



ARABSPINE COURSE DIPLOMA

Module 1

Course Highlight Day-2

Lumbar Spine
Basic Science & Pathology

Lumbar Disc Herniation
and Sciatica

Lumbar Canal Stenosis (LCS)

Spondylolisthesis

Degenerative Spine Disease

Serious Spinal Conditions

DAY-2

(MODULE-1)

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Lumbar Canal Stenosis (LCS):

NATURAL HISTORY

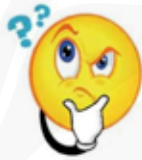
NATURAL HISTORY OF LUMBAR SPINAL STENOSIS (LSS)

LSS

- Common disease of the spine in geriatric population
- Increased
 - Population ageing
 - Accuracy of diagnostic methods
- The number of detected cases of LSS have increased

LSS

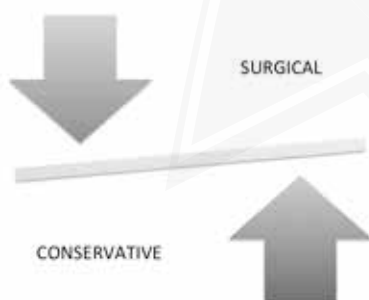
- LSS is one of the most common reasons to perform spinal surgery in elderly
- SURGERY
 - ✓ Usual complications
 - ✓ Rate of success ranges from 57-95%
 - Turner JA, Spine, 1992
 - Thome C, J Neurosurgery, 2005
 - ✓ Rate of revision surgery 6.5-27%
 - Javid MJ, J Neurosurg, 1998
 - Martin BI, Spine, 2007
 - Jansson K, Eur Spine J, 2005
 - Caputy AJ, J Neurosurg, 1992
 - ✓ The outcome of revision surgery is less than index surgery



- 20% of asymptomatic individuals over 60 y/o have LCS on imaging
(Boden, J of Bone and Joint Surgery, 1990)
- No direct relationship between the extent of the stenosis and clinical Sx
Herno A, Spine, 1994, 1999
- This fact remains unexplained

- Most of the elderly population exhibit radiological findings of spine degeneration on spine imaging
- 80% of subjects aged over 70 years has stenotic findings on MRI
— Sasaki K 1995, Eur Spine J 4:71–76

- **knowledge of the natural history of LSS is crucial.**



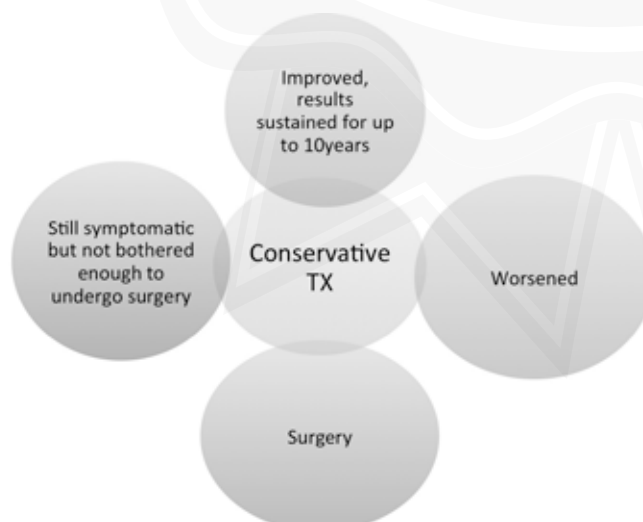
ANECDOTAL REPORTS

- no scientific value but indicate that some patients do not deteriorate with time and are able to tolerate their disability without surgical decompression.

STUDIES

- No well conducted studies
 - ✓ Not randomized, retrospective, no clear or various inclusion criteria
 - ✓ Small number of patients precluding definite conclusions
- Follow-up between 3 to 10 years

NO DEFINITE CONCLUSIONS OR GUIDELINES TO RECOMMEND SURGICAL VS CONSERVATIVE TX



FACTS

- Overall results of surgery are better than those of medical treatment.
- Faster resolution of pain
- Increased chance to improve an eventual neurological deficit
- Earlier return to work and lower costs for society

OUTCOME AFTER LCS SURGERY

- LITERATURE SURVEY
- ✓ Success rate after initial decompression 80-85% (90%)
- ✓ The results after surgical decompression deteriorates with time
- ✓ Further degenerative changes and bone re-growth carries a risk of restenosis
- ✓ Success rate of redo surgery 50%

PREDICTOR FACTORS FOR WORSENING AND NEED FOR SURGERY

- Severe stenosis / complete block
- Multilevel stenosis
- Scoliosis
- Spondylolisthesis
- SEVERE UNREMITTING PAIN
- IMPAIREMENT OF FUNCTIONAL STATUS
- NEUROLOGICAL DEFICIT

SURGICAL PROCEDURE

- Advanced age does not increase the morbidity, nor does it decrease patient satisfaction or lengthen the return to activity
 - Fredman et al, Eur Spine J 11:571 – 4
 - Ragab et al, Spine 28:348 – 53
- Elderly patients with spinal fusion have increased complication rate
 - Stromqvist, Acta Orthop Scand 72:99 – 106
 - Ciol MA, J Bone Joint Surg Am 74:536 – 43
- Therefore less invasive surgical approaches may be of particular interest.

LCS - TAKE HOME MESSAGE

- Treatment should start with well-organized and closely monitored conservative therapy.
- If the pain remains mild or moderate with no major disability, conservative care can be continued with fair chances of stability or even improvement.
- If the low-back and leg pain remains or becomes severe, surgery offers a good chance of stable improvement.
- Overt stenosis, Spondylolisthesis, Scoliosis probably better with surgery

Lumbar Canal Stenosis (LCS):

CLINICAL ASSESSMENT

Lumbar Spinal Stenosis- Clinical Assessment



Define "Lumbar Stenosis"

- Narrowing of spinal canal

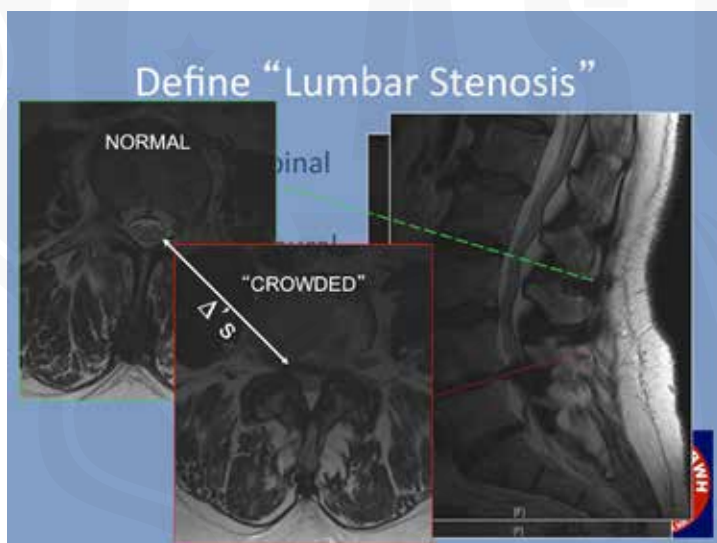


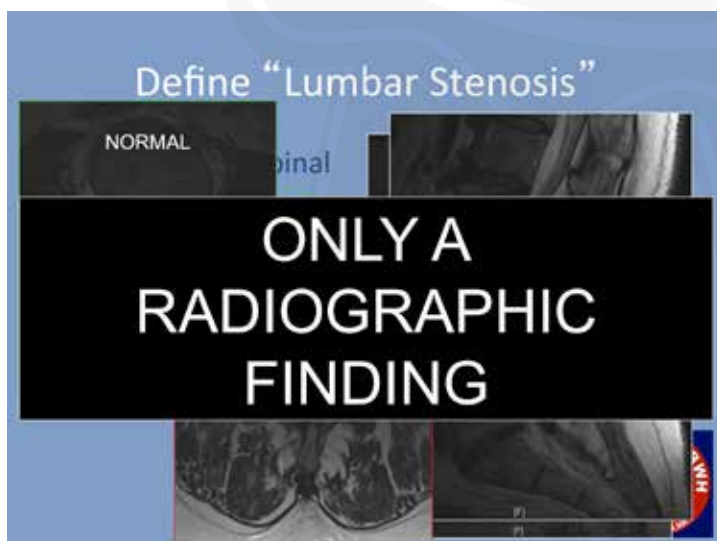
Define "Lumbar Stenosis"

- Narrowing of spinal canal
- Narrowing of neural foramina









Lumbar Stenosis can lead to:

- Symptoms
 - neurogenic claudication (b/l leg fatigue)
 - radiculopathy (u/l leg pain)
 - back pain



Lumbar Stenosis ≈ Clinical Syndrome

- NASS Clinical Guidelines
- "...buttock or lower extremity pain, w/ or w/o back pain, associated with diminished space available for the neural and vascular elements in the lumbar spine"



Lumbar Stenosis ≈ Clinical Syndrome

- NASS Clinical Guidelines
- "...characteristic..features [that include] exercise or positionally-induced neurogenic claudication [and] relieved with forward flexion, sitting and/or recumbency"



In a nutshell



Who is affected?

We see them everyday...

- Older (usually)
- Walk slowly
- Cane/Walker
- Stooped forward
- Frequent Stops



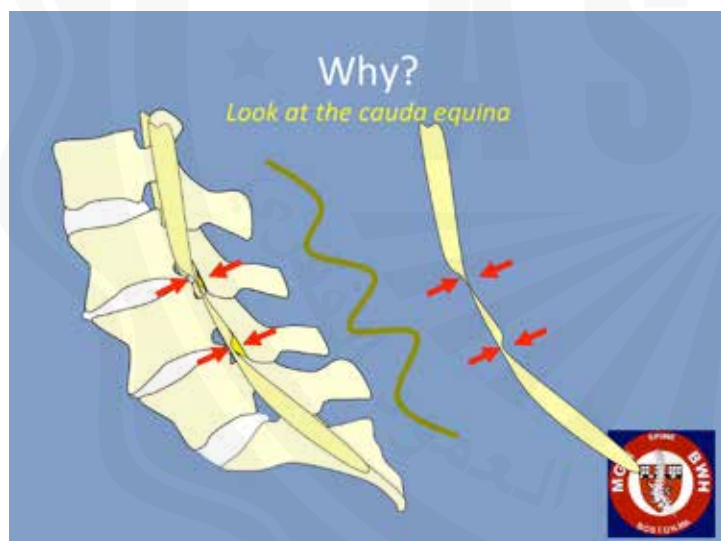
Why?

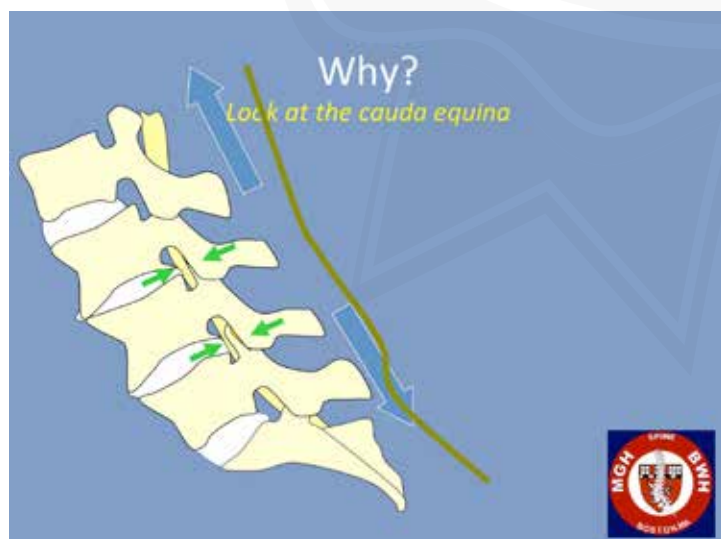


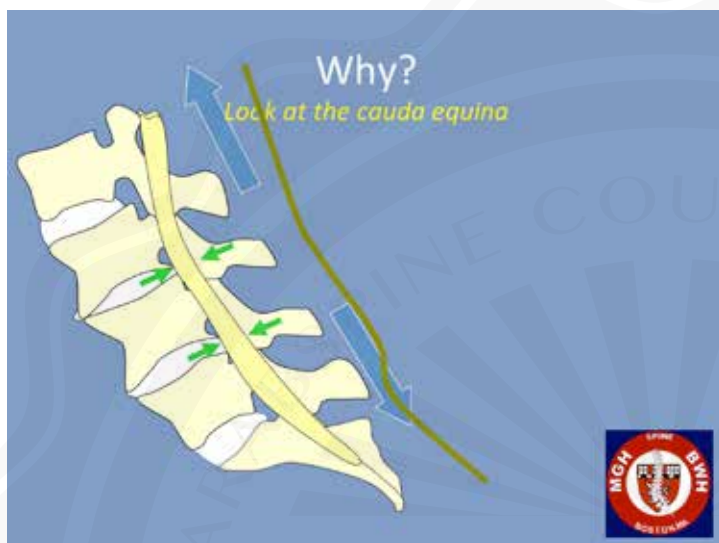
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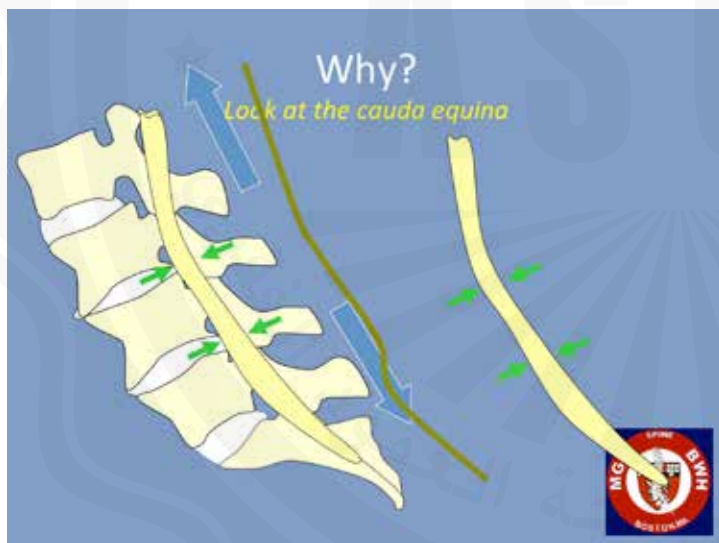


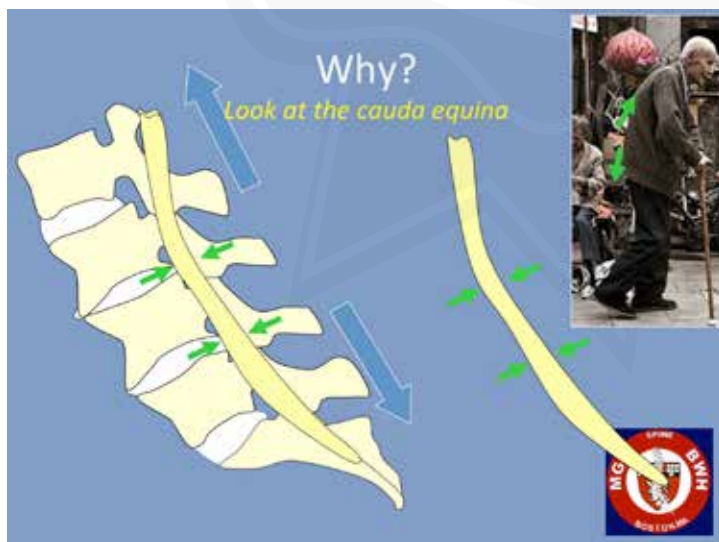












Diagnosis by History

- Supermarket
- “Shopping Cart Sign”



I can walk much farther if I lean on the shopping cart



Diagnosis by History

- “What stops you from walking as far as you want?”



My legs get tired and hurt, so I stop for a while



Important Questions to Ask

- B/B
- weakness
- balance
- pain meds
- neck pain/hand dexterity



Important Questions to Ask

- B/B
- weakness
- balance
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- neck pain/hand dexterity

Cervical + Lumbar Stenosis



Important Questions to Ask

- B/B
- weakness
- balance
- pain meds
- neck pain/hand dexterity

Cervical + Lumbar Stenosis

priority



Physical Examination

- Neuro Exam.....fairly normal
 - Motor/Sensory
 - Hyporeflexic
 - UE and Les
 - Hoffmans



Physical Examination

- Neuro Exam.....fairly normal
- ROM.....decreased
– pain w/ extension



Physical Examination

- Neuro Exam.....fairly normal
- ROM.....decreased
- Gait
– slow
– shuffled (r/o Parkinson' s)

walk the hallway



Radiographic Workup

- Plain Films



Radiographic Workup

- Plain Films

- flexion



- extension



TRANSLATION (SLIPPAGE)



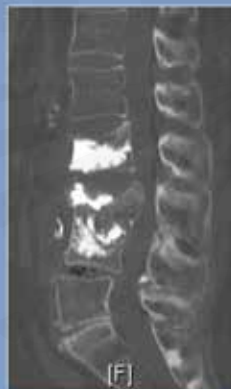
Radiographic Workup

- Plain Films

- CT--sometimes

- if can't get MRI

- P-maker
 - Ferrous hardware
 - Brain clips



(F)



Radiographic Workup

- Plain Films

- CT--sometimes

- if can't get MRI

- previous surgery

- **best** way to evaluate bone



?



Radiographic Workup

- Plain Films
- CT--sometimes
 - if can't get MRI
 - previous surgery
 - **best** way to evaluate bone
 - CT myelogram: alternative to MRI



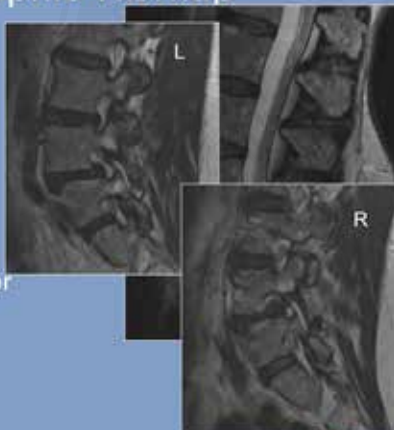
Radiographic Workup

- Plain Films
- CT--sometimes
- MRI
 - imaging of choice
 - T2-workhorse
 - **myelogram effect**



Radiographic Workup

- Plain Films
- CT--sometimes
- MRI
 - imaging of choice
 - T2-workhorse
 - Paramedian cuts for foramen



Radiographic Work-up

- Plain Films
- CT--sometimes
- MRI
 - *Disc
 - #Facet joint
 - ^Ligamentum Flavum



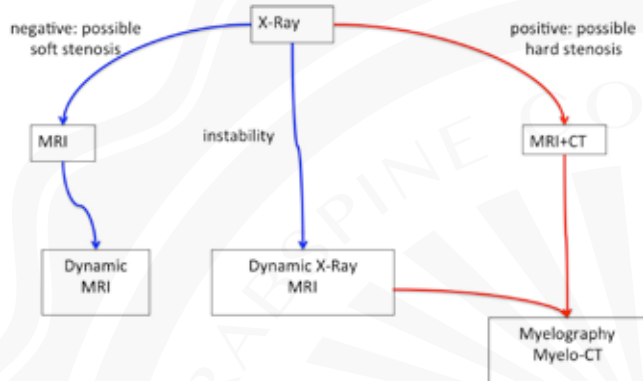
Now showing!

PATHOANATOMY

Lumbar Canal Stenosis (LCS):

IMAGING OF L.C.S.

