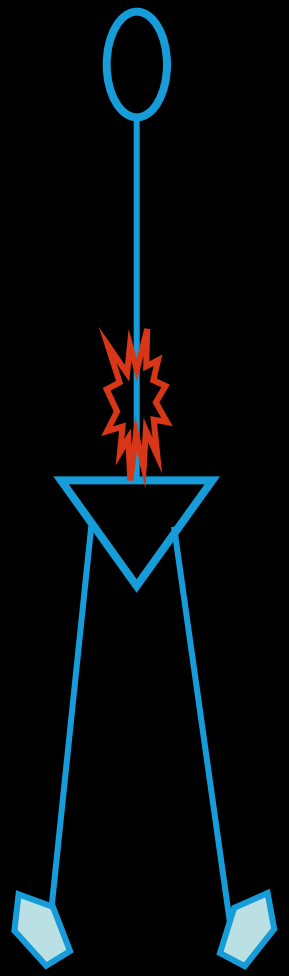
Symptom patterns

- 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 surgiclly managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

Matsunaga J Neurosurg (Spine 2) 2000

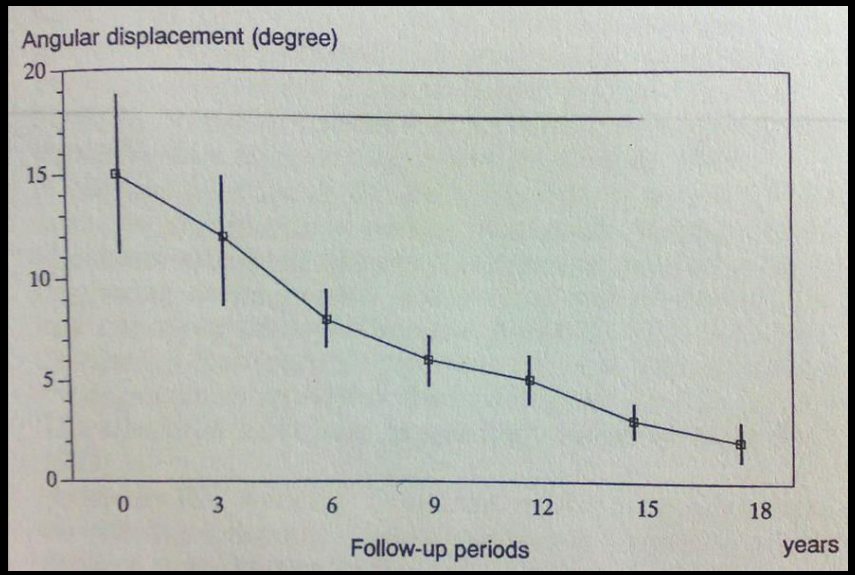
- 667 patients (Jan 1981 – Oct 1989)
- 145 patients not operated (35 offered but refused)
- Minimum 10 year follow up

Non surgiclly 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

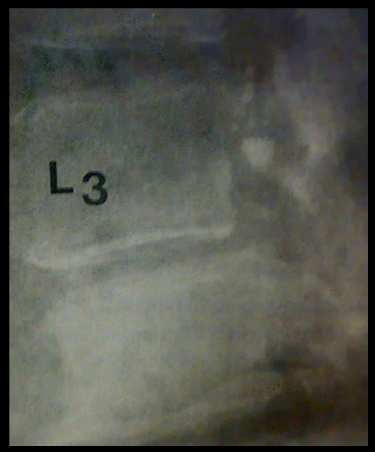


Non surgiclly managed patients with degenerative spondylolisthesis: 10 – 18 year follow-up study

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 surgiclly 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 surgiclly 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 surgiclly 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