Imaging stenosis flow chart

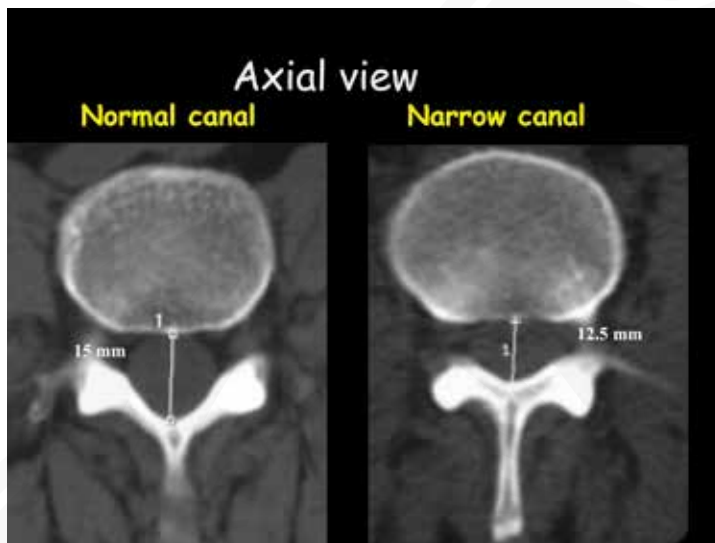


Myelography and CT myelography

- Modality of choice for those unable to undergo MRI
- Good for post op hardware if placed
- Excellent imaging but invasive
- Replaced by MRI

Imaging stenosis

- Dimensions mm and mm²
- Canal morphology
- Anterior stenosis
- Lateral stenosis with root impingement
- Narrow central canal



Parameters	Our study (1998-2000, Jordanian)	Cinamon et al. (1990), France (Jordanian)	Thomsen & Lee (1997), Korea	Witkowski et al. (1992), Netherlands
SCV-L4 (mm ²)	1470 (0.007)	1318 (0.010)	-	-
SP-L4 (mm ²)	142 (0.139)	149	+	+
SP-L4 (mm ²)	128 (0.050)	145	+	+
DIA-L4/L5 (mm)	20 (0.011)	22	+	+
DIA-L4/L5 (mm)	22 (0.069)	24	-	-
DIL-L4/L4 (mm)	12 (0.060)	12 (0.300)	-	10
DIL-L4/L5 (mm)	13 (0.046)	15 (0.500)	-	14
SP-L4/L4 (mm ²)	113 (0.013)	153 (0.010)	+	+
SP-L4/L5 (mm ²)	133 (0.347)	157	-	-
DAP-L4 (mm)	14 (0.494)	17 (0.670)	14	14
DAP-L5 (mm)	17 (0.241)	18 (0.300)	14	14
DIP-L4 (mm)	23 (0.133)	26 (0.001)	23	22
DIP-L5 (mm)	30 (0.177)	31 (0.001)	26	23
SC-L4 (mm ²)	229 (0.110)	288 (0.001)	+	-
SC-L5 (mm ²)	282 (0.022)	350 (0.010)	-	-

SFC: Area of dural sac L4: 142 L5: 128
 DIA: Interarticular diameter L4: 20 L5: 22
 DIL: Interligamentous diameter L4: 12 L5: 13
 DAP: Antero-posterior diameter L4: 14 L5: 15
 DIP: Interpedicular diameter L4: 23 L5: 30
 SC: Area of spinal canal L4: 229 L5: 281

Imaging of acquired degenerative stenosis

- *Soft and Hard stenosis: MRI - CT*
- *Secondary or "Dynamic" stenosis: Dynamic X-Ray , Dynamic MRI, AL-CT*

Soft Stenosis

The reduction of canal, foraminal and lateral recess diameters is due to:

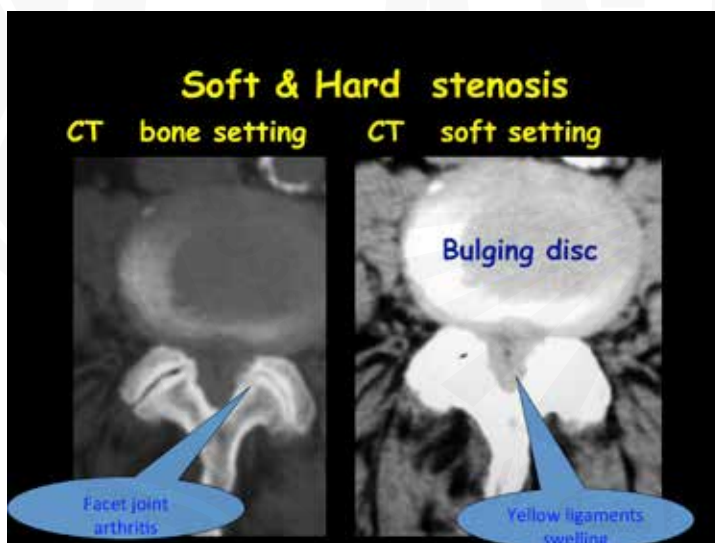
- Discal height reduction and disc protrusion
- Yellow ligament “relaxation & swelling”
- Foraminal stenosis



Hard Stenosis

The reduction of canal, foraminal and lateral recess diameters is due to:

- Hypertrophy of facets joint
- Marginal osteophytes
- Ligaments calcifications
- Calcified discal protrusion



Secondary or “Dynamic” Stenosis

- Anterolisthesis (causing canal stenosis)
- Retrolisthesis (predominantly causing foraminal stenosis)
- Multisegmental deformity

Instability RED FLAGS

- X-Rays
 - Disc vacuum
 - Traction spur osteophytes
 - Facet joints arthritis
- MRI
 - Facet joint effusion in supine position (CT and MRI)
 - Interspinous effusion
 - Serpiginous aspect of the nerve roots

Conclusions

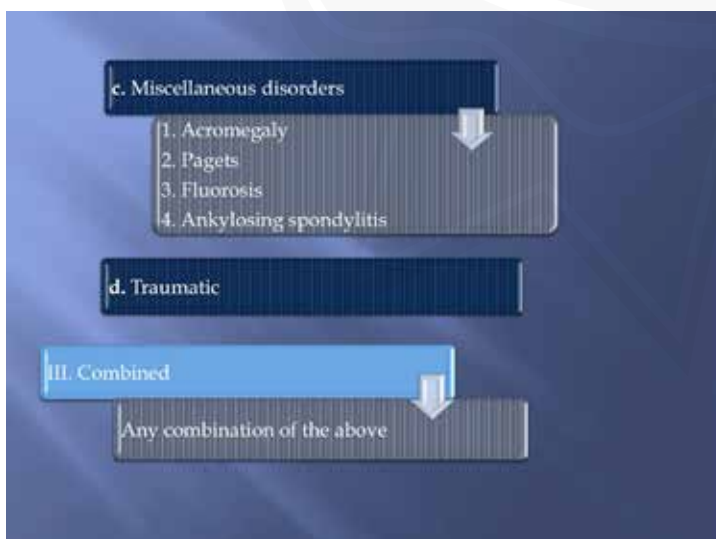
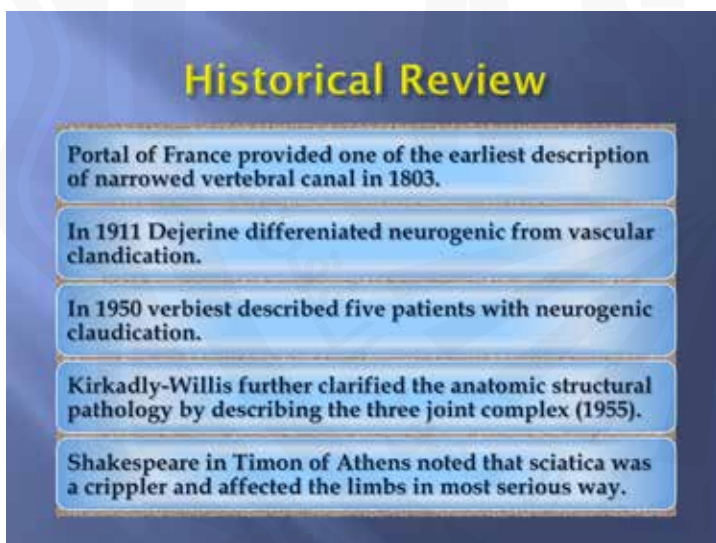
The constitutional and the acquired stenosis are linked together the first being the start of the second.

Today it is easy to study the bony part of the spinal canal or the foramina with a CT, and their soft and mobile tissues with an MRI.

The correspondence between imaging and clinics is of the maximum importance and clinics, in any case, must lead the diagnostic rationale to avoid severe diagnostic errors.

Lumbar Canal Stenosis (LCS):

CONSERVATIVE TREATMENT



Pathological process in spinal stenosis

- ❑ Mechanical compression of neural element
- ❑ Edema and venous congestion
- ❑ Ischemic neuritis
- ❑ Leakage of neurotoxins such as phospholipase and leukotiene B, leading to increase inflammation

Classification of spinal stenosis

I. Congenital/ developmental

- a. Idiopathic
- b. Achondroplastic
- c. Osteopetrosis

II- Acquired

a. Degenerative

- 1. Central
- 2. Lateral recess and foraminal

b. Iatrogenic

- 1. Post laminectomy
- 2. Post fusion
- 3. Post discectomy

What was highly suggestive of degenerative canal stenosis

Bilateral buttock pain

Flexion gait

Priapism during walking

Neurogenic claudication

Slowly progressive neurological deficit

Atrophy and weakness goes with lateral recess syndrome

Symptoms

1. Neurogenic claudication	90%
2. Radiculopathy	10%
3. Pain	96%
4. Numbness	75%
5. Weakness	40%
6. Bilateral	68%
7. Back pain	65%
Pain relief	
Sitting	90%
Lying	85%
Flexion at waist	84%

Presence of selected physical findings in patients with spinal stenosis

Physical findings	Literature review	Ours
Limited lumbar extension	66 – 100%	86%
Straight leg raising	10 – 90%	63%
Absent knee reflexes	10 – 50%	34%
Absent ankle reflexes	50 – 68%	60%
Muscle weakness	18 – 52%	37%
Sensory deficit	32 – 58%	43%

(Adapted from Katz J.N., Douglas, M., Stucki et al. 1994)

Disc herniation and disc bulge

Vital to be differentiated because

Can be differentiated by feeling and by MRI

Acute presentation with neurological deficit is highly suggestive of associated disc herniation

Treatment of lumbar canal stenosis is either

- ▣ Operative
- ▣ Or Conservative

This depends on so many parameters

- ▣ Neurological deficit
- ▣ Degree of stenosis
- ▣ Patients complaints
- ▣ Response to treatment
- ▣ The psychological background

Non operative treatment

- ▣ Rest in bed
- ▣ Pain control by analgesia and anti inflammatory medications
- ▣ Physio-therapy
- ▣ Trunk - stabilization exercise program
- ▣ Epidural steroid injections
- ▣ Selective nerve block

Epidural steroid injection

- ▣ Potent anti inflammatory medications
- ▣ Ability to reduce oedema
- ▣ Desmoplastic activity (reduce fibrosis and adhesion)
- ▣ Draw back
- ▣ Not scientifically validated long term outcome
- ▣ No confirmed statistical significance
- ▣ Meta analysis showed that epidural steroids have little short-term advantage, over placebo, for the treatment of leg pain

Complications of epidural steroids (in frequent)

- ▣ Hypercorticism
- ▣ Epidural hematoma
- ▣ Temporary paralysis
- ▣ Retinal haemorrhage
- ▣ Epidural abscess
- ▣ Chemical meningitis
- ▣ 5% incidence of dural puncture
- ▣ Headache occur in 1-5% of patients

The ideal candidate for epidural steroid injection

- ▣ Acute radicular symptoms or neurogenic claudication
- ▣ Lack of response to traditional analgesics and rest
- ▣ Significant impairment of daily activity

Medications

- ▣ Analgesia
- ▣ Non steroidal anti inflammatory
- ▣ Muscle relaxant
- ▣ Antidepressant
- ▣ Or combination
- ▣ Oral or injectable steroids ???

Physical Therapy?

- ❑ No clear evidence in the RPRL
- ❑ Suggestion that “Flexion Distraction” may be of benefit
- ❑ Treatments in the unit, home flexion exercises

Operative treatment

- ❑ Should be done on solid basis only NOT for any other reason or reasons
- ❑ Increasing pain
- ❑ Neurological deficit
- ❑ Very narrow canal (any correlation between MRI and clinical findings?)
- ❑ Lack of response to conservative treatment

SUMMARY

Medications- triple threat

Epidural Therapy, Physical Therapy

Lumbar Canal Stenosis (LCS):

DECISION MAKING AND SURGICAL OPTIONS

Main Surgical Decision: Degenerative Spondylolisthesis and Stenosis

- Laminectomy alone vs
Laminectomy plus fusion

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The NEW ENGLAND JOURNAL of MEDICINE

ESTABLISHED IN 1812

APRIL 14, 2016

VOL. 374 NO. 15

A Randomized, Controlled Trial of Fusion Surgery for Lumbar Spinal Stenosis

Peter Försth, M.D., Ph.D., Gylli Ólafsson, M.Sc., Thomas Carlsson, M.D., Anders Frost, M.D., Ph.D.,
Fredrik Borgström, Ph.D., Peter Fritzell, M.D., Ph.D., Patrik Öhagen, Karl Michaëlsson, M.D., Ph.D.,
and Bengt Sandén, M.D., Ph.D.

Laminectomy plus Fusion versus Laminectomy Alone for Lumbar Spondylolisthesis

Zohar Chagarescu, M.D., James O'Brien, Ph.D., William E. Barlow, M.D.,
Xiang Qiu, Ph.D., Noémie Tassin, Ph.D., Suley N. Magge, M.D.,
Jean-Vincent C. Coumans, M.D., J. Fred Hartington, M.D.,
Sapideh Amirkhanyan, M.D., J. Sanford Schwartz, M.D., Volker K.H. Sonntag, M.D.,
Fred G. Barker, II, M.D., and Edward C. Benzel, M.D.

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Background

- “SSSS” study: Swedish Spinal Stenosis Study
- Randomized controlled trial of the efficacy of fusion surgery in addition to decompression surgery in patients with lumbar spinal stenosis, with or without degenerative spondylolisthesis.

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Methods

- 247 patients between 50 and 80 years of age at multiple centers from 2006 to 2012
- Randomization was stratified according to preop degenerative spondylolisthesis (135 patients) or its absence
- Degenerative spondylolisthesis was defined as the presence of a vertebra that had slipped forward at least 3mm in relation to the vertebra below it on lateral XR; flex/ex was not performed.

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Table 1. Inclusion and Exclusion Criteria.
Inclusion Criteria
Pseudoclaudication in one or both legs and back pain (score on visual-analogue scale >50)*
1 or 2 adjacent stenotic segments (cross-section area of the dural sac ≤75 mm ²) between L2 and the sacrum on magnetic resonance imaging
Duration of symptoms >6 mo
Written informed consent
Exclusion Criteria
Spondylolysis
Degenerative lumbar scoliosis (Cobb angle >20 degrees)
History of lumbar spinal surgery for spinal stenosis or instability
Stenosis not caused by degenerative changes
Stenosis caused by a herniated disk
Other specific spinal conditions (e.g., ankylosing spondylitis, cancer, or neurologic disorders)
History of vertebral compression fractures in affected segments
Psychological disorders (e.g., dementia or drug abuse) that caused the surgeon to consider participation to be inappropriate

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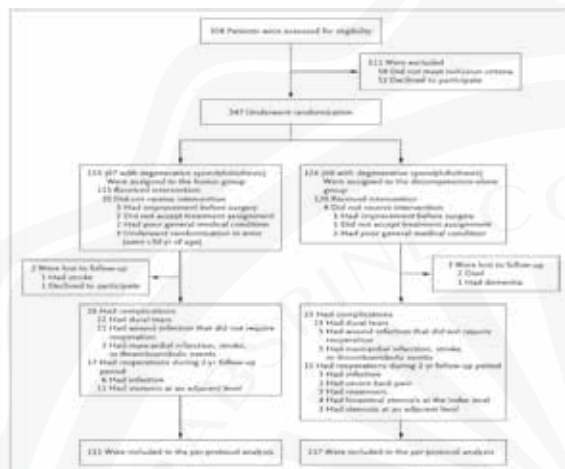


Table 2. Baseline Characteristics of the Patients.*

Characteristic	Absence of Degenerative Spondylolisthesis		Presence of Degenerative Spondylolisthesis	
	Fusion Group (N = 46)	Decompression Alone Group (N = 52)	Fusion Group (N = 67)	Decompression Alone Group (N = 68)
Age — yr	68±9	66±8	68±7	67±7
Female sex — no. (%)	19 (41)	29 (56)	11 (16)	16 (23)
Smoker — no. (%)	7 (15)	9 (17)	9 (13)	10 (15)
Degree of vertebral slip — mm	—	—	7.4±2.6	7.4±2.8
ASA score — no. (%)				
1 or 2	38 (83)	48 (92)	57 (85)	53 (78)
3	8 (17)	4 (8)	10 (15)	15 (22)
QDI score†	43±13	41±13	41±13	41±14
EQ-5D score‡	0.40±0.31	0.37±0.33	0.39±0.31	0.36±0.30
VAS score for back pain§	59±28	61±25	64±20	63±24
VAS score for leg pain¶	65±19	61±24	64±21	65±22
ZCQ score				
Symptoms severity	3.4±0.72	3.5±0.68	3.4±0.6	3.3±0.5
Physical function	2.4±0.68	2.5±0.55	2.6±0.5	2.5±0.5
Result of 6-minute walk test — min**	312±155	311±128	309±117	313±110

Outcomes

- Primary outcome
 - Score on ODI 2 years after surgery
- Secondary outcomes
 - Patient-reported outcomes
 - Swespine questionnaire
 - Zurich claudication questionnaire (ZCQ)
 - EQ-5D QOL survey
 - 6 minute walk test
 - Health economic evaluation

Results

- No significant difference in the mean score on ODI at 2 years:
 - Fusion group: 27
 - Decompression-alone group: 24
 - $P=0.24$
- No significant difference in the decrease in ODI score at 2 years:
 - Fusion group: -15
 - Decompression-alone group: -17
 - $P=0.36$

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Results

- No significant difference in the results of the 6 minute walk test at 2 years:
 - Fusion group: 397m
 - Decompression-alone group: 405m
 - $P=0.72$

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Results

- Results were similar between patients with and those without spondylolisthesis:
 - Fusion group ODI: 25
 - Decompression-alone ODI: 21
 - $p=0.11$
- No significant differences in clinical outcomes between the groups existed at 5 year analysis.

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Table 3. Outcomes in the Per-Protocol Population^a

Outcomes	Absence of Degenerative Spondylolisthesis				Presence of Degenerative Spondylolisthesis			
	Fusion Group (N=46)	Decompression-Along Group (N=55)	P Value	Relative Risk (95% CI)	Fusion Group (N=57)	Decompression-Along Group (N=48)	P Value	Relative Risk (95% CI)
During the procedure								
Operating time — min	130(47)	80(28)	<0.01		145(44)	35(40)	<0.001	
Amount of bleeding — ml	945(48)	285(33)	<0.01		485(49)	115(34)	<0.001	
At 2 yr								
ODI score	29(20)	27(18)	0.70		31(19)	31(18)	0.14	
EQ-5D score	0.65(0.11)	0.59(0.10)	0.80		0.65(0.11)	0.66(0.12)	0.90	
VAS score for back pain	41(12)	45(11)	0.46		36(19)	26(20)	0.13	
VAS score for leg pain	35(11)	36(11)	0.46		32(19)	25(21)	0.68	
20Q score								
Symptom severity	2.6(1.8)	2.5(1.1)	0.46		2.4(1.9)	2.4(1.9)	0.98	
Physical function	1.8(1.7)	1.6(1.4)	0.80		1.8(1.4)	1.7(1.7)	0.51	
Patient satisfaction	2.2(1.9)	2.1(1.9)	0.43		2.1(1.9)	1.9(1.4)	0.32	
Revisit of 90-minute walk test — m	437(104)	418(138)	0.34		311(132)	386(144)	0.80	
Reporting satisfaction with the surgery — no. (%)	33 (53)	27 (51)		0.89 (0.47-1.40)	43 (84)	43 (89)		0.96 (0.74-1.28)
Reporting decrease in back pain — no. (%)	33 (70)	33 (60)		1.28 (0.79-1.91)	53 (90)	54 (92)		0.97 (0.63-1.44)
Reporting decrease in leg pain — no. (%)	38 (82)	38 (69)		1.19 (0.74-1.93)	52 (90)	49 (79)		1.07 (0.68-1.70)
Reporting increase in walking distance — no. (%)	40 (85)	41 (80)		1.10 (0.70-1.73)	57 (98)	57 (98)		1.02 (0.60-1.73)

Results

- Exploratory subgroup analysis:
 - Spondy greater than 7.4mm (range 7.4-14.3)
- No difference between treatment groups at baseline or 2 years:
 - Fusion group: 25
 - Decompression-alone group: 25
 - p=0.98

Results

- Mean length of hospitalization was 7.4 days in fusion group vs 4.1 days in decompression-alone group (p<0.001).
- Operating time was longer, amount of blood loss was greater, and surgical costs were higher in the fusion group than in the decompression-alone group.