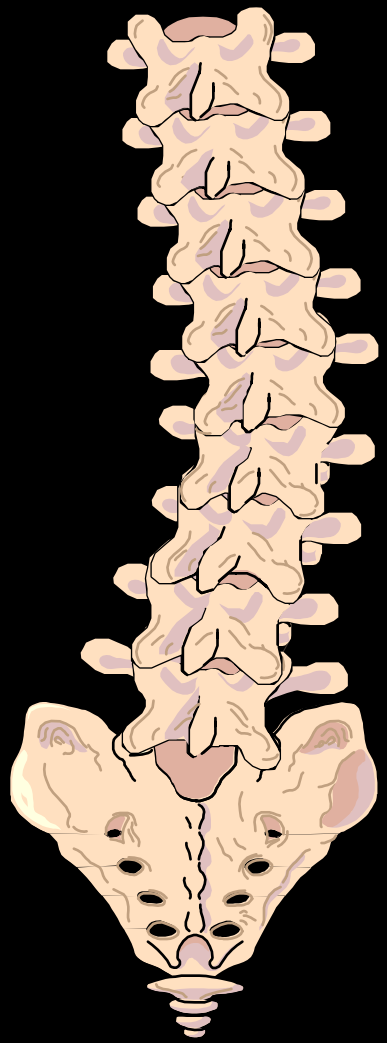
Degenerative scoliosis

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:

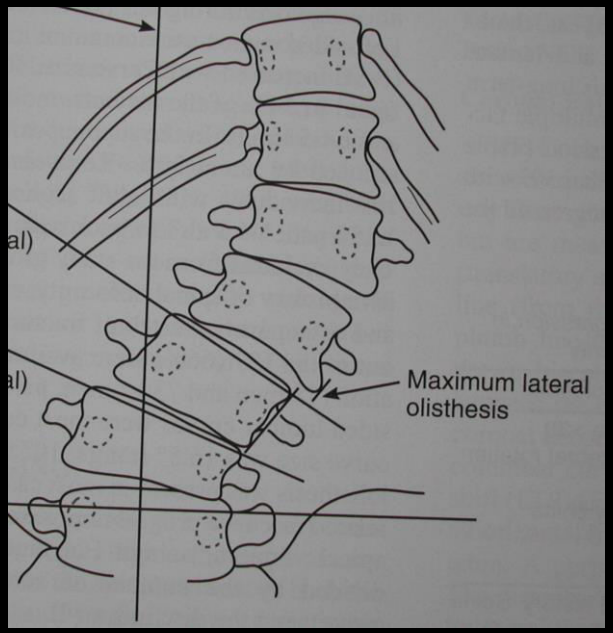
- ⊕ Axial rotation on the vertical axis
- ⊕ Lateral translation towards the convexity
- ⊕ Anterior translation in the sagittal axis

Short curves: T11, 12 → L5, S1

Cobb < 30°

Lateral translation

- Commonest at L34
- ↑ age
- ↑ 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