Table 4. Resource Use.^a

Variable	Fusion Group (N=113)	Decompression- Alone Group (N=113)	P Value
During the procedure			
Length of hospital stay (days)	7.4±8.4	4.1±6.1	<0.001
Mean operation costs (\$2.5-\$)	12,200	5,400	
At 2 yr			
No. of visits to doctors	3.3±5.3	1.8±5.3	0.49
No. of visits to other health care professionals	13±32	22±45	0.18
Total no. of days receiving benefits of any kind	81±172	41±117	0.35
No. of patients using analgesics for back problems at 2 yr (%)	42 (40)	40 (37)	0.57

Results

- During a mean follow-up of 6.5 years, additional lumbar spine surgery was performed in 22% of the patients in the fusion group and in 21% of those in the decompression-alone group.

Conclusions

- "Among patients with lumbar spinal stenosis, with or without degenerative spondylolisthesis, decompression surgery plus fusion surgery did not result in better clinical outcomes at 2 years and 5 years than did decompression surgery alone."

THE NEW ENGLAND JOURNAL OF MEDICINE

ORIGINAL ARTICLE

Laminectomy plus Fusion versus Laminectomy Alone for Lumbar Spondylolisthesis

Zohar Ghogawala, M.D., James Dziura, Ph.D., William E. Butler, M.D.,
Feng Dai, Ph.D., Norma Terrin, Ph.D., Subu N. Magge, M.D.,
Jean-Valery C.E. Coumans, M.D., J. Fred Harrington, M.D.,
Sepideh Amin-Hanjani, M.D., J. Sanford Schwartz, M.D., Volker K.H. Sonntag, M.D.,
Fred G. Barker, II, M.D., and Edward C. Benzel, M.D.

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Background

- “SLIP” study: Spinal Laminectomy versus Instrumented Pedicle screw study
- Randomized controlled trial of the effectiveness of instrumented fusion (pedicle screws + titanium rods) and laminectomy vs laminectomy alone in treatment of grade I degenerative spondylolisthesis.

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Methods

- 66 patients between ages of 50-80 years (mean 67) at 5 centers from 2002-2009
- Stable grade I degenerative spondylolisthesis (3-14mm) AND symptomatic lumbar spinal stenosis/neurogenic claudication with or without lumbar radiculopathy.
- Exclusion criteria:
 - Lumbar instability (>3mm motion on flex/ex)
 - Judged by surgeon to have instability due to h/o mechanical LBP with axial loading
 - Previous lumbar surgery
 - ASA class IV or higher

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Table 1. Baseline Characteristics of the Patients.^a

Characteristic	Decompression- Alone Group (N = 35)	Fusion Group (N = 31)
Age — yr	66.5 ± 8.0	66.7 ± 7.2
Female sex — no. (%)	27 (77)	26 (84)
Walking capacity — min†	16.0 ± 14.7	15.1 ± 8.7
Motor deficit — no./total no. (%)‡	8/34 (24)	8/31 (26)
SF-36 physical component summary score§	34.7 ± 7.0	31.5 ± 7.3
Physical function	44.7 ± 22.8	38.7 ± 23.7
Bodily pain	33.9 ± 16.3	28.1 ± 13.3
Vitality	45.0 ± 19.8	47.7 ± 23.3
ODI score¶	36.3 ± 15.2	38.8 ± 16.0
Body mass index	27.1 ± 6.1	29.5 ± 6.5
Degree of spondylolisthesis — mm**	6.5 ± 2.3	5.6 ± 2.2
Spinal canal area at the level of listhesis — mm²**	39.2 ± 45.1	38.1 ± 27.7
Flexion-extension movement at listhesis — mm**	1.3 ± 1.0	1.6 ± 1.4
ASA class III — no./total no. (%)††	0/33	3/28 (11)
Rotatory scoliosis >15 degrees — no./total no. (%)**	3/31 (10)	4/27 (15)
Lateral scoliosis >15 degrees — no./total no. (%)**	7/31 (23)	3/27 (11)
Disk space height — mm**‡‡	7.3 ± 2.6	8.2 ± 2.9

Methods

- Each patient was assessed for suitability for randomization by a panel of 10 expert spine surgeons who reviewed a clinical vignette and 4 standardized XR and MRI images.
- Randomized to decompression alone vs laminectomy + fusion

Methods

- Surgery:
 - Lumbar laminectomy and medial facetectomy +/- pedicle screws/titanium rod construct
 - No BMP
 - No interbody devices
 - No MIS techniques

Outcomes

- Primary outcome measure
 - Change in physical-component summary score of Medical Outcomes Study 36-item Short Form Health Survey (SF-36) 2 years after surgery (scored 0-100 with higher scores indicating better QOL)
- Secondary outcome measure
 - Score on Oswestry Disability Index (scored 0-100 with higher scores indicating greater disability due to back pain)

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Minimum clinically-important difference

- Determined on basis of previous studies
- SF-36 physical-component summary score: 5 points
- Oswestry Disability Index: 10 points

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Results

- Rate of follow-up:
 - 89% at 1 year
 - 86% at 2 years
 - 68% at 4 years
- Initially, study was specified to continue for 5 years, but was restricted to 4 years after high dropout rates and limited funding.

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Results

- Difference in SF-36 physical component summary score at 2 years:
 - Fusion group: 15.2
 - Decompression group: 9.5
 - Difference of 5.7 points
 - 95% CI 0.1 to 11.3; p=0.046
- The increase in SF-36 scores remained greater in the fusion group at 3 years and 4 years (difference at 4 years 6.7 points; p=0.02 for both years).

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Results

- Changes in the Oswestry Disability Index (ODI) scores at 2 years did not differ significantly:
 - Fusion group: -26.3
 - Decompression group: -17.9
 - P=0.06

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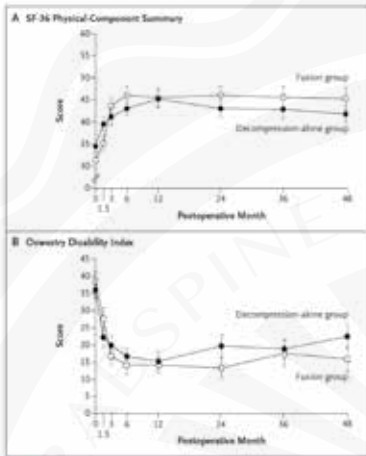
29

Table 2. Changes in SF-36 Physical-Component Summary and ODI Scores from Baseline.*

Outcome	Change from Baseline		Difference in Change, Fusion vs. Decompression Alone (95% CI)	P Value
	Decompression Alone Group	Fusion Group		
SF-36 physical component summary score				
Baseline†	34.7	33.5	NA	NA
1.5 mo	6.3	5.1	-1.1 (-5.9 to 3.7)	0.64
3 mo	7.7	12.2	4.5 (-0.7 to 9.7)	0.09
6 mo	9.2	15.6	6.4 (1.3 to 11.7)	0.02
1 yr	11.9	15.3	3.9 (-1.5 to 9.4)	0.16
2 yr	9.5	15.2	5.7 (0.1 to 11.3)	0.046
3 yr	7.9	15.3	7.4 (1.1 to 11.7)	0.02
4 yr	7.4	14.1	6.7 (1.2 to 12.3)	0.02
ODI score				
Baseline†	36.1	38.8	NA	NA
1.5 mo	-15.1	-12.4	2.9 (-7.4 to 13.2)	0.58
3 mo	-17.0	-22.2	-5.2 (-13.9 to 3.5)	0.24
6 mo	-20.1	-25.9	-5.8 (-14.4 to 3.2)	0.21
1 yr	-22.2	-26.1	-3.9 (-12.8 to 5.0)	0.38
2 yr	-17.9	-26.3	-8.5 (-17.3 to 0.3)	0.06
3 yr	-17.2	-21.8	-4.6 (-14.7 to 5.6)	0.37
4 yr	-14.7	-23.7	-9.0 (-18.0 to 0.1)	0.05

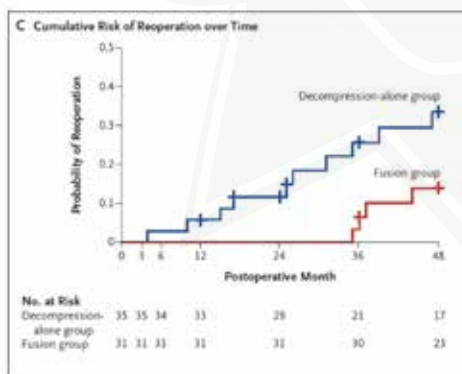
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Results

- Cumulative rate of reoperation was 14% in fusion group vs 34% in the decompression-alone group (p=0.05).
 - All reoperations in decompression-alone group were at index level to address instability
 - All reoperations in fusion group were at an adjacent level



Results

- More blood loss and longer hospital stays occurred in the fusion group than the decompression-alone group ($p<0.001$).

Table 3. Surgical Complications.*

Variable	Decompression- Alone Group (N=35)	Fusion Group (N=31)	P Value
Estimated blood loss			
No. of patients with data	34	31	
Mean — ml	83.4±63.5	513.7±334.4	<0.001
Length of stay in the hospital			
No. of patients with data	33	30	
Mean — days	2.6±0.9	4.2±0.9	<0.001
Duration of operation			
No. of patients with data	34	30	
Mean — min	124.4±34.2	289.6±66.3	<0.001
Major complications — no./total (%)	2/35 (6%)	1/31 (3%)	1.0

Conclusions

- “Among patients with degenerative grade I spondylolisthesis, the addition of lumbar spinal fusion to laminectomy was associated with slightly greater but clinically meaningful improvement in overall physical health-related QOL than laminectomy alone.”

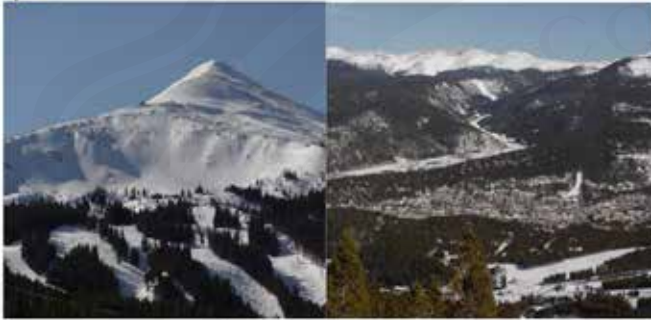
Lumbar Canal Stenosis (LCS):

DECOMPRESSION TECHNIQUES (LCS)

Breckenridge, Colorado

Rocky Mountain

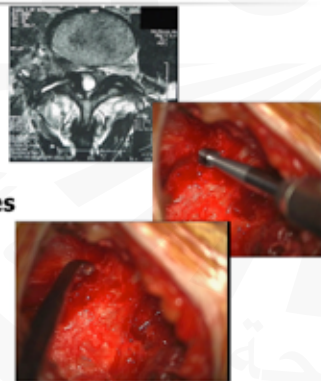
"Champagne Powder"



4 Key Skills

2 Cognitive/2 technical

- 3D Anatomic Analysis of Pathology
- Spinal Canal
 - Entry
 - Orientation
 - Identification structures
 - Nerve root
- Skilled use of side-cutting burr
- Skilled use small 3-0 angled curette



Wong Personal Collection

Surgical Issues Posterior Approach

- Traditional
 - Laminectomy
- Minimally Invasive
 - Micro Decompression
 - Laminotomy
 - Laminoplasty
- Analysis of Pathology



Laminectomy

vs.

Laminaplasty

Laminectomy

- Post Struc/2° Stabilizers Sacrifice
- Extent dissection
 - Recovery
 - Blood loss
- Foraminal Decomp

Laminaplasty

- 2° Stabilizers Intact
- Minor Dissection
- Ipsilateral Foramen Mid
- Bilat Foramen Exit Zone



Concepts in Spine Anatomy/ Pathology

Ian Macnab

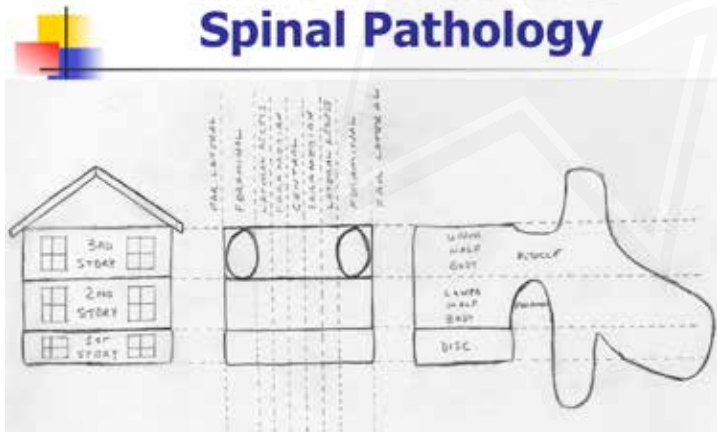
- Medial – lateral
- Central/lateral recess/ foraminal/

John McCulloch

- Inferior – superior
- 3 stories

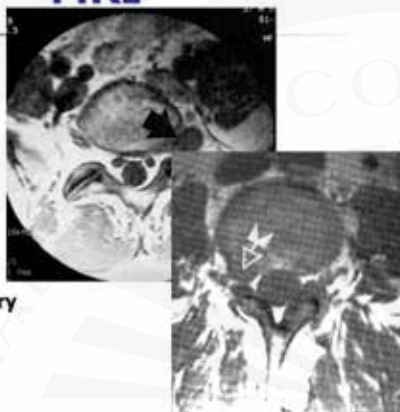


Grid Orientation to Spinal Pathology



Read Axial Images CT/ MRI

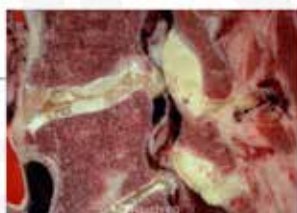
- **Anterior**
 - Disc density
 - Bone density
- **Middle**
 - Foramen – hole
 - Pedicle – bone
- **Anterior**
 - Disc = 1st story
 - Bone = 2nd / 3rd story
- **Middle**
 - Foramen = 2nd story
 - Pedicle = 3rd story



Overview: Pathology

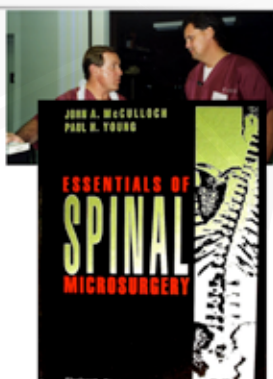
- **Spinal Stenosis** is a *First Story* disease.

- John A. McCulloch



?Bilateral Decompression via Unilateral Laminotomy?

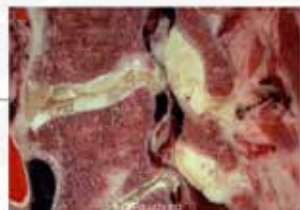
- **Paul Young**
 - Neurosurgeon
 - St. Louis, Mo
 - Director **PAWS** (Practical Anatomy WorkShop)
 - 1st AAOS cadaver
 - Co-author
 - Essentials of Spinal Microsurgery



Overview: Sx Options

■ Stenosis No Spondylo

- Congenital
- Lipomatosis
- Degen-Analysis Pathol



■ Stenosis + Spondylo

- Grade I
 - Few mm
 - ↓ disc height
 - Stable F/E

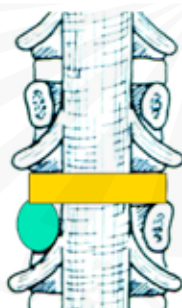


- Scoliosis
 - 10° - 15°
- Lateral Listhesis
 - 1-2 mm/stable

"PALs" for Windows Medial Laminotomy

■ External

- Facet
- Pars Interarticularis
- Superior edge inferior lamina



■ Canal

- Pedicle
- Disc

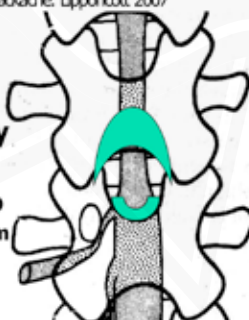
Wong D, Transfeldt E. Macnab's Backache. Lippincott 2007

Tight Stenosis Canal Entry

Wong D, Transfeldt E. Macnab's Backache. Lippincott 2007

■ Ligamentum Flavum Anatomy

- Attach-Sup Undersurf/Inf Abut
- Hypertrophied – Mushroom Cap
 - Separate hypertrophied layers from inferior
 - Resect
 - Keep last layer for dural protect



■ Burr Sup Lamina 1st

- Protect dura
- Keep Ligamentum tension
 - Release upper first
 - Curette under to release point



Koebler.com

Background Context Slip Progression

- Normal pre-op align
 - Midline laminectomy
 - 31% slip
- Pre-Op Degenerative Spondylo Grade I
 - Midline laminectomy
 - 73% slip progression



Mardjetko SM, Connolly PJ, Shott S. Degenerative lumbar spondylosis: A meta-analysis of the literature 1970–93. *Spine* 1994;19:2256S–65S.

Background Context Clinical Outcome - SPORT

- SS+Spondy 601 pt/369 (61%) Sx
 - Sx incl fusion 347/94% (78% metal)
- SS 634 pt/394 (62%) Sx
 - Sx incl fusion 43/11% (53% metal)
- Baseline same exc spondy more Female
- Both groups better with Sx vs non Sx
- Spondylo outcome better vs SS

Pearson A et al. Degenerative Spondylolisthesis Versus stenosis. Does a Slip Matter? Comparison of Baseline Characteristics and Outcomes (SPORT). *Spine* 2010; 35:298-305.

Stability with MIS Decompression

- Finite element analysis remove posterior elements
 - Laminectomy
 - MIS
- Extension vs intact
 - Lam 4X/MIS 2X
- Flexion
 - Lam 3.6X/MIS 1.6X



Bresnahan L, Fessler R et al. A Biomechanical Evaluation of Graded Posterior Element Removal for Treatment of Lumbar Stenosis. *Spine* 2008;34:17-23.

Stability with MIS Decompression

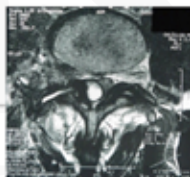
- McCulloch/Young approach
- 57 pts 27m/30f av age 69.6
- F/U 5 yr min/mean 6 yrs (5-8)
- 27 SS/20 spondylo/10 scoli
- Slip progression
 - 1.2% +/- 3.1% SS
 - 2.4% +/- 4.7% Spondylo
 - 0.0% +/- 0.0% Scoli
- Clinical outcome NSD



Toyoda H et al. Clinical Outcome of Microsurgical Bilateral Decompression via Unilateral Approach for Lumbar Canal Stenosis. Spine 2011;36:410-415.