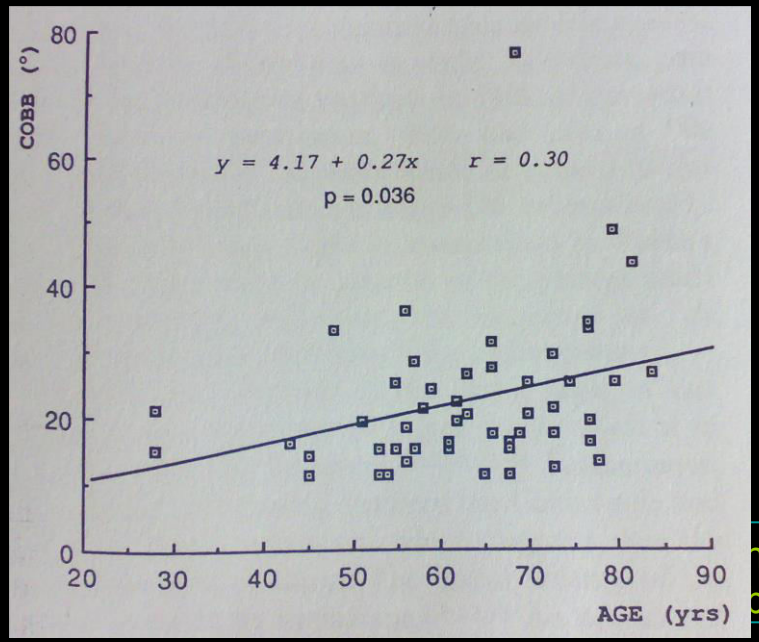
Progression of adult scoliosis

- 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

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

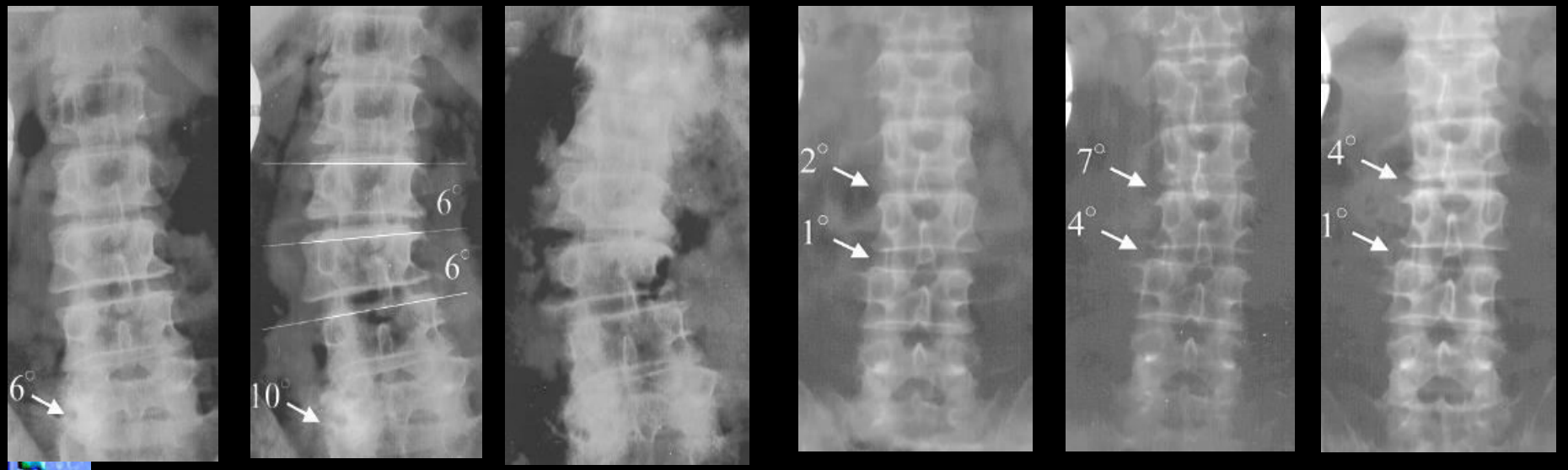
Changes in curvature and lordotic angle in early phases of degeneration

Murata Spine 2002

Progress

Regress

51 yrs 59 yrs 64 yrs 48 yrs 51 yrs 54 yrs



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Lateral rotatory olisthesis v neural canal dimensions

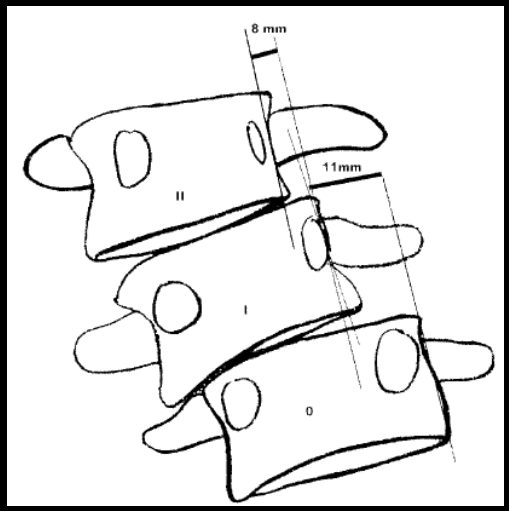
Ploumis Spine 2006

- Radiographic review
- 87 patients
- Mean age 69 yrs

Lateral rotatory olisthesis 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



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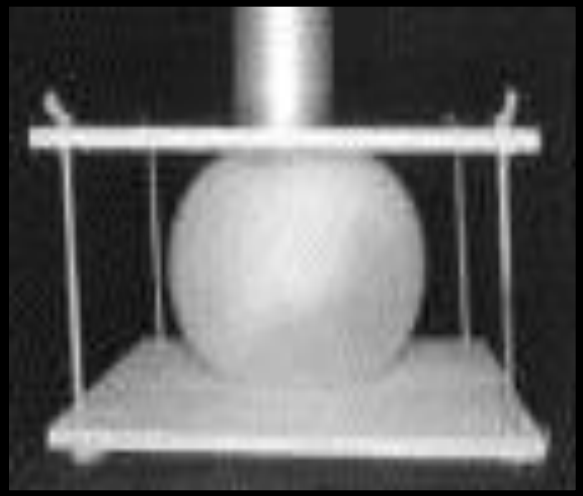
The adult scoliosis

Aebi ESJ 2005

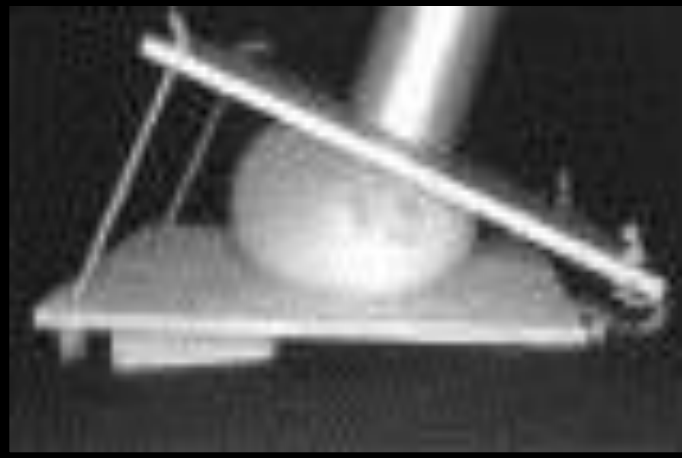


Asymmetric load

+

Degeneration

=



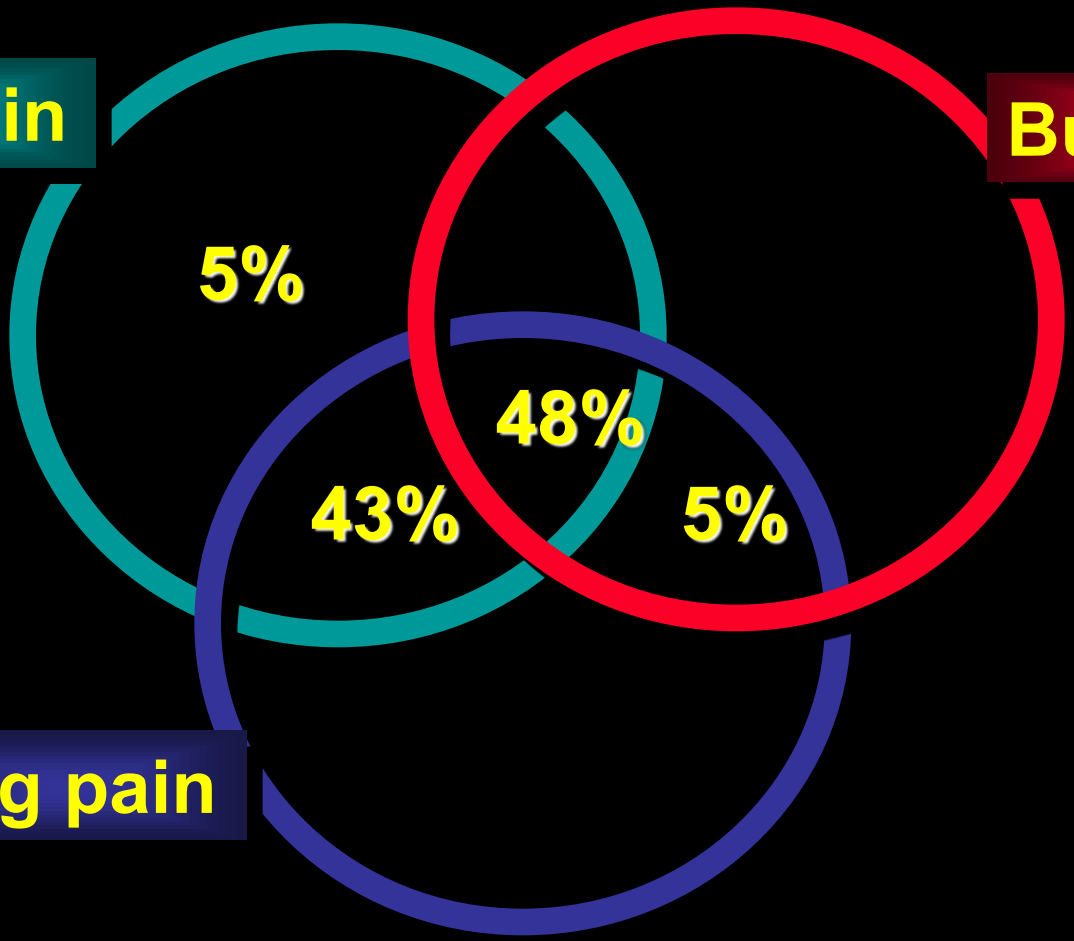
Pain syndromes: Axial; radicular; stenosis