Synovial Cyst

- Inflammatory/adherent
 - Incorporated with ligamentum
- Sufficient exposure key
 - Superior
 - Inferior
 - Medial
- Separate from dura
 - 3-0 curette
 - Small McCulloch hook
 - ***Patience!***



Lumbar Canal Stenosis (LCS):

INTERSPINOUS DEVICES

Symptomatic Lumbar Spinal Stenosis

- Surgical Options:

1. Laminectomy
2. Laminectomy + Fusion
3. Interspinous Devices



ISD

- What is the indication?
- Treating which pathology?
- What is the goal of treatment?
 1. Distraction?
 2. Dynamic Stabilization (restriction)?
 3. Fusion?



Mechanical Properties

- Interspinous device's (spacers) main mechanical goal is *distraction* between adjacent SPs.
- Blocking extension at same level.



Bénigas J. Mechanical supplementation by non-rigid fixation in degenerative intervertebral lumbar segments: The Wallis system. Eur Spine J. 2002;11(Suppl 2):S164-S169.

1st RCT



Zucherman JF, Hsu KY, Hartjen CA, et al. A multicenter, prospective, randomized trial evaluating the X-STOP interspinous process decompression system for the treatment of neurogenic intermittent claudication: two-year follow-up results. *Spine* 2005;30(2):1351-8.

- Between May and July 2000, Nine US centers.
- FDA oriented, Investigational Device Exemption (IDE) study.
- 200 lumbar spinal stenosis patients randomized to receive either **X-STOP** or **non-operative care** (including epidural steroid injections and analgesic medication plus physical therapy as necessary).
- They observed a significantly greater improvement (ZCQ, SF-36) in clinical symptoms within 2 years in the X-STOP group compared with nonoperative at all time points.

Indications

Lumbar spine (L1 to S1)

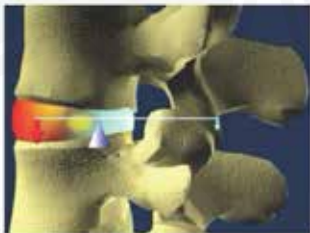
- Lumbar Spinal stenosis.
Degenerative spondylolisthesis (grade I).*
- Discogenic low back pain.
- Lumbar disc herniation.
- Facet arthropathy.



* Anderson JB, Tribus CB, Kitchel SH. Treatment of neurogenic claudication by interspinous decompression: application of the X-STOP device in patients with lumbar degenerative spondylolisthesis. *J Neurosurg Spine* 2006;14(3):71.

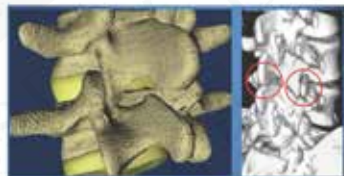
ISD Biomechanics
At Instrumented Level

- Decrease in flexion-extension ROM.
- Significant increase in neural foramen and spinal canal dimension.
- Decrease in intradiscal pressure in neutral and extended position.



ISD Biomechanics

- Decrease in mean peak pressures, average pressures, contact area and force at the **facets**.
- No significant alteration of kinematics or accelerated disc degeneration at adjacent levels.
- No significant change in intervertebral angle, posterior disc height, and interspinous process distance.



ISDs

Heterogeneous and very populous group of implants

Surgical techniques:

- Percutaneous
- Open
- +/- Decompression

Materials:

Metal (Titanium)
Peek
Silicone



Percutaneous ISD



Open IDS



Open IDS

Implant	Wells	X-STOP®-STOP®	Coflex ("Interspinous U")	DIAM
Company	Akhtor spine	Kyphon Inc.	Paradigm spine	Medtronic
Launch	2002 (new)	2002	1994 (The U)	2001
Developer	Someres J	St Francis Inc.	Someres J	Taylor J
FDA Status	Approved for clinical trial	Approved for clinical use	Approved for clinical trial	Approved for clinical trial
Composition	Blocker—PEEK	Titanium alloy body and PEEK spacer (X-STOP®)	Titanium alloy	Silicone Core with polyester sleeve
Technique	Removal of supraspinous ligaments necessary	Preserves supraspinous ligament	Removal of supraspinous ligaments necessary	Preserves supraspinous ligament
Implant				

ISDs

How do you look at it?

- Minimally invasive, stand alone.
- Non-fusion, non-destructive, fully reversible.
- Low complication rate.
- Immediate symptoms relief, Faster recovery and rehabilitation.
- Clinically proven!

Case illustration

- 70-yr.-old F with disabling LBP and INC.



ISD vs Decompression



Methods

- **Five high-quality RCTs**, including a total of **918** patients.
- **Symptomatic lumbar spinal stenosis** in whom the latter had failed for 3 to 6 months.
- Compared **surgical procedures** (the implantation of a specific type of ISD or decompressive surgery, +/- fusion) with a miscellanea of **conservative treatments**.

Results

- In all the studies, surgery led to *better* results for pain, disability, and quality of life (although not for walking ability).
- Results of surgery were *similar* among patients with and without spondylolisthesis, and slightly better among those with neurogenic claudication than among those without it.
- The advantage of surgery was remained for up to 2 to 4 years, although at the end of that period differences tended to be smaller.

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Recommendations

Further RCTs Needed!

1. Compare the ISD with decompression surgery.
2. Compare different surgical techniques and ISD in specific subsets of patients.
3. Define indication criteria for the different surgical procedures.
4. Define learning curves for all these procedures.
5. Implement registries and post-marketing surveillance methods and not be conducted by the industry or by authors who harbor conflicts of interest.

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ISD Efficacy

Eur Spine J (2011) 20:1596–1606
DOI 10.1007/s00586-011-1873-8

REVIEW ARTICLE

Effectiveness of interspinous implant surgery in patients with intermittent neurogenic claudication: a systematic review and meta-analysis

Wouter A. Moolen • Mark P. Arts •
Ronald H. M. A. Bartels • Wilco C. H. Jacobs •
Wilco C. Peul

The main objective was to perform a meta-analysis of all systematic reviews, randomized clinical trials and prospective cohort series to quantify the *effectiveness* of IPDs and to evaluate the potential side effects.

Methods

- Data from all studies **prospectively** describing clinical results based on validated outcome scales and reporting complications of treatment of patients with INC with ISD placement.
- Searched MEDLINE, EMBASE, Web of Science, Cochrane (CENTRAL), CINAHL, Academic Search Premier, Science Direct up to July 2010.

Results

- *Eleven* studies (253), 2 independently RCTs and 8 prospective cohorts were available.
- Total 563 patients were treated with ISDs.
- All studies showed *improvement* in validated outcome scores after 6 weeks and 1 year, compared with conservative treatment.
- Overall complication rate was 7%.

Recommendations

- RCT comparing ISD with standard bony decompression.
- More analysis on complication and device failure rates and cost-effectiveness studies.
- Should patients with lumbar spinal stenosis be guarded against instrumented surgery or the use of ISD on the basis of the current evidence?

Recent Review

Epstein NE. A review of interspinous fusion devices: High complication, reoperation rates, and costs with poor outcomes. Surg Neurol Int 2012; 3: 7

- 11.6%-38% complication rate.
- 4.6%-85% reoperation rate.
- 66.7%-77% incidence of poor outcomes.

Conclusions

- ISDs may provide good outcome for selected patients with sDLSS.
- ISD+ decompression vs only decompression.

Lumbar Canal Stenosis (LCS):

MIS FOR LCS

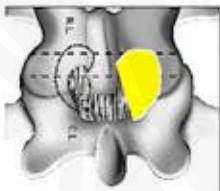
MINIMALLY INVASIVE SPINE SURGERY

Hypothesis for being less invasive

- Small skin incision
- Less tissue damage
- Less bleeding
- Fewer infection
- Reduced postoperative pain
- Less postoperative analgesia
- Faster rate of recovery



FENESTRATION / LAMINOTOMY

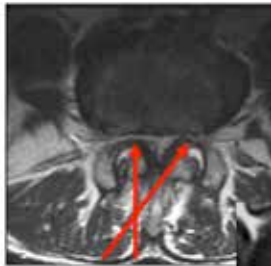


UNI-/ BILATERAL
UNI-/ MULTISEGMENTAL
PRESERVE THE FACETS
EXTEND DECOMPRESSION BY UNDERCUTTING THE FACETS AND LAMINA

MICROSURGICAL UNILATERAL APPROACH AND BILATERAL DECOMPRESSION



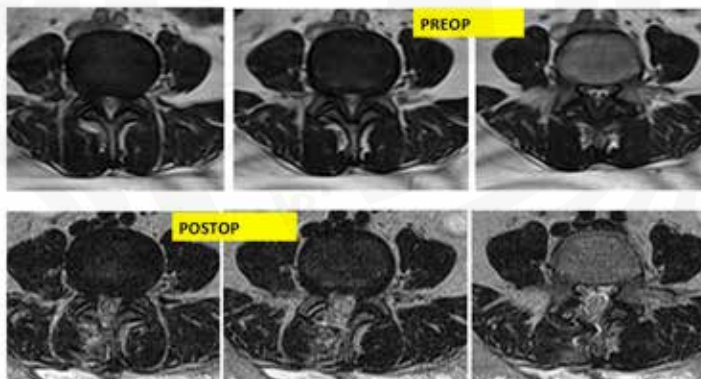
CLASSICAL FENESTRATION ON ONE SIDE
UNDERCUTTING THE SPINOUS PROCESS & CONTRALATERAL LAMINA
PRESERVE THE MULTIFIDUS MUSCLE ON CONTRALATERAL SIDE
DIFFICULT TO DECOMPRESS THE CONTRALATERAL DISC



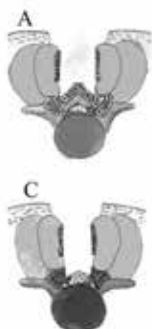
POSTOPERATIVE APPEARANCE OF BILATERAL DECOMPRESSION THROUGH UNILATERAL APPROACH



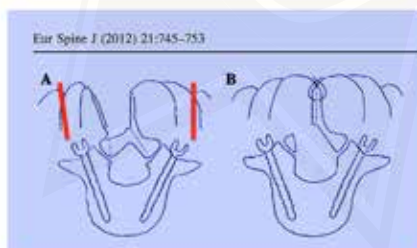
CASE EXAMPLE



SPINOUS PROCESS SPLITTING TECHNIQUE



KOTA WATANABE, J Neurosurg Spine 3:405-408, 2005.



Eiji Mori et al, Eur Spine J, 2012

PRESERVE THE INSERTION OF MULTIFIDUS CAN BE COMBINED WITH WILTSE APPROACH TO INSERT SCREWS AND CAGE

DECOMPRESSION THROUGH INTERSPINOUS LIGAMENT FIBERS



INCISION THROUGH SUPRASPINOUS LIGAMENT FIBERS WITH PRESERVATION OF THE LIGAMENT INSERTION ON SPINOUS PROCESSES
 DRILLING THE CAUDAL PART OF THE CRANIAL SPINOUS PROCESS
 DISSECTION THROUGH THE INTERSPINOUS LIGAMENT FIBERS AND BETWEEN MULTIFIDUS
 EXPOSURE OF THE LIGAMENTUM FLAVUM AND CRANIAL & CAUDAL LAMINAE
 CANAL DECOMPRESSION WITH UNDERCUTTING OF FACETS / LAMINAE
 YOSHIMOTO, SPINE, 2014

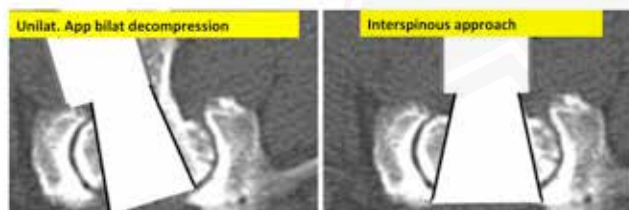
MIDLINE CUT THROUGH SUPRASPINOUS LIGAMENT FIBERS



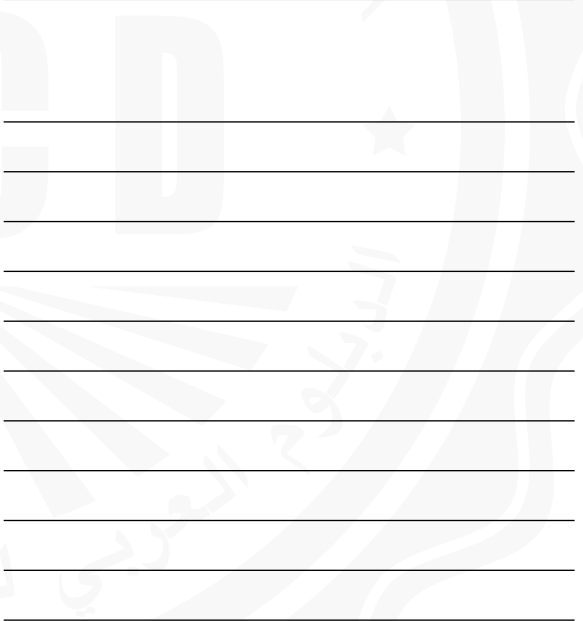
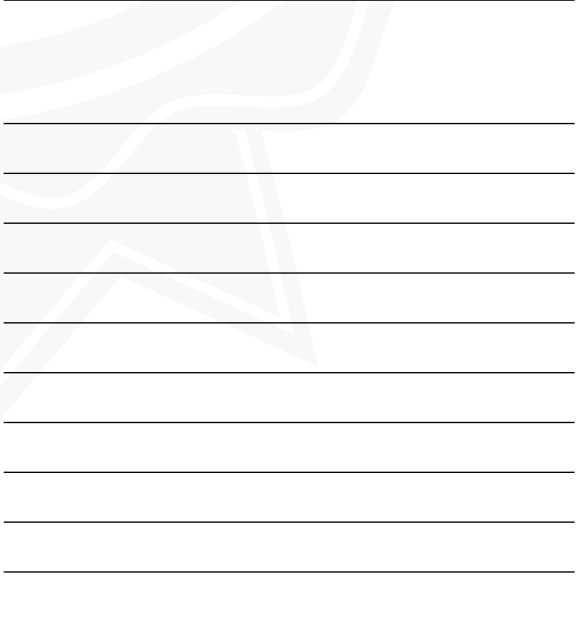
DRILLING THE CAUDAL PART OF THE CRANIAL SPINOUS PROCESS



DECOMPRESSION THROUGH INTERSPINOUS LIGAMENT FIBERS



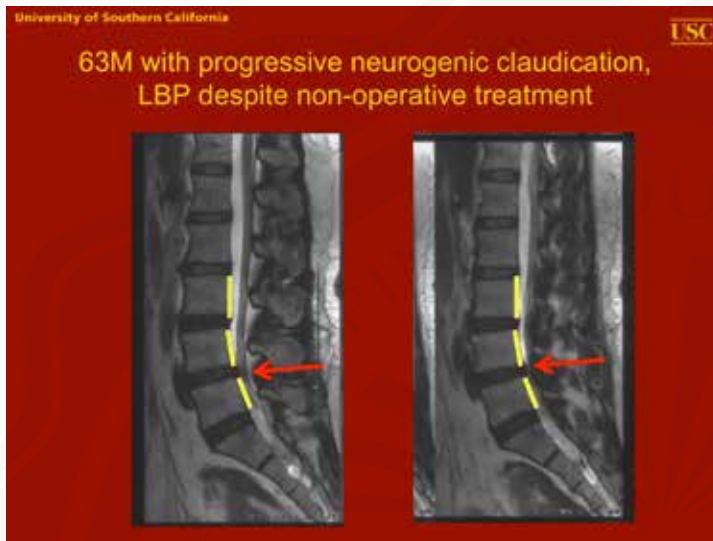
OFFERS A SYMMETRICAL WORKING CHANNEL
 VERY EFFICIENT FOR CANAL DECOMPRESSION OF THE UPPER LUMBAR SEGMENTS
 WHERE THE CANAL IS NARROWER AND FACETS SMALLER
 CAN BE ALSO PERFORMED FOR L4-L5

[illegible][illegible]

- 

Lumbar Canal Stenosis (LCS):

LCS: TO STABILIZE OR NOT?



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Lumbar Canal Stenosis (LCS)

- Degenerative condition
- Significant disability
 - Function
 - Walking ability
 - Quality of Life
- Surgical treatment > conservative treatment

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Surgical Treatment of LCS

- Decompression
- Decompression + stabilization
 - Minimize risk of future instability
 - Improve LBP symptoms
- 50% undergo fusion surgery in U.S.
 - Necessity?

- Registry study
 - N²QOD
- N=726
 - LCS
 - No spondy
 - No deformity
- BP ≥ 5 (1-10)
- Decompression only

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USC

Crawford et al. cont...

- Back pain
 - Significant improvement at 3- and 12-month follow up
- Leg pain
 - Significant improvement at 3- and 12-month follow-up
- ODI
 - Significant improvement at 3- and 12-month follow-up

Variable	Score	p Value
Back pain		
Baseline score	7.62	
3-mo score	3.19	0.000
12-mo score	3.66	0.002
Leg pain		
Baseline	7.23	
3-mo score	2.85	0.000
12-mo score	3.07	0.001
EQ-5D		
Baseline score	0.55	
3-mo score	0.76	0.000
12-mo score	0.75	0.613
ODI		
Baseline score	49.11	
3-mo score	27.20	0.000
12-mo score	26.38	0.000

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Crawford et al. Conclusions

- Patients with LCS and clinically significant LBP improve after decompression only through first postoperative year
 - No spondylolisthesis or deformity
- “Back pain” not necessarily an indication for fusion in patients with LCS

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Swedish Spinal Stenosis Study

The NEW ENGLAND
JOURNAL of MEDICINE

ESTABLISHED IN 1812 APRIL 14, 2016 VOL. 374 NO. 15

A Randomized, Controlled Trial of Fusion Surgery for Lumbar Spinal Stenosis

Peter Försrh, M.D., Ph.D., Gylfi Ólafsson, M.Sc., Thomas Carlsson, M.D., Anders Frost, M.D., Ph.D., Fredrik Borgström, Ph.D., Peter Fritzell, M.D., Ph.D., Patrik Öhagen, Karl Michaëlsson, M.D., Ph.D., and Bengt Sandén, M.D., Ph.D.

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SSSS

- Prospective, RCT
- N=247
 - Neurogenic claudication
 - Back pain
 - 1-2 levels
 - +/- Spondylolisthesis (
- 2-year ODI
- Per-protocol analysis

Table 1. Inclusion and Exclusion Criteria.

Inclusion Criteria Pseudoclaudication in one or both legs and back pain (score on visual-analogue scale >30)* 1 or 2 adjacent stenotic segments (cross-section area of the dural sac ≤75 mm ²) between L2 and the sacrum on magnetic resonance imaging Duration of symptoms >6 mo Written informed consent	Exclusion Criteria Spondylolysis Degenerative lumbar scoliosis (Cobb angle >20 degrees) History of lumbar spinal surgery for spinal stenosis or instability Stenosis not caused by degenerative changes Stenosis caused by a herniated disk Other specific spinal conditions (e.g., ankylosing spondylitis, cancer, or neurologic disorders) History of vertebral compression fractures in affected segments Psychological disorders (e.g., dementia or drug abuse) that caused the surgeon to consider participation to be inappropriate
---	--

* Scores on the visual-analogue scale range from 0 to 100, with higher scores indicating more severe pain.