Rarely neurology

Never cosmesis

Clinical picture

Grubb et al 1988 Spine 13:241

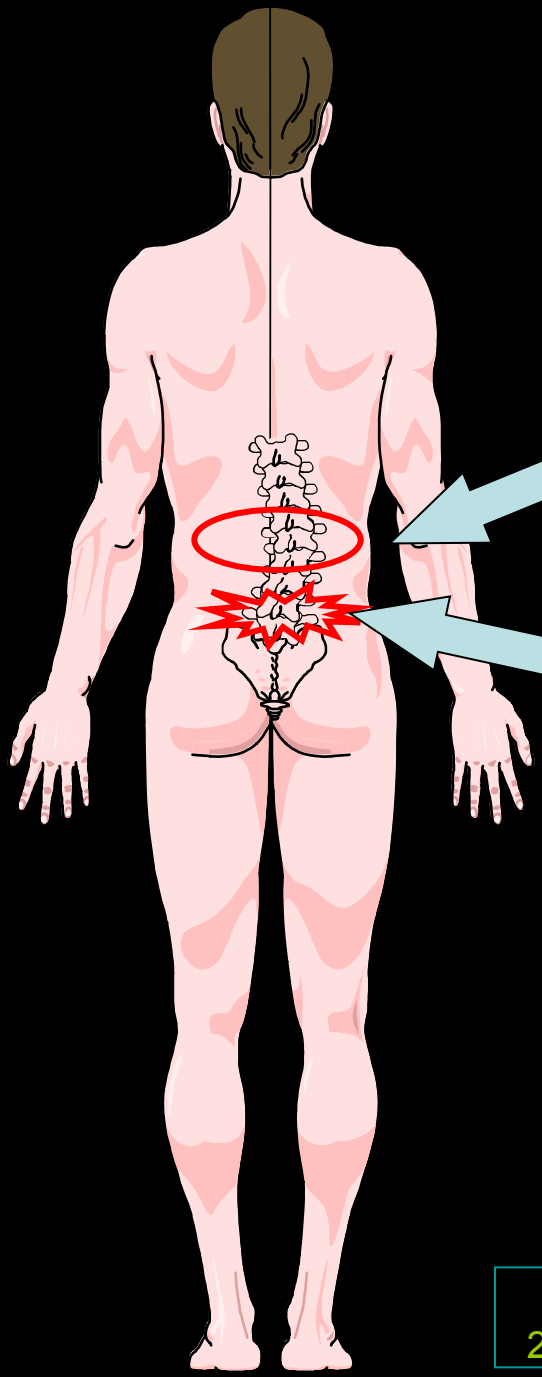


Associated canal stenosis

Grubb et al 1988 Spine 13:241

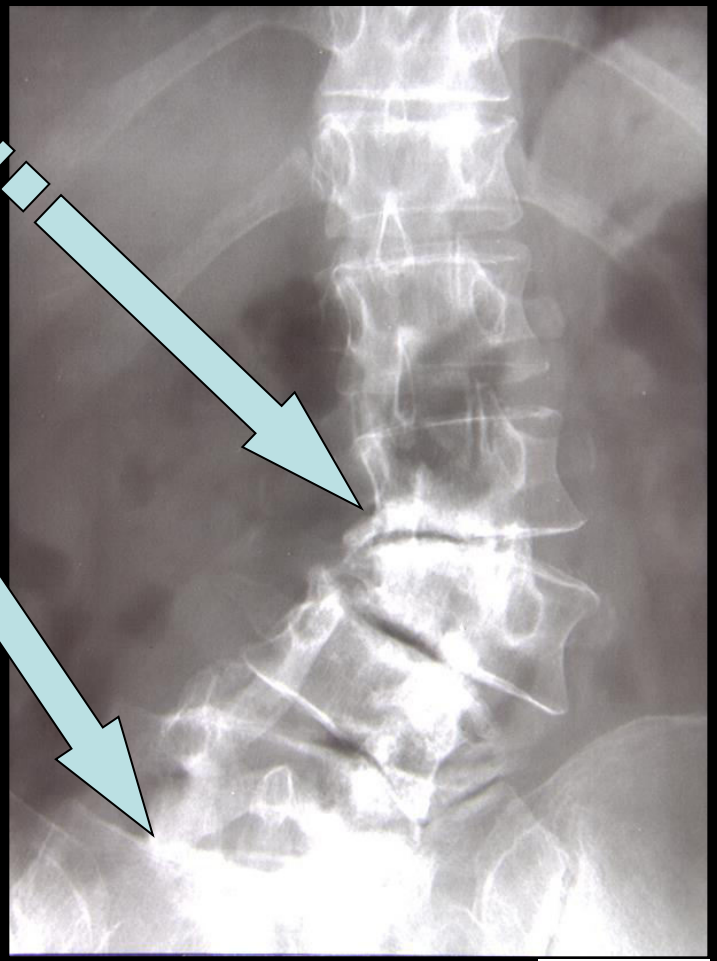
- 75% symptoms of spinal stenosis
- 33% did not have relief with sitting
- 48% stood forward flexed
- No root tension signs

Axial pain



Apical

L5S1



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Incidence of low back pain in adult scoliosis

- Back pain 59% (≈ general population)

  Kostuik Spine 1981

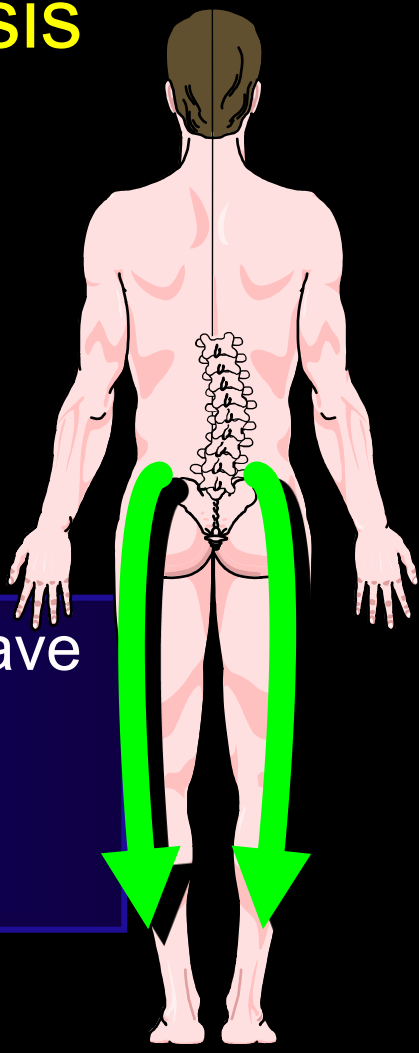
- 86% Back pain (34% with rotatory olisthesis)