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Table 1. Outcomes in the Post-Operative Population *

Outcome	Absence of Degenerative Spondylolisthesis			Presence of Degenerative Spondylolisthesis		
	Fusion Group (N=84)	Decompression- Alone Group (N=52)	P Value	Fusion Group (N=67)	Decompression- Alone Group (N=58)	P Value
During the procedure						
Operating time -- min	116±47	85±28	<0.01	146±44	85±40	<0.01
Amount of bleeding -- ml	334±118	155±71	<0.01	385±114	111±71	<0.01
At 2 yr						
OFA score	26±21	17±18	0.70	25±19	21±18	0.11
EQ-5D score	0.42±0.13	0.19±0.11	0.40	0.41±0.11	0.49±0.18	0.29
VAS score for back pain	41±31	45±31	0.56	36±29	38±23	0.11
VAS score for leg pain	35±31	36±31	0.46	33±30	26±31	0.60
EQ-5D score						
Symptom severity	2.8±1.8	2.5±1.1	0.41	2.4±1.8	2.8±1.7	0.34
Physical function	1.9±1.7	1.8±0.8	0.20	1.9±1.8	1.7±1.1	0.31
Patient satisfaction	2.0±1.7	2.2±0.9	0.75	1.9±1.6	1.5±0.8	0.10
Percent of 6 months walk with or without assistive device -- no. (%)	41 (50)	41 (80)	0.38	14 (21)	39 (67)	0.08
Reoperation time to walk with or without assistive device -- no. (%)	21 (25)	17 (33)	0.89	11 (16)	35 (60)	0.04
Reoperation decrease in back pain -- no. (%)	11 (13)	11 (21)	1.18	11 (16)	34 (59)	0.07
Reoperation decrease in leg pain -- no. (%)	10 (12)	11 (21)	1.19	12 (18)	48 (81)	0.07
Reoperation increase in walking distance -- no. (%)	40 (49)	41 (80)	1.11	38 (56)	31 (52)	0.80

- No significant differences in pain scores
- No significant differences in 6-min walk
- Holds true for patients with spondy (even >7mm slip)

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Health Resource Utilization

Table 4. Resource Use.*

Variable	Fusion Group (N=113)	Decompression- Alone Group (N=119)	P Value
During the procedure			
Length of hospital stay (days)	7.4±8.4	4.1±6.1	<0.001
Mean operation costs (U.S. \$)†	12,200	5,400	
At 2 yr			
No. of visits to doctors	1.3±3.3	1.8±5.3	0.49
No. of visits to other health care professionals	13±32	22±45	0.13
Total no. of days receiving benefits of any kind	61±172	41±117	0.35
No. of patients using analgesics for back problems at 2 yr (%)	42 (40)	40 (37)	0.57

- Fusion Group
 - Higher Direct Costs
 - Similar Indirect Costs at 2 years
- Reoperation: 22% (fusion)/21% (decomp)

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Limitations of SSSS

- Stability?
 - Biomechanical characteristics predisposing to 'instability'
 - Facet joint edema
 - Flex-ex radiographs
 - >10° angulation
 - >4mm motion
- MIS approaches?
 - Operative time, EBL, LOS, reoperation rate
- Indications for reoperation?

Take Home Points for LCS

- Back pain can improve with decompression only
- Decompression + fusion not superior to decompression alone (even + Spondy)
 - Fusion increases direct hospital costs
- Patient-specific factors should always be taken into consideration



Thank You



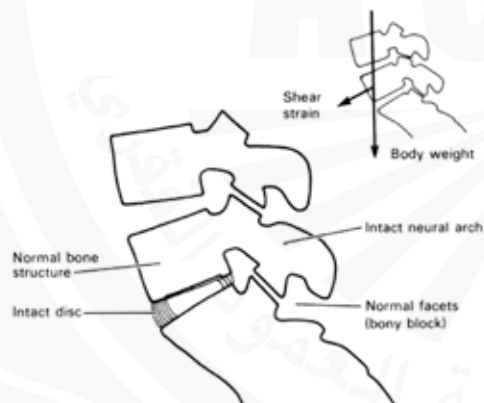
Spondylolisthesis:

CLASSIFICATION - NATURAL HISTORY

- **Definition:** anterior displacement of a vertebra relative to the vertebra below (reverse = retrolisthesis)



- The normal locking mechanisms resisting forward displacement of the vertebral body



• Classification (Wiltse)

Type	Description
Type 1 Dysplastic (congenital)	With a defect in the upper sacrum or arch of L5
Type 2 Isthmic	Pars problem
Type 2A	Lytic (defect in the pars)
Type 2B	Elongation of the pars
Type 2C	Acute traumatic pars fracture
Type 3 Degenerative	Disc & facet degeneration, leading to segmental instability & gradual slippage
Type 4 Post-traumatic	Fracture of neural arch other than pars
Type 5 Pathologic	Weakening of neural arch due to disorders of bone
Iatrogenic	Excessive removal of bone following spinal decompression

Grading (Meyerding):

- Amount of vertebral subluxation in the sagittal plane.
- Superior end plate of the subjacent vertebra is divided into quarters & the location of the posterior margin of the listhetic vertebra within these divisions is determined.



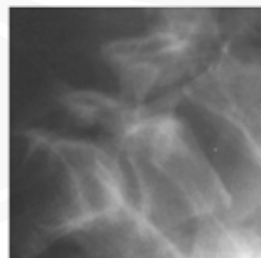
Grade	
I	0-25% subluxation
II	25-50% subluxation
III	50-75% subluxation
IV	75-100% subluxation
Spondylolysis (V)	Complete or >100%

- **Dysplastic Spondylolisthesis**

- Dysplasia (aplasia) of L5/S1 facet joints.
- Spina bifida occulta at L5.
- F:M = 2:1.
- Frequently beyond 50% even to 100% (concomitant elongation of the pars/frank lysis).
- During the adolescent growth spurt.
- LBP.
- Short trunk compared to the LL.
- Crease across the front of the abdomen.
- Hamstring tightness: abnormal gait /inability to bend.
- Lumbosacral kyphosis.



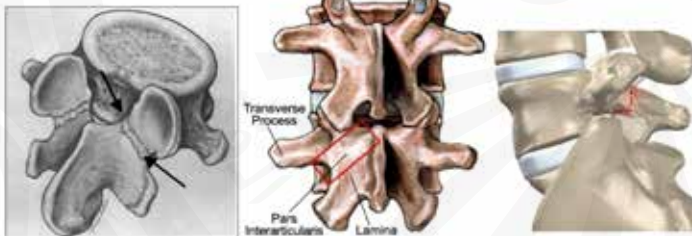
Anteroposterior radiograph demonstrates the "Napoleon's hat" sign. (b) Lateral radiograph demonstrates approximately 70% slip, with posterior wedging of L5 and rounding of the superior endplate of S1. Note the pars defect of L5 (arrows).]



Spondylolysis

- **Definition** A defect in the pars interarticularis (a fibrocartilagenous cleft).
- **Anatomy**
 - **Pars interarticularis** = Thin bicortical region of the posterior arch of the lumbar vertebra, where the lamina & the inferior articular process intersect with the pedicle & superior articular process.
- **Site** 95% of defects occur at the L5 level (usually bilateral)/ Highest biomechanical forces on pars.

- **Pars Interarticularis**

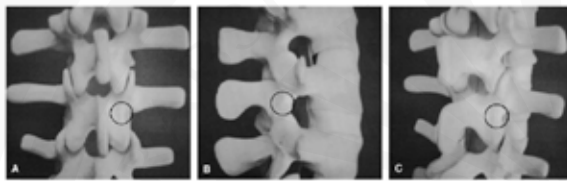


- **Aetiology & Pathophysiology**

- Stress fracture, 2ry to chronic low grade trauma from repetitive spinal hyperextension /rotation/ axial loading.
- Genetic predisposition to a dysplastic cartilaginous region in the developing posterior arch.



- With lumbar spine extension, the inferior articular process of the cranial vertebra impacts the pars of the caudal vertebra → Repetitive impacts can produce a stress fracture.
- Lumbar hyperextension activities (gymnastics)/ lumbar hyperextension 2ry to spinal deformity, such as Scheuermann disease → spondylolysis.
- Never has been reported in individuals who cannot walk.



• Epidemiology

- Incidence in the general population: 4-8%
- Develops between ~6yrs of age (minimal stresses of ADL/ genetic predisposition) & early adulthood
- More in young, athletic population
- Certain sporting activities: reaches 23-63%
- Boys > girls
- Family history
- Race: Inuit 25%

- ❖ Gymnastics
- ❖ Wrestling
- ❖ Weight lifting
- ❖ Pole vaulting
- ❖ Diving
- ❖ Swimming (esp. the butterfly stroke)
- ❖ Tennis (esp. serving)
- ❖ Volleyball

• Clinical Picture

- Commonly asymptomatic or associated with LBP from other causes (Is it the cause?).
- A high index of suspicion: young (typically sporting/ 15-16 yrs) patient C/O exacerbation of LBP with activity.
- Acute or gradual onset LBP, exacerbated by motions such as twisting & hyperextension.
- The sporting population suffer from greater relative loss of function.
- Incidence of LBP increases with age.
- Referred pain into buttocks /posterior thigh.
- True radicular pain very rare.

• Why is pars defect painful?

- Soft tissue at the pars defect (spondylolysis ligament)
 - ❖ High density of neural tissue.
 - ❖ Neuropeptides associated with sensory /nociceptive transmission.
 - ❖ Defective healing of the pars defect is probably due to the stretching of these neural elements.
- Associated degenerate disc or facet joint.
- Acute stress fracture (pain subsides once the acute processes subside).
- Segmental instability caused by the structural defect in the pars.

• Physical Examination

- Standing one-leg lumbar extension manoeuvre → accentuation of pain (Load shift to pars/ also painful if there is pathology of the facet joints).
- Lumbar paraspinous muscle spasm/ tenderness.
- Forward bending usually painless, but extension to an upright posture may produce pain.
- Pain throughout the lumbar spine range of motion.



Pain is usually elicited on the affected side but lessens or disappears when the maneuver is repeated on the contralateral leg

• Natural History

- Unpredictable progression: subtle stress reaction → olisthesis.
- Period of most likely & rapid slipping: 9-15 years.
- Slippage is rare after the vertebral growth is complete (18-21 years).
- Competitive sports does not affect the progression of olisthesis.
- Unilateral pars defects are not associated with spondylolisthesis or significant disability.
- Bilateral pars defects:
 - ❖ Develop symptomatic progression in only a small percentage in long term F.up studies
 - ❖ 5% incidence of progression of slip in adulthood

• Pathological Spondylolisthesis

- Rheumatoid arthritis.
- Metastasis.
- Paget's.
- TB.
- GCT.
- Arthrogryposis.
- Syphilis.



• Traumatic Spondylolisthesis

- Severe trauma.
- Fracture to pedicles/ facets.
- May occur gradually over a few weeks or months.
- Best demonstrated by CT.
- MRI: associated soft tissue injury (rupture of the disc & posterior ligamentous complex).

• Degenerative Spondylolisthesis

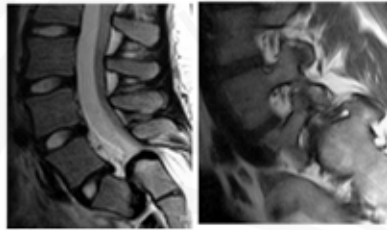
- Degenerative incompetence of the posterior facet joints/ disc.
- L4/5 > L5/S1 (10 times).
- F>M 6:1 → facet degeneration in association with primary generalized osteoarthritis.
- >50yrs of age (most common in 6th decade).
- Degree of slip never exceeds 30% (rarely > G1).
- More sagittally oriented facets than those without.
- Spinal Stenosis
 - ❖ Neurogenic claudication.
 - ❖ Radicular symptom.
- Long history of back pain prior to LL symptoms.
- Consider: vascular insufficiency/ peripheral neuropathy.

• Clinical Picture

- Even high-grade spondylolisthesis can remain asymptomatic.
- Low back pain
 - ❖ Causes:
 - Chronic lumbar muscle strain secondary to lumbar hyperlordosis & sagittal malalignment.
 - Referred pain from:
 - Degenerative disc.
 - Degenerative facet joint.
 - Fibrocartilagenous pars defect.
 - Increased stress on the annulus fibrosus at the slip level (strained AF).
- Referred pain into buttocks & posterior thigh (common in the adult with back pain).
- Radicular pain (sciatica) or paresthesia in a dermatomal pattern below the knee.
 - ❖ More specific for nerve root impingement.
 - ❖ May be accompanied by corresponding neurologic deficits.
- Neurologic symptoms & signs result from impingement on the exiting nerve root by:
 - ❖ Hypertrophic fibrocartilagenous or bony tissue at the site of the pars defect.
 - ❖ Vertebral end plate osteophytes.
 - ❖ Nerve root traction from static or dynamic listhesis.
 - ❖ Disc bulges/ herniations.
 - ❖ Rarely: between the L5 transverse process & the sacral ala (large TP/ slip >20%).



- With isthmic (unlike degenerative): the vertebral body & posterior elements are dissociated.
 - ❖ Forward slip of body does not result in central stenosis.
 - ❖ Complete occlusion of the cauda equina is unlikely, unless:
 - High grade listhesis: the thecal sac gets stretched over the posterosuperior border of the sacrum.



• Physical Examination

- Palpable step-off at the spinous process above the slip level.
- Shortened trunk.
- Loss of lumbar lordosis/ spasm.
- Associated scoliosis.
- Lumbar hyperlordosis in persons with increased sacral inclination.
- Limited lumbar spine range of motion, with worsening pain on extension.
- Tight hamstrings (popliteal angle/ abnormal gait).
- Heart shaped buttocks/ transv. abdominal crease.
- Sciatica typically not associated with +ve SLR (nerve tension).
- Neurological examination (L5).
- High grade: Rectal examination → Cauda equina S.

• Hamstring tightness

- Phalen-Dickson sign: tight hamstrings & knees-bent/hips-flexed gait
- Mechanism that causes tight hamstrings is not entirely clear
 - ❖ Cauda equina irritation → reflex spasm
 - ❖ Try to the vertical position assumed by the sacrum in higher grades of slippage, with resultant flexing of the pelvis, so that the hips cannot extend sufficiently. This results in knees flexed to permit the patient to stand upright
- Manifestations
 - ❖ Inability to flex the trunk with straight knees.
 - ❖ Restriction of SLR.
 - ❖ Waddling or short-stepped gait with flexed knees.

- Pelvic rotation/ tilt (top of S1 horizontal) results in:
 - Inability of the hips to extend sufficiently to permit the patient to stand upright.
 - Lumbosacral kyphosis/ 2ry thoracolumbar lordosis.
 - Relative posterior prominence of the posterior parts of the iliac crests → heart shaped buttocks.



• Imaging

- Lateral view LS spine (Standing)
 - ❖ Pars defect.
 - ❖ Grading degree of slip.
 - ❖ Spinous process & post. elements remain behind.
 - ❖ Measurement of slip angle.
 - ❖ Lumbar index.
 - ❖ Pelvic incidence.
- Oblique lateral views
- AP view (associated scoliosis / spina bifida)
- Note dysplastic features such as:
 - ❖ Trapezoidal L5 vertebra.
 - ❖ Sacral doming.
 - ❖ Deficient inferior articular process.
- Note degenerative changes as:
 - ❖ Loss of disc height.
 - ❖ Osteophyte formation.

• Slip Angle

- Measures kyphosis at the listhetic level.
- Angle between a line perpendicular to the posterior margin of the subjacent vertebral body & a line parallel to the superior (inferior) end plate of the olisthetic vertebra.
- Remodeling at the inferior border of L5 may make this measurement difficult.



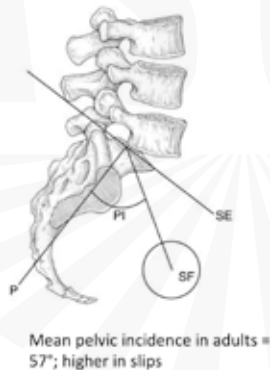
• Lumbar Index

- A measure of deformity of the listhetic vertebral body (trapezoidal shape).
- Calculated by dividing the height of the posterior cortex (P) of the olisthetic vertebral body by the height of the anterior cortex (A) of the vertebral body. The value is expressed as a percentage ($P/A \times 100\%$).
- A low lumbar index correlates with high-grade slips (< 75: high degree slip at presentation).



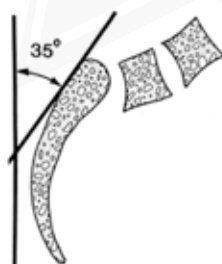
• Pelvic Incidence

- A measure of lumbosacral-pelvic orientation that is related to spinal sagittal alignment.
- Calculated by drawing a reference line (SE) along the superior end plate of S1. A line (P) is drawn perpendicular to the reference line from the midpoint of the S1 superior end plate. A second line is drawn from the midpoint to the center of the femoral heads (SF). PI is the angle between these lines.



• Sacral Inclination

- Angle between the posterior aspect of the sacrum & the vertical.
- With higher degrees of slippage the sacrum becomes more vertical & sacral inclination decreases.



- Progression of listhesis d.t. increased gravity shear stresses across the lumbosacral joint.
- **Risk factors of slip progression**
 - Young (adolescent growth spurt).
 - Dysplastic > isthmic.
 - Female.
 - Initial slippage > 50% (adolescent/ child).
 - High-grade slips (Meyerding grade III, IV & V).
 - High slip angle > 55° (growing child).

Spondylolisthesis:

SURGERY FOR GRADE 1- 2

Spondylolisthesis Surgery for Grade I- II

Anatomy



Classification

- Dysplastic spondylolisthesis
- Isthmic spondylolisthesis
- Degenerative spondylolisthesis
- Traumatic spondylolisthesis
- Pathological spondylolisthesis
- Iatrogenic spondylolisthesis

Group	Number of cases	Males	Females
I (Congenital)	66	20	46
II (Spondylolytic)	164	93	71
III (Traumatic)	3	3	0
IV (Degenerative)	80	22	58
V (Pathological)	6	4	2
Total	319	142	177

Newman & Stone
JBJS Br 1963; 45: 39 - 59

Dysplastic spondylolisthesis

- True congenital spondylolisthesis
- Malformation of the LS junction
- Small incompetent facet joints
- Very rare
- Rapid progression
- Severe neurological symptoms.

Isthmic spondylolisthesis

☛ Type A

- Most common under 50 years
- Biomechanical stress
- Repetitive mechanical
- Heavy work or sports
- Fatigue fracture
- Pars interarticularis.

Isthmic spondylolisthesis

☛ Type B:

- Elongated pars
- No separation
- Repeated minor
- Trabecular stress fractures of the pars
- Sub-acute stress fractures
- Then heal
- Vertebral body is displaced farther
- May fail to heal and result as a full pars defect.

☛ Type C:

- Extremely rare
- A cute pars fracture
- Traumatic lumbar hyperextension injury

Degenerative spondylolisthesis

- ☛ Most common type over 50 years
- ☛ Rarely under 50
- ☛ No pars fracture or elongation
- ☛ Intact neural arch
- ☛ Due to destruction of the joints
- ☛ Usually presented with claudication

Traumatic spondylolisthesis

- ☛ Extremely rare
- ☛ Fracture pars
- ☛ Hangman's Fracture in CS
- ☛ Rare in LSS

Pathological spondylolisthesis

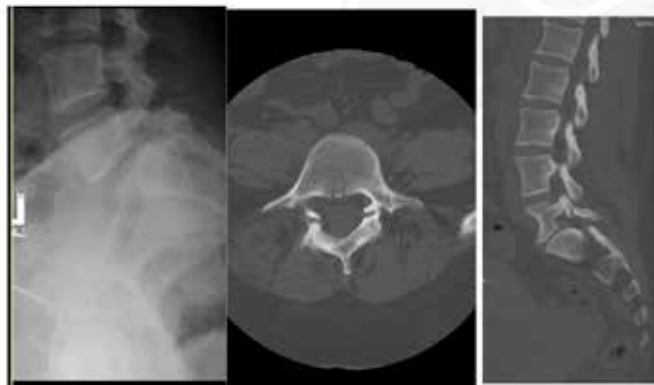
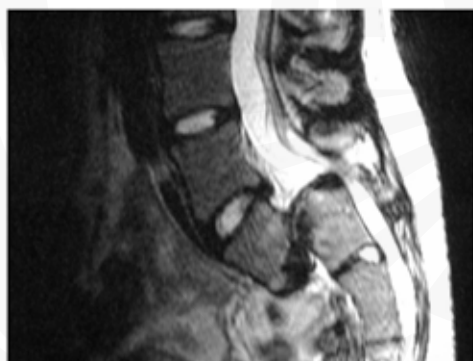
- ☛ Systemic disorders
 - Osteoporosis
 - Paget's disease
 - Metastatic carcinoma

Iatrogenic Spondylesthesis

- ☛ Post decompression surgery
- ☛ Excessive removal of
 - Lamina
 - Facets
 - Pars

Grading

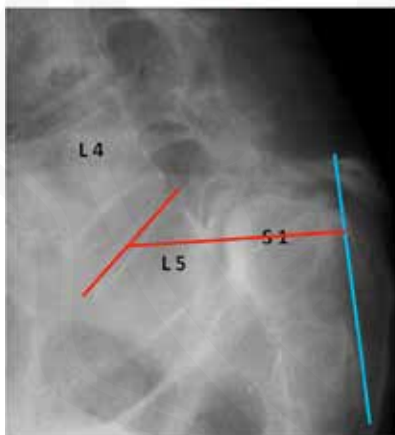
- Grade I
 - Less than 25%
- Grade II
 - 25%-50%
- Grade III
 - 50%-75%
- Grade IV
 - Up 100%
- Grade V
 - Spondyloptosis
- Low grade
 - I&II
- High grades
 - III, IV & V



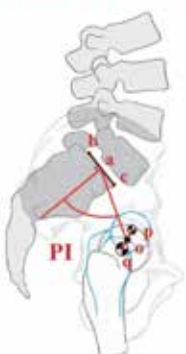
Degenerative



Slip angle



Pelvic incidence



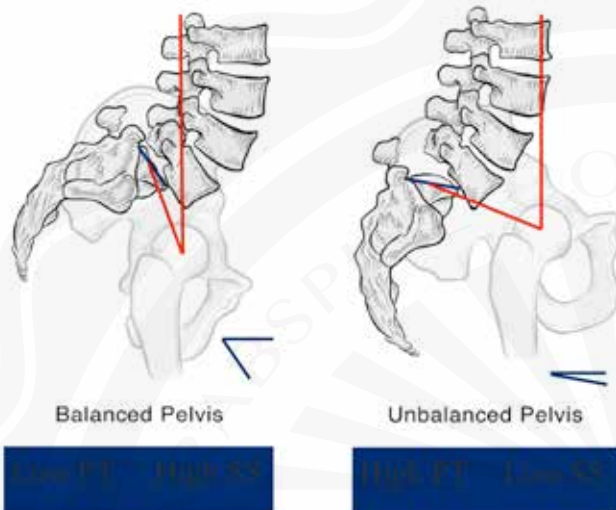
Pelvic tilt



Sacral slope



$$PI = PT + SS$$



Conservative treatment

- 20 Adequate trial
- 20 3-4 months
- 20 Multimodality approach
- 20 Psychological concern
- 20 Motivation
 - Comply and no excuses
- 20 Adequate compliance
- 20 Weight loss
- 20 Exercise
- 20 Stretch



Surgery

- 20 Indications
 - Failed conservative treatment
 - Symptomatic radiographic instability
 - Slip progression
 - More than grade II
 - Symptomatic grade III
 - Symptomatic grade IV
 - Symptomatic Grade V
 - Spondyloptosis
 - Acute nerve compression
 - Bowel or bladder incontinence
 - Severe back and leg pain
 - Abnormal neurology
 - Positive diagnostic injections



Contraindication

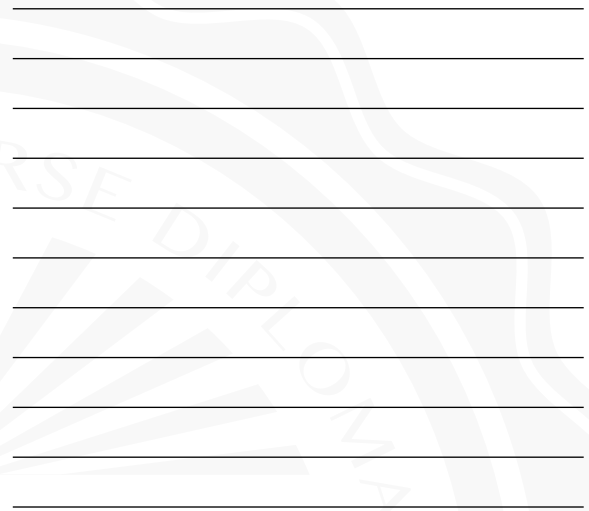
- ☞ Relative
- ☞ Multilevel disease
- ☞ Poor patient motivation
- ☞ Poor compliance
- ☞ Low activity
- ☞ Osteoporosis
- ☞ Tobacco abuse

Decision

- ☞ Individualized for each patient
- ☞ Think of the natural history
- ☞ Severity and duration of symptoms
- ☞ Co-morbidities
- ☞ Choice of surgery based on symptoms
 - Axial back pain only
 - Fusion only may work
 - Radicular pain only
 - Decompression only
 - Limited
 - Axial and radicular pain
 - Combined decompression and fusion

Surgery goals

- ☞ Address the pars defect
- ☞ Decompress the foraminal stenosis
- ☞ Address the degenerate disc/s
- ☞ Address the dynamic instability



ASCD

- fusion

situ PL fusion

fusion options

- [illegible]

Anterior approach

- ☛ Usually fusion required
- ☛ Disc removal 100%
- ☛ Instrumentation usually needed
- ☛ Advantages
 - Interbody fusion
 - Large fusion surface
 - Maintain height
 - Widen neuroforamina

Anterior approach

- ☛ Disadvantages
 - Limited visualization
 - Of nerves
 - Lordosis
 - Downward tilt of the disc
 - Injury
 - Nerves
 - Vessels
 - Ureter
 - Impotence

Dorsal approaches

- ☛ Indicated in isthmic type
 - If no disc disruption
- ☛ Degenerative lesthesis
 - Fuse L4-5
 - To include L5-S1
 - More stress on other segments
 - Floating fusion

Fusion without decompression

- Fusion only
- Chronic refractory pain
- Instability
- No radicular pain
- Can relieve symptoms
 - Nerve traction
 - Intermittent compression
 - Spinal canal
 - Lateral recess
 - Neuronal foramen

Fusion without decompression

- Advantages
 - Good results
 - Stability
 - Less OR time
 - Less complications
- Disadvantages
 - No decompression

Decompression

- absolute indications
 - Neurological deficit
 - Leg pain
 - Sphincter dysfunction
 - Claudication

Decompression

- ☛ Anatomical derangements
- ☛ Degenerative lesthesis
 - Facet hypertrophy
 - Ligaments thickening
 - Synovial cyst
 - Bony osteophytes
- ☛ Isthmic lesthesis
 - Multifactorial
 - pars enlargement
 - Bulging disc
 - Ligaments

Decompression

- ☛ Spinal stenosis
- ☛ Lateral recess stenosis
- ☛ Foraminal stenosis
- ☛ Laminectomy
- ☛ Avoid
 - Radical laminectomy
 - Excessive facetectomy
 - Disc violation

Gill procedure

- ☛ Decompression
- ☛ Described by Gill 1955
- ☛ No fusion
- ☛ Removal of loose element
 - Lamina
 - Facet
 - Foraminotomy



Carragee JBJS Am 1997

Gill procedure

- Effective treatment
- Contraindicated in
 - Young adolescent
 - Less than 30 years
- Never in isolation
- High Pseudarthrosis rate

Fusion and instrumentation

- Failed conservative treatment
- Instability
- Axial back pain
- Instrumentation
 - Better fusion rate
 - Better initial stability
 - Restore lumbar lordosis
 - Non fusion high risk population
 - Smokers

Fusion only

- L5 S1 only adequate
- Improvement in leg pain
- Even no decompression
 - Dynamic compression
 - Traction



Burkus JBJS Am 1992
Frennerd Spine 1991
DeLobresse Clin Orthop 1996

Fusion only

Instrumented fusion

- Better fusion rate
- Better stability
- Restoration of lordosis
- Better clinical outcomes

Un-instrumented fusion

- Osteoporosis

Zdeblick Spine 1993
Yuan Spine 1994
Ricciardi Spine 1995
Moller Spine 2000



Fusion only

- Level
- Consider levels above
- Above level changes
- Higher slip angle
- Retro-listhesis



Interbody Fusion

- Anterior column support
- Biomechanical advantage
 - Large fusion area
 - Compression load
- Better disc removal
- Indirect decompression
- Indirect reduction
- Build in the lordosis



Interbody fusion techniques

PLIF
TLIF
DLIF
OLIF
ALIF



Decompression, Fusion & instrumentation

- ☛ Can work for grade I&II
- ☛ Combined advantages
- ☛ Better fusion rate
- ☛ Better decompression
- ☛ Direct & indirect
- ☛ Prolonged surgery
- ☛ Implant

Combined anterior & posterior approach

- ☛ Anterior approach
- ☛ To insure 360 degrees fusion
- ☛ Not indicated for low grade
- ☛ Usually high grade
- ☛ Complications
- ☛ Single approach fusion 80%
- ☛ Reserved for failed previous fusion

Par repair

- 70 Young population
- 70 Isthmic type
- 70 Spondylolysis
- 70 Intact disc on MR
- 70 Grade I
- 70 Technique
 - Screws & hooks
 - Pars screw



Poor outcome

- 70 Poor patient selection
- 70 Inadequate conservative management
- 70 Inadequate diagnosis
- 70 Other causes of pain
- 70 Elective procedure
- 70 Multilevel degeneration
- 70 Patient expectations
- 70 Technical factors
 - Inadequate exposure
 - Inadequate decompression
 - Inadequate fixation

Pediatric population

- 70 Low grade slip and or spondylolysis
 - Conservative
- 70 Surgery may be indicated
 - Progression beyond Gr II
 - At presentation, > Gr III
 - Persisting pain; neurologic deficit
 - Progressive postural deformity
 - Gait abnormality

Summary

- ☛ Careful patient selection
- ☛ Always try conservative management
- ☛ Medication
- ☛ Physical therapy
- ☛ Evaluate patients symptoms & goals
- ☛ Careful selection of the approach

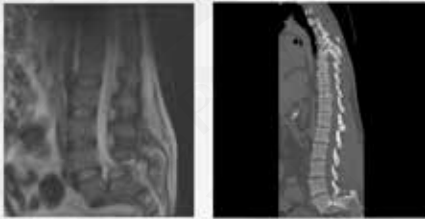
Summary

- ☛ Evaluate your setup
- ☛ Equipment's
- ☛ Skills
- ☛ Select approach
- ☛ Decompression alone may be effective
- ☛ Consider fusion when needed
- ☛ Decompression & fusion
 - Combined benefits
- ☛ MIS can be used
- ☛ Reserve anterior approach for high grade

Spondylolisthesis:

SURGERY FOR HIGH GRADES

Management of High-Grade Spondylolisthesis



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Disclosures

Guy (a) Alphatec; (b) Spinal Kinetics, Spinal Ventures, Mimedix; (c) DePuy-Synthes Spine, K2M, Flexuspine, Mimedix, Aesculap; Safe Orthopedics (d) DePuy-Synthes Spine, K2M, Paradigm Spine

Key: (a) royalties; (b) stock/options; (c) consulting/SAB; (d) Speaker/ faculty; (e) Research; (f) Fellowship and related research; (g) other

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High-Grade Spondylolisthesis

- In Greek, "spondylo" means vertebra and "listhesis" means to slip

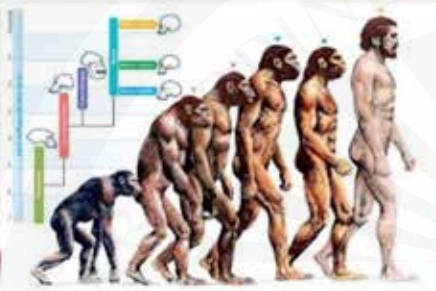
Occurs in 2-6% of the population



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Spondylolisthesis

- Related to development of lumbar lordosis and erect posture
- Never been recognized in other species
- Never documented in non-ambulatory human beings
- Only one congenital case reported

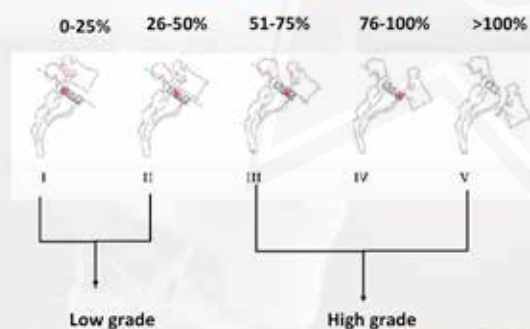


Wiltse, Newman, McNab

- I Dysplastic
- II Isthmic A. Lysis; elongation; Acute pars fracture
- III Degenerative 20%
- IV Traumatic (vertebral #s other than the pars)
- V Pathological (neoplastic or metabolic, Paget's, OI)
- VI Post-surgical



Spondylolisthesis – Spondylosis Meyerding 1931



High-Grade Spondylolisthesis



Low grade

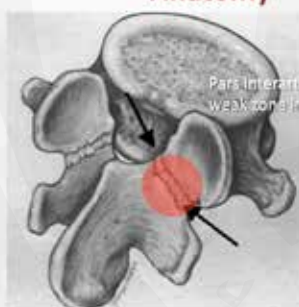
High grade

High-grade spondylolisthesis is defined as Meyerding grade III, IV, or V with an increased L5-S1 kyphosis / slip angle

Bridwell, Neurosurg Clin N Am, 2006

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Spondylolisthesis – Spondylosis Anatomy



Part of vertebra located between the interior and superior articular processes of the facet joint

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Spondylolisthesis - Spondylosis

- Most common level is L5-S1, although spondylolisthesis can occur at L4-5 and rarely at higher levels

L5-S1	87%
L4-5	10%

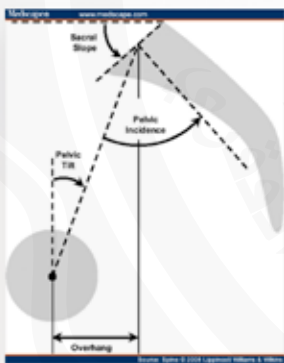


Risk Factors for Spondylolisthesis and Spondylolysis

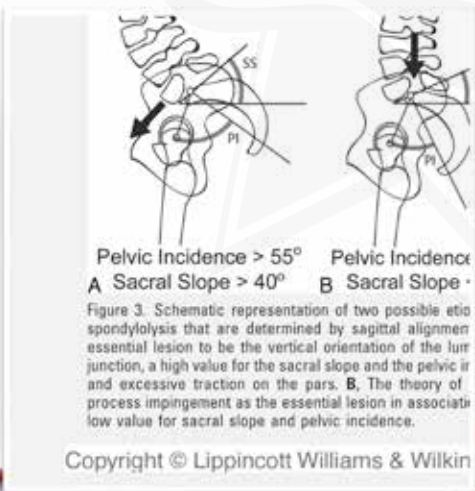
- Etiology is multifactorial
- Genetic risk factors
 - Higher rate in certain family
 - Higher rate in some race (Eskimos)
 - Greater rate in males
- Mechanical risk factors
 - Higher occurrences in gymnasts, football players, and heavy laborers
 - Repetitive stress/injuries to the pars
 - Increased shear force from high pelvic incidence and sacral slope



Spinopelvic Alignment



- Pelvic incidence is the angle between the perpendicular to the sacral endplate at its midpoint and a line connecting the same point to the center of the femoral heads
- Increase PI is associated with increased sacral slope and verticalization of S1 end plate
- Verticalization of L5-S1 disc space and Increase shear force



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Sagittal Alignment of the Spine and Pelvis in the Presence of L5-S1 Isthmic Lysis and Low-Grade Spondylolisthesis

Pierre Fournouy, MD,* Sohrab Gollogly, MD,* Eric Berthoinaut, PhD,† Hubert Labelle, MD,‡ and Mark Weidenbaum, MD§

Parameter	Label	Normal Average	Average	Minimum	Maximum	SD
Spondylolisthesis	%	2.0%	27.42%	0.40	45.38	8.52
Pelvic incidence	PI	51.31	65.52*	34.71	88.81	15.33
Sacral slope	SS	35.32	47.95	25.73	78.88	12.22
Pelvic tilt	PT	15.99	17.58	1.40	42.75	8.47
L5 incidence	L5	22.42	26.90*	3.49	79.52	15.12
L5-S1 extension	L5-S1 _{ext}	-12.89	-4.58*	-21.99	15.26	6.22
Thoracic kyphosis	TK	42.25	44.17	15.20	82.7	12.62
Lumbar lordosis	LL	57.43	73.84*	38.71	108.68	12.69
No. of vertebrae with isthmia	NI	4.4	3.1	2.25	10.50	1.96
L5 wedge	L5 _w	8.52	13.87	4.52	32.90	5.24
L4-L5 extension	L4-L5 _{ext}	-12.15	-11.56	-27.00	-0.91	5.26
L4 wedge	L4 _w	3.18	6.52	-2.38	15.95	4.51

*Statistically different (P < 0.05).

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SDSG Classification

pelvis with unbalanced spine. Figure 5 illustrates clinical examples of these six postures.

In a recent clinical assessment of this refined version of the classification system, Mac-Thiong et al. [13] found improved and substantial intra- and inter-observer reliability similar to other currently used classifications for spinal deformity, with an overall intra- and inter-observer agreements of 80% (kappa: 0.74) and 71% (kappa: 0.65), respectively. Further improvements in reliability are expected with a computer-assisted classification technique.