  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

Spine An international journal for the study of the spine

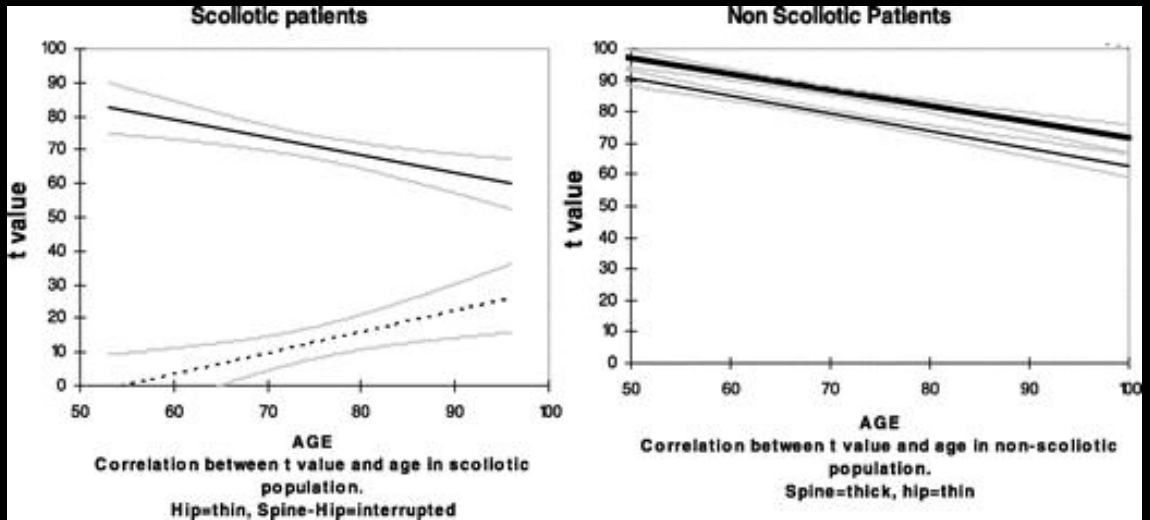
Discordant high BMD values

Pappou Spine 2006

- Hip BMD more reflective than lumbar spine

  Thevenon Spine 1987

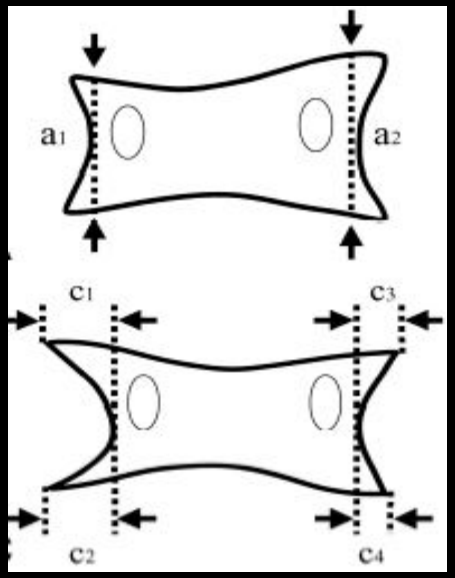
- Lumbar scoliosis is a marker for osteoporosis

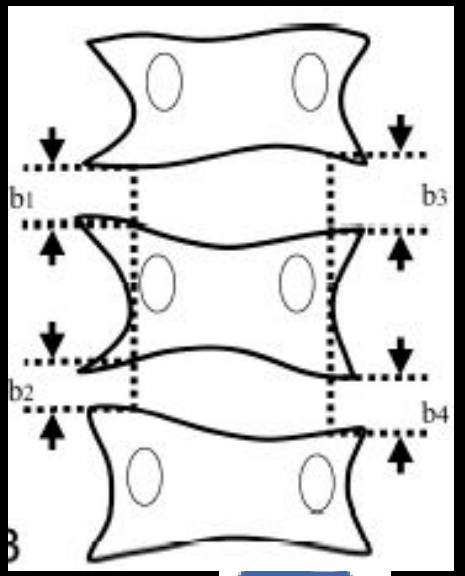


Prospective study of de-novo scoliosis in a community based cohort

Predictors (logistic regression):

- 20% baseline disc index
- > 5mm lateral osteophyte difference





London

Adult scoliosis: SF-36 and nutritional factors in elderly volunteer population

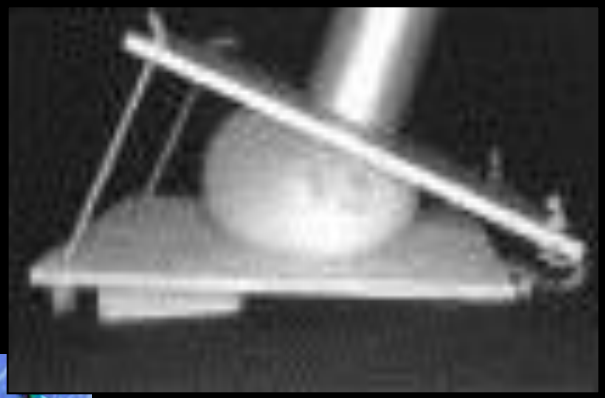
Schwab Spine 2005

- 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

Sagittal imbalance

Degenerative scoliosis

Degenerative spondylolisthesis