Clinical relevance

Currently, the literature for deformity is mainly on the sagittal plane, mostly the sagittal plane. Patients with deformity are prone to conservative treatment. While deformity, the

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Clinical Presentation of Spondylolisthesis/ Spondylolysis

- Back pain
- L5 radiculopathy
 - Motor or sensory changes
 - Foot drop
 - Difficulty walking

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Clinical Work-Up

- Lumbar spine X-rays
 - Flexion / extension views to determine instability
 - See femoral heads to measure spinopelvic parameters
- MRI
 - Determine degree of neural compression
 - Eliminate other pathologies
- 36-in long-cassette X-rays
 - Measure spinopelvic parameters
 - Determine sagittal balance
 - Apply parameters of adult spinal deformity surgery
 - Restore C7 plumb line; goal SVA < +5cm
 - Restore spinopelvic alignment
 - Goal PT <20 degrees
 - Goal LL = PI ± 9 degree



Treatment Options

- Low grade spondylolisthesis
 - Observation
 - Medical treatment of pain symptoms
 - Surgical can be indicated with failure of conservative treatment
- High grade spondylolisthesis
 - Surgery is recommended for all high grade spondylolisthesis



Surgical Options

- Decompression only
- Decompression and in-situ fusion
- Decompression with instrumented fusion with or without reduction
- Bohlman's procedure
- Gaines procedure



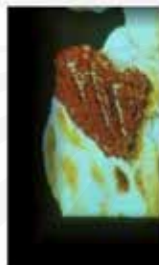
Decompression Only

- Decompression only (Gill's laminectomy)
- No generally indicated or recommend in the modern era
- Risk of instability
 - Slip progression
 - Progressive pain
 - Progressive radiculopathy



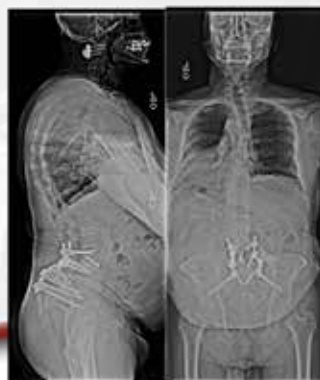
Decompression and In-Situ Fusion

- No reduction
- High rate of pseudoarthrosis
- Requires casting or other rigid immobilization



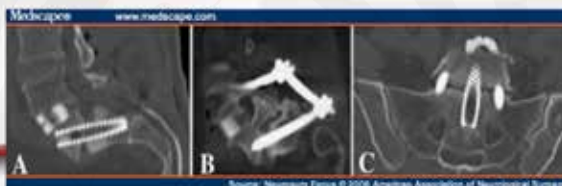
Decompression and Fusion with Instrumentation

- Provide immediate stability
- Improves fusion rate
- Allows for slip reduction
- Allows for early post-operative mobilization
- Discectomy and interbody fusion can be improve reduction as well as fusion



Bohlman's Procedure

- Described in 1982
- Provides anterior column support
- Provides resistances to shear across lumbosacral junction



Gaines Procedure

- A stage procedure
- 1. Anterior approach for L5 Vertebrectomy
- 2. Posterior approach with instrumentation, reduction of L4 onto S1, and posterolateral fusion

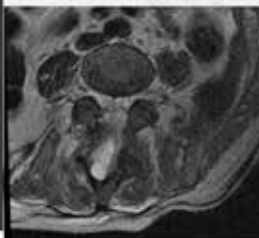
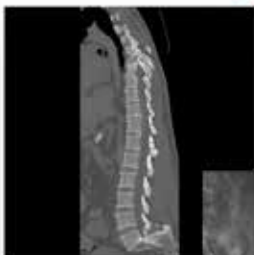
high-grade *spondylolisthesis* and :
two-stage *procedure*: L5 *vertebr*

L5 Vertebrectomy for
Rob


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Case Example

- 41M fell off a cliff and suffered multiple leg fractures and lumbar fractures
- Placed in bedrest for 2 months
- Had preserved DF/PF and bladder/bowel functions





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Reduction vs. No Reduction

No Reduction

- Pro
 - Straightforward operation
 - Decrease neurological risks
- Con
 - No improvement in slip angle or pelvic tilt
 - Overall lack of global sagittal alignment improvement

With Reduction

- Pro
 - Improve spinopelvic parameters
 - Improve global sagittal alignment
- Con
 - Increased surgical complexity
 - Significant risk of L5 nerve injury

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When to Reduce?

pelvis with unbalanced spine. Figure 5 illustrates clinical examples of these six postures.

In a recent clinical assessment of this revised version of the classification system, Mac-Thiong et al. [13] found improved and substantial intra- and inter-observer reliability similar to other currently used classifications for spinal deformity, with an overall intra- and inter-observer agreements of 80% (kappa: 0.74) and 71% (kappa: 0.65), respectively. Further improvements in reliability are expected with a computer-assisted classification technique.

Clinical relevance

Currently, the literature for decision-making is mainly on the mostly the slip patients with severe to conservative slips. While deformity th

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- Persistent lumbosacral kyphosis
- Sagittal imbalance
- Mismatched spinopelvic parameters

Operation. The gaitance and stabilizer 1 placed prone on a table made to allow external view. After the instrument was investigated, a stable art throws at the L4–5 placed bilaterally. It was obtained using chosen due to the ability to facilitate formation, stress on the more evenly on the integrity of the pelvis as a osteotomies were given.



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cept, normal vaginal balance does return to normal. The intention is to reduce a patient's need for the use of such microbicide implants.

Presidential and Executive
was referred to our institution.

29

- Fixed kyphosis requires an osteotomy for correction
- Sacral osteotomy to correct the L5-S1 angle and pelvic incidence
- Change of PI to match altered lumbar lordosis

[illegible]

Parameter	Preop Angle (°)	Postop Angle (°)	Norm Values
pelvic incidence	88	65	51.8
sacral slope	65	49	39.7
pelvic tilt	22	14	12.1
lumbar lordosis	68.7	61.4	42.7
L5 incidence angle	71	32	NR

J. Neurosurg: Spine / Volume 6 / April, 2007

[illegible]

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Summary

- Spondylolisthesis is a common condition among ambulatory human beings
- Low-grade spondy can be managed conservatively
- Surgical treatment is recommended for high-grade spondylolisthesis
- Spinopelvic and sagittal alignment parameters are critical for treatment planning and success
- Reduction should be considered with alterations in spinopelvic parameters or sagittal imbalance but the risk to the L5 nerve root should be weighted



Degenerative Spine Disease:

DEGENERATIVE SPINE DISEASE: OVERVIEW AND CONSERVATIVE TREATMENT

What is DSD NOT DDD?

• A group of conditions that involve a loss of normal structure and function in the spine:

1. Disc: Degeneration, Herniation/ Sequestration, Nerve Roots affection
2. Spondylosis: Vertebral Body Osteophytes, Facet Joint Arthrosis, Synovial Cysts
3. Spinal stenosis
4. Spondylolethesis
5. Paravertebral tissues : muscle sore or spasm, tendinitis



Pathophysiology

- Pain can originate from bone, joints, ligaments, muscles, nerves and intervertebral disks, as well as other paravertebral tissues
- It is the normal effects of aging → Infection, tumors, muscle strains, or arthritis
- Pressure on the spinal cord and nerve roots associated with spinal degeneration may be caused by disc displacement or herniation
spinal stenosis
osteoarthritis, cartilage breakdown at spinal joints.

Be aware of the RED FLAGS

Fracture:

- Age >70
- History of osteoporosis
- Trauma
- Corticosteroid use

Tumor:

- Age >50
- History of previous cancer
- Unexplained weight loss

Infection:

- Fever, chills
- Recent skin or urinary infection
- Immunosuppression
- IVDU
- Recent spine surgery

Neurologic:

- Sciatica
- New onset urinary/fecal incontinence
- Abnormal neurologic exam: motor, sensory, reflexes

Conservative Treatment

- Bed Rest and Advice to Stay Active
- Reducing the Risk of Degenerative Disc Disease:
 - Smoking
 - Avoid over weight
- Self care:
 - Learning proper posture and lifting techniques
 - Stress → relaxation exercise
- Brace Wear and Other Orthotics as shoe insoles

[illegible]

Conservative Treatment

Medical treatment

- OTC
- Narcotics
- Topicals
- Muscle Relaxers

[illegible]

Conservative Treatment

Holistic therapy

- Chiropractic
- Acupuncture
- Acupressure
- Deep tissue massage
- Nutritional supplements
- Biofeedback

[illegible]



Degenerative Spine Disease:

DECISION MAKING FOR SURGICAL MANAGEMENT

*"The decision is more important
than the incision."*

Anonymous

Controversy in Treatment

- Surgical:
 - Fusion vs Arthroplasty vs Dynamic Stabilization
 - Fusion: ? approach, ? graft, ? instrumentation
 - Open vs MIS
 - Approach: ALIF, PLIF, Circumferential, TLIF
 - Graft: allograft, autograft
 - Instrumentation: need? type?
 - Arthroplasty: Total Disc vs Nucleus Pulposus
 - Dynamic Stabilization

Rationale of Fusion

- To eliminate pathologic segmental motion and its accompanying symptoms, especially low back pain

SPINE Volume 25, Number 22, pp 2333-2339
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2001 Volvo Award Winner in Clinical Studies: Lumbar Fusion Versus Nonsurgical Treatment for Chronic Low Back Pain

A Multicenter Randomized Controlled Trial From the Swedish Lumbar Spine Study Group

Peter Fritzell, MD,* Ole Hagg, MD,† Per Westberg, MD,† Anders Nordwall, MD, PhD,† and the Swedish Lumbar Spine Study Group

- 294 patients, 19 centers, over 6 yr
- Strict criteria: LBP > leg pain, > 2 yr, no nerve root compression, and failure of non-surgical treatment
- The patient must have been on sick leave (or have had "equivalent" major disability) for at least 1 yr
- Randomized into 4 groups: 72 conservative, 222 had one of 3 fusion sx (PLF, PLF+instrument, ALIF or PLIF)
- 98% follow-up at two years.

Fritzell et al. 2001, *Spine* 2 yr Results

- Excellent or Good: 46% of surgery vs 18% of conservative (P= 0.0001)
- More surgical patients rated their results as 'better' or 'much better' (63% versus 29%) (P= 0.0001)
- Significantly greater improvement in pain (VAS) and disability (Oswestry scale) in surgery groups
- The "net back to work rate" was significantly in favour of surgery (36% versus 13%) (P= 0.002)
- No significant differences in any of these outcomes between the three surgical groups.

BMPs and Lumbar Fusion

SPINE Volume 27, Number 23, pp 2462-2471
© 2002, Lippincott Williams & Wilkins, Inc.

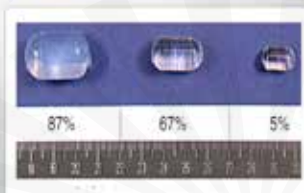
Use of Recombinant Human Bone Morphogenetic Protein-2 to Achieve Posterolateral Lumbar Spine Fusion in Humans

A Prospective, Randomized Clinical Pilot Trial
2002 Volvo Award in Clinical Studies

Scott D. Boden, MD, James Kang, MD, Harvinder Sandhu, MD, and John G. Heller, MD

Arthroplasty

- Total Disc Arthroplasty:
 - Metal-Polyethylene-Metal: SB Charité III, ProDisc II
 - Metal-on-Metal: Maverick, FlexiCore
- Nucleus Pulposus Arthroplasty:
 - Intradiscal implants
 - In situ curable polymers: silicone, polyurethane



Rationale of Total Disc Arthroplasty

To treat chronic LBP due to DDD while addressing the limitations of lumbar fusion:

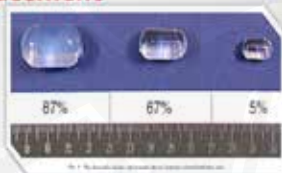
By preserving motion at the operated segment, arthroplasty will reduce the incidence of adjacent segment disease

1. Problems due to graft site harvest & pseudarthrosis
2. Posterior paraspinal soft tissue structures spared

Nucleus Pulposus Replacement



AIM : to restore biomechanical functions of the annulus by placing annular fibers in tension



Dynamic stabilization

Rationale

- Dynamic stabilization aims at restricting painful motion while enabling normal movement
- Interspinous implants distract the spinous processes and restrict extension:
 - reducing the posterior annulus pressures
 - theoretically enlarging the neural foramen

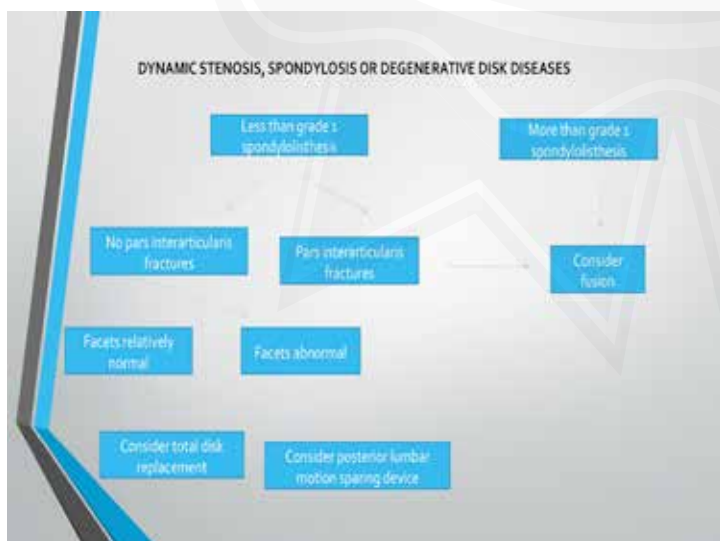


Dynesys® System



Dynamic Interspinous Process Technology









Take Home Messages

- Know the natural history of the disease
- Know your patient
- Correlate clinical findings, MRI and discograms if needed
- Until definitive evidence available, choose the most cost-effective available treatment option: cognitive therapy, exercise, fusion, arthroplasty, dynamic stabilization



Cochrane Review - Surgery for Degenerative Lumbar Spondylosis
Gibson & Waddell, August 2005

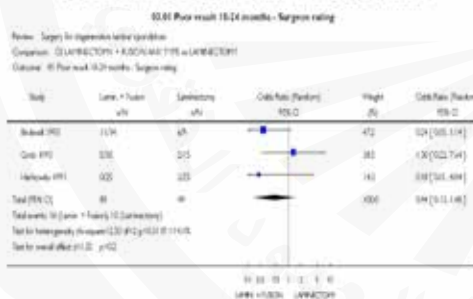
- 31 RCTs
- 3 sections:
 1. Surgery for spinal stenosis and nerve root compression: 8 RCTs
 2. Surgery for back pain: 8 RCTs
 3. Comparison of fusion techniques: 15 RCTs

Cochrane Review - Surgery for Degenerative Lumbar Spondylosis

Gibson & Waddell, August 2005

1. Surgery for spinal stenosis or nerve compression: 8 RCTs, only 3 pooled
- Postero-lateral fusion ($\pm$ instrumentation) vs decompression alone (Herkowitz 1991, Bridwell 1993, Grob 1995):
 - 139 pt, pooled OR 0.44, 95% CI 0.13, 1.48
 - Surgeon rating as success of procedure

Fig. 5. Comparison 53. LAMINECTOMY + FUSION ANY TYPE vs LAMINECTOMY



Cochrane Review - Surgery for Degenerative Lumbar Spondylosis

Gibson & Waddell, August 2005

2. Surgery for back pain: 8 RCTs
 - 2: surgery vs no surgery
 - 3: intra-discal electrotherapy
 - 3 ongoing RCT: arthroplasty
- No pooled data because of heterogeneity of procedures

Fritzell et al. 2001, *Spine* 2 yr Results

- Excellent or Good: 46% of surgery vs 18% of conservative ($P=0.0001$)
- More surgical patients rated their results as 'better' or 'much better' (63% versus 29%) ($P=0.0001$)
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- No significant differences in any of these outcomes between the three surgical groups.

Fritzell et al. 2004, *Spine J* NOT in Cochrane

- Abstract, ISSLS 2004 Meeting
- 5-10 year follow-up of the RCT
- 18% surgical & 31% non-surgical dropouts
- 10 pt non-surgical group [?] OR
- No significant difference between the two groups in patient overall rating, ODI-score, VAS

Ivar Brox et al. 2003, *Spine*

- Norwegian trial
- Compared
 - posterolateral fusion with pedicle screws and post-operative physiotherapy, vs
 - 'rehabilitation' program: an educational intervention and a 3 week course of intensive exercise sessions, based on cognitive-behavioural principles
- 64 patients with LBP > 1 yr plus disc degeneration at L4/5, L5/S1 or both
- 97% follow-up at one year and ITT analysis

Ivar Brox et al. 2003, *Spine*

- No significant differences in any of the main outcomes of independent observer rating, patient rating, pain, disability or return to work
- Radiating leg pain improved significantly more after surgery
- At one-year follow-up, the conservative group had significantly:
 - Less fear-avoidance beliefs
 - Better forward flexion
 - Better muscle strength and endurance

Fairbank et al. 2005, *BMJ*
NOT in Cochrane

- UK, Multicenter (15), RCT
- Criteria: LBP > 1yr, surgical candidates but surgeon and patient uncertain which treatment strategies was best
- Fusion (surgeon choice) or an intensive rehabilitation
- 176 surgery, 173 rehab
- 81% follow-up at 2 yr

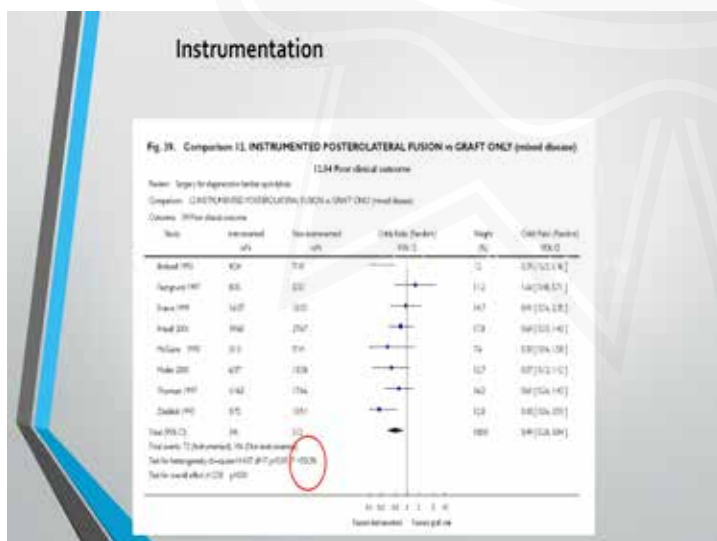
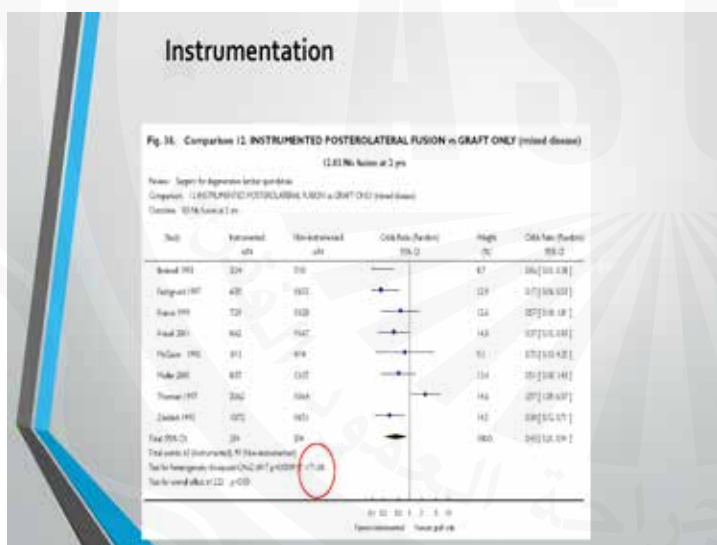
Fairbank et al. 2005, *BMJ*
NOT in Cochrane

- The mean Oswestry index changed:
 - 46.5 to 34.0 in the surgery group
 - 44.8 to 36.1 in the rehabilitation group.
 - Estimated mean difference between groups was -4.1 (95%CI -8.1, -0.1; P = 0.045) in favor of surgery
- No difference in other outcomes: walking distance & SF-36

Cochrane Review - Surgery for Degenerative Lumbar Spondylosis
Gibson & Waddell, August 2005

3. Comparison of fusion techniques: 15 RCTs, very heterogeneous

- 8: instrumentations
- 4: approach
- 3: electrical stimulation to enhance fusion



Boden et al. 2002, *Spine*

- All 25 patients were available for follow-up evaluation
- Radiographic fusion rate was:
 - 40% (2/5) in the autograft/TSRH group
 - 100% (20/20) with rhBMP-2 group with or without TSRH internal fixation ($P = 0.004$).
- A statistically significant improvement in Oswestry score was seen:
 - at 6 weeks in the rhBMP-2 only group (-17.6; $P = 0.009$),
 - at 3 months in the rhBMP-2/TSRH group (-17.9; $P = 0.003$), but
 - not until 6 months in the autograft/TSRH group (-17.3; $P = 0.043$).
- At the final follow-up assessment, Oswestry improvement was greatest in the rhBMP-2 only group (18.7; $P = 0.001$).
- The SF-36 Pain Index and PCS subscales showed similar changes

Arthroplasty

- Total Disc Arthroplasty:
 - Metal-Polyethylene-Metal: SB Charité III, ProDisc II
 - Metal-on-Metal: Maverick, FlexiCore
- Nucleus Pulposus Arthroplasty:
 - Intradiscal implants
 - *In situ* curable polymers: silicone, polyurethane



Results

- Multiple prospective cohort studies
- 4 ongoing multicenter RCTs: SB Charite, ProDisc, and Maverick
- No comments on ongoing trials

Clinical Results of PDN®

- >3,500 since 1996 (Raymedica.com)
- 423 implants in the literature (1996-2002):
 - Success rate: 60% to 85%
 - Removed in 10%: endplate failure, extrusion
- Ongoing Canadian study: Ottawa, Toronto & Halifax

Dynamic Stabilization Devices
Dynamic Interspinous Process Stabilization

Dynamic Stabilization

- Alters the mechanical loading of the motion segment by unloading the disc
- Adjunct or alternative to fusion
- Especially helpful if the pathology of postural back pain is altered load transmission

Nockels, Spine 2005

Graf



Results

- Ongoing RCT: Dynesys vs Posterior Lumbar Fusion with autograft and pedicle screw
- Few case series and prospective cohort
- Ongoing RCT for Wallis, www.spinalconcepts.com
- Ongoing RCT for X STOP (Zucherman et al. 2004, *Eur Spine J*)

Degenerative Spine Disease:

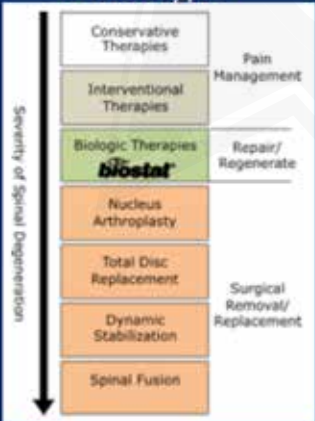
FUSIONS FOR DEGENERATIVE SPINE DISEASE

Case Study

- 46 yo F
- 1 ½ years of disruptive axial LBP radiating down her LLE
- ODI 26
- Masters degree in mechanical engineering.
- Pain scores: 3-8/10
- Pain with: bend/lift/sneeze/sit
- PT (manual, exercise)
- ESI x 2, non-dx facet blocks
- TENS
- Medications (Norco, Flexeril, Lyrica)



Paradigm



Success of Pedicle Screw Fixation

- ▣ Roy-Camille '86- 100% fusion rates with screws and plates!
- ▣ Louis '86- 97.4% fusion rate with pedicle screws
- ▣ Steffee '93- 90% good-excellent results
- ▣ Dickman '94- 101 articles 5756 pts. Device related complication rate 12.5%
- ▣ Lonstein '99- Device complication rate: 2.4%

Lumbar Fusion

Zdeblick: *Spine* 1993, p983-91, 124 patients entered into prospective study. Diagnosis included isthmic and degenerative spondylolisthesis, degenerative disc disease, degenerative scoliosis with spinal stenosis, repair of previous lumbar pseudarthrosis.

Group I : PL fusion without instrumentation.

Group II : PLF + semirigid pedicle screw system

Group III: PLF + rigid pedicle screw system

Lumbar Fusion

Zdeblick: *Spine* 1993: Results

Clinical outcome

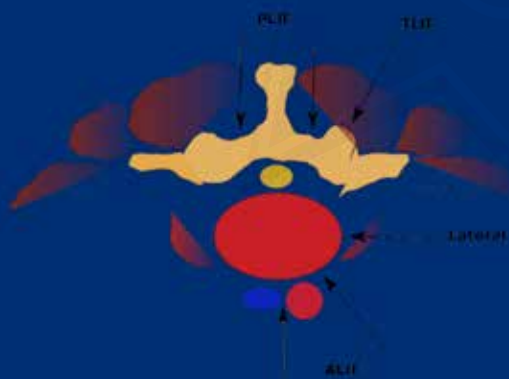
	Fusion	exc	good	Fair/poor
Group I (no instr)	65%	49%	22%	29%
Group II (semirig)	77%	60%	29%	11%
Group III (rigid)	95%	70%	24%	5%

Lumbar Fusion Options For Lumbar Spine

Options

- ▣ Lumbar Discectomy and PL fusion (Onlay)
- ▣ Lumbar discectomy and PL instrumented fusion
- ▣ Trans-foraminal Interbody Fusion (TLIF)
 - Open/MIS
- ▣ Anterior interbody fusion: ALIF/OLIF
 - Standalone
 - Posterior instrumented fusion
 - Open / MIS
 - Lateral interbody Fusion
 - Stand alone/ with posterior instrumentation
- ▣ Axial Lumbar interbody fusion
- ▣ Interspinous fusion

Interbody Fusion Approaches

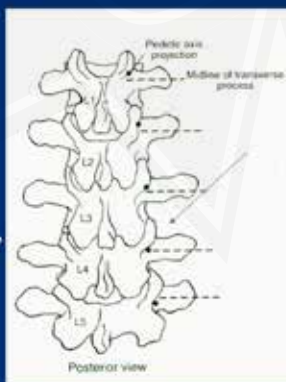


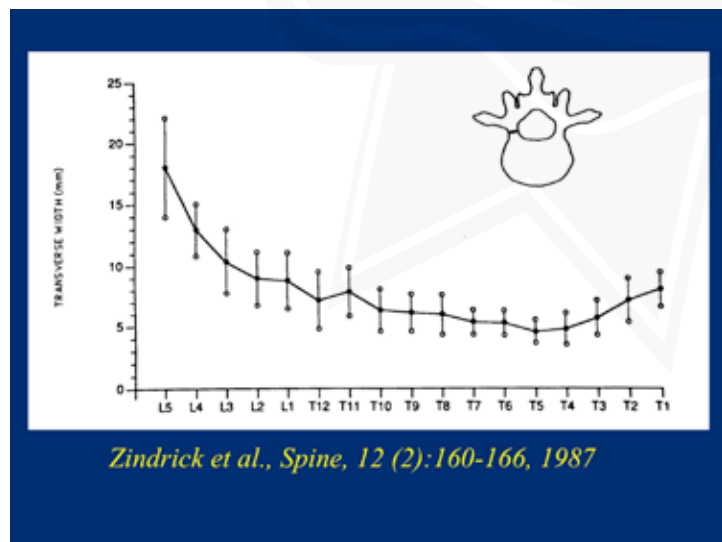
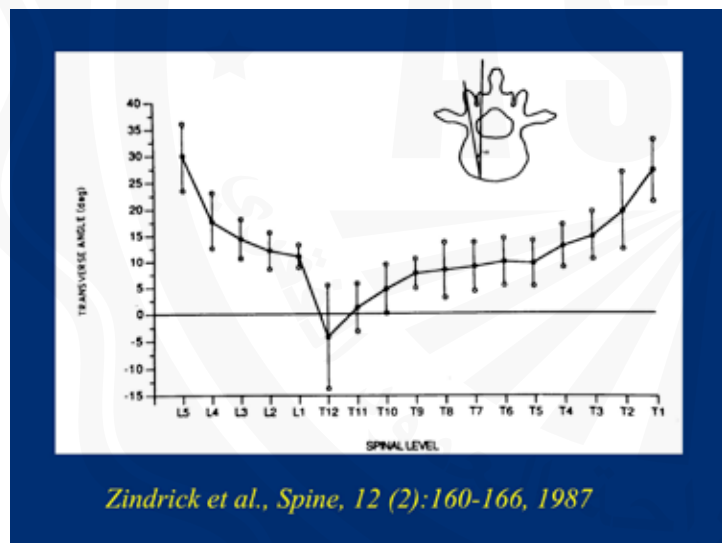
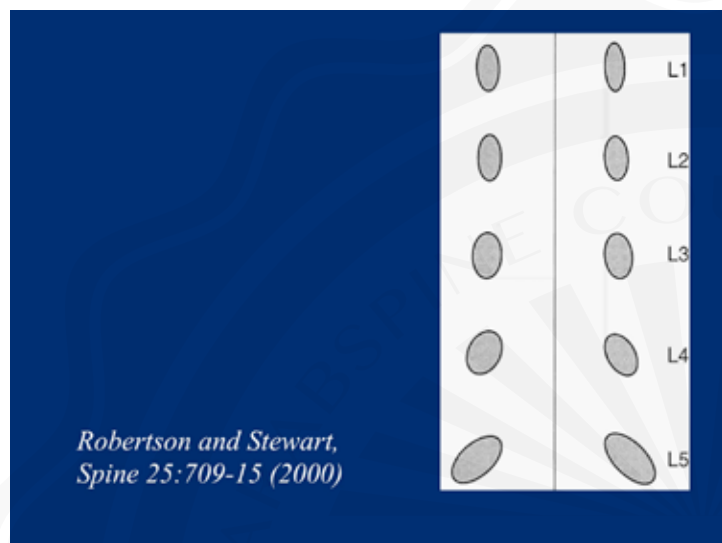
PL Instrumented Fusion



Lumbar Spine Pedicles

- Pedicle Entry
 - Midline TP and lateral edge of SAP
 - Accessory process
- Medial angulation 5-25°
- Beware of "overgrown facets"
- Entry site moves superior higher in spine





Why? Interbody Fusions

- ▣ Removal of “Pain Generator”
- ▣ Increase Stability (Flexion)
- ▣ Increase Fusion Surface Area
- ▣ Restoration of Disk Height and Segmental Lordosis

Historical Background

- ▣ Albee-1911, Tibia for PLF in Spinal TB
- ▣ Burns-1933 (ALIF) autogenous tibial peg
- ▣ Briggs, Cloward, Jaslow-1940's-PLIF-Bone fragments in discs space post discectomy
- ▣ Bagby-Basket Cages for Horses (ALIF)

Posterior Lumbar Interbody (PLIF) Fusion

- ▣ Direct decompression
- ▣ Exposes spinal cord elements
- ▣ Retraction risks to nerves



Transforaminal Lumbar Interbody (TLIF) Fusion

- ❑ Avoids spinal sac
- ❑ Direct decompression
- ❑ Less Potential nerve irritation

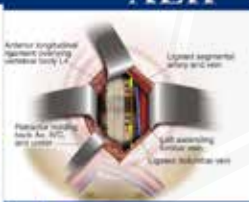


Anterior Lumbar Interbody (ALIF) Fusion

- ❑ Excellent visualization of disc space
- ❑ Avoids spinal cord
- ❑ Approach risks to organs and vascular structures



ALIF



Lateral Interbody (LIF) Fusion

Approach for L4-L5 and above

- ☐ Reduces muscle trauma
- ☐ L5-S1 not accessible because of pelvis

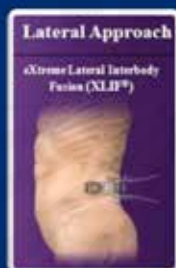


LIF Surgical Approach

☐ Lateral Interbody Fusion (LIF)

☐ Advantages:

Does not require entry through back muscles, bones, or the retraction of major blood vessels



LIF

☐ Symptoms

- Pain in the back, buttocks, or leg

☐ LIF Correction

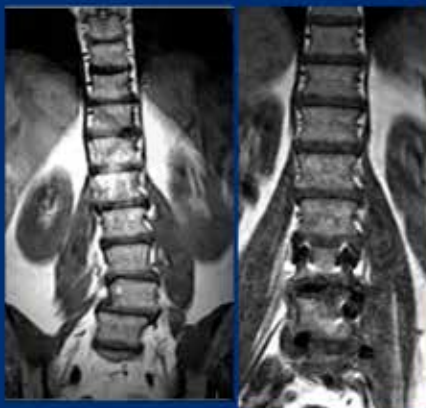
- Reduces motion between the vertebrae
- Corrects alignment
- Restores proper disc height
- Alleviates pain



Disc Degeneration before LIF

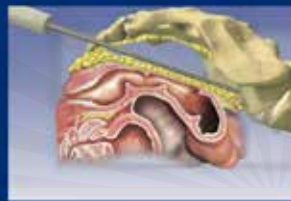


Restoration of height after LIF

[illegible][illegible][illegible]

Axial Lumbar Interbody (AxiaLIF) Fusion

- ▣ Has ability to spare 100% of Annulus
- ▣ Preservation of Tissues & Muscles
- ▣ Dynamic Decompression via Distraction



AxiaLIF Pre-Sacral Fusion

Unique Features

- ▣ Only interbody graft option where:
 - No muscle is dissected
 - No ligaments are cut
 - The disc annulus is preserved

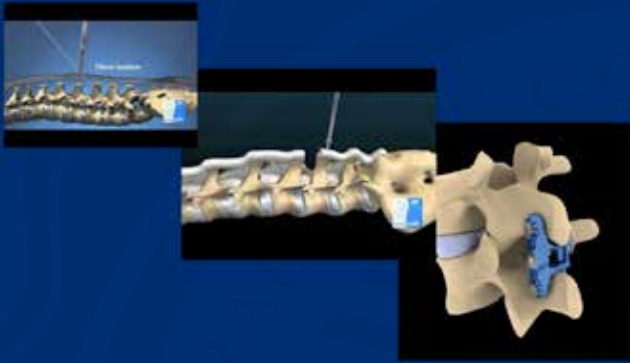
AxiaLIF



Distraction



Interspinous Fusion



When To Do Which?

- ❑ Posterior- Need decompression
Not too much deformity
Obesity
Prior ALIF?
Young male?
- ❑ Anterior- No bony decompression needed
Deformity severe disc collapse
Experienced

Advantages Posterior

- ▣ One surgery
- ▣ Neural Decompression
- ▣ Familiar
- ▣ No access surgeon needed
- ▣ Supplemental fixation better
- ▣ Easier to correct long segment deformities

Disadvantages Posterior

- ▣ Nerve,Dural injury
- ▣ Paraspinal muscle damage “*FusionDisease*”
- ▣ Technically difficult to get good size implant in disc space
- ▣ End plate preparation not as thorough
- ▣ Restoration of disc space height more difficult
- ▣ Need supplemental fixation?
- ▣ More blood loss

Advantages Anterior

- ▣ No paraspinal muscle trauma
- ▣ Less blood loss
- ▣ Better end plate preparation
- ▣ Better implant sizing and tensioning
- ▣ Ability to correct segmental collapse better
- ▣ Stand alone? With or without ant fixation

Disadvantages Anterior

- ❑ Overall fixation not as good esp above L5-S1
- ❑ Unfamiliar territory
- ❑ Need another surgeon
- ❑ Need to worry about things you don't usually worry about (retrograde ejaculation,dvt ureter,lymphatics,sympathetics)
- ❑ Can be kyphogenic
- ❑ Difficult reoperation at or near same level

When to Posteriorly Instrument?

- ❑ Probably all PLIF's and TLIF's
- ❑ Most ALIF's esp. if not screw in cages or post. elements compromised or annulus not in tension
- ❑ Sagital or Coronal Plane correction needed

Anterior Instrumentation?

- ❑ ALIF
- ❑ Anticipate anterior graft extrusion
- ❑ ALL and Anterior Annular Restoration
- ❑ Can safely place
- ❑ Tall disk space difficult to manage with Screw in Cages



[illegible][illegible][illegible]

Degenerative Spine Disease:

MIS FOR LBP DEGENERATIVE SPINE DISEASE



Historical Background

- ▶ Not a new Concept
- ▶ Halsted-minimal damage to tissue
- ▶ Optimal patient outcome
- ▶ Competitive market
- ▶ Health care climate
- ▶ Outpatient surgery
- ▶ Etc...

Is there one approach

- ▶ Different modalities
- ▶ One size fits all?
- ▶ Combination of techniques
- ▶ Is something better than another

Progression

- ▶ Evolution of less invasive surgery:
 - microscopic advances
 - endoscopy
- Burman-1931 endoscopy in spine
Foley 1997-neuroendoscopic microdiscectomy
1998-METREx system



Other Advances

- ▶ Instrumentation
- ▶ Image-guided technology
- ▶ Bone morphogenetic proteins
- ▶ Polymethylmethacrylate
- ▶ Surgical techniques

Definitions

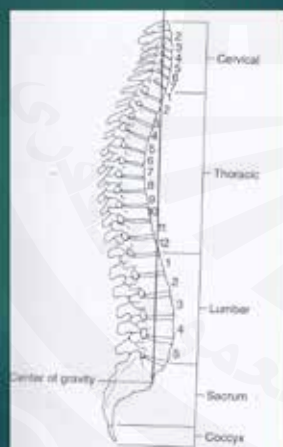
- ▶ Minimal, need to understand and define
- ▶ Less Invasive
- ▶ Tissue injury
- ▶ Healing
- ▶ Post op care
- ▶ Cost
- ▶ Marketing

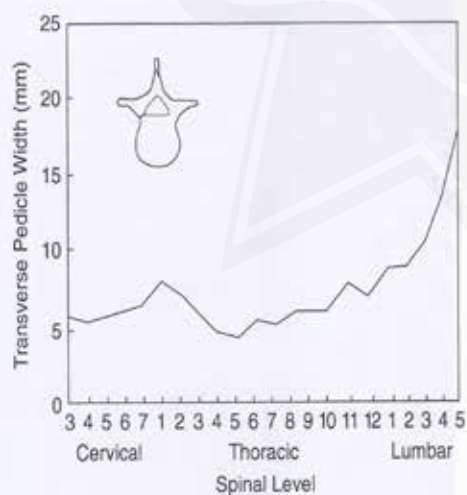
What is the Impact

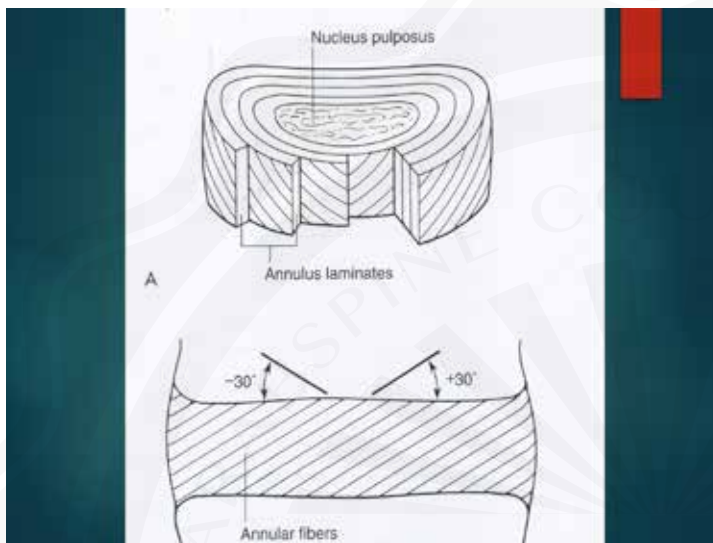
- ▶ What did we achieve
- ▶ Where are we going
- ▶ New technology
- ▶ The Future



The Lumbar Spine







The Degenerative Process

- ▶ Degeneration = Dessication
- ▶ As aging occurs nucleus replaced by collagen
- ▶ Disc space height loss occurs
- ▶ Fissures and clefts develop in the annulus, and may extend to the periphery
- ▶ Hyaline cartilage of the end plates thins, particularly centrally

Biomechanical Considerations

- ▶ Stability
- ▶ Mobility
- ▶ Synchrony between: muscles, ligaments and bones
- ▶ Healthy state means optimal efficiency

Discogenic pain

- ▶ How to alleviate
- ▶ Excision
- ▶ Replacement
- ▶ Regeneration
- ▶ Genetic manipulation
- ▶ Present
- ▶ Future

Less Invasive surgery- Rationale

- ▶ Evolution or revolution
- ▶ Good results
- ▶ Less complications
- ▶ More cost effective?
- ▶ Progression

Outcome Measurement Tools

- ▶ Pain scales: verbal, visual, numerical, etc
- ▶ Disability: Oswestry, neck pain index,
- ▶ Psychometric assessment
- ▶ Patient satisfaction
- ▶ Outcome assessment tools and scales
- ▶ Short-form36

Image-Guidance

- ▶ May be useful
- ▶ Applications vary
- ▶ Advantages
- ▶ Limitations
- ▶ Improvement in technology

Intraop Monitoring

- ▶ SSEP's
- ▶ Motor evoked potentials
- ▶ Spontaneous EMG
- ▶ Stimulus-evoked EMG
- ▶ Anesthesia



Monitoring for pedicle screws

- ▶ Continuous EMG
- ▶ Evoked EMG
- ▶ Nerve integrity monitoring (NIM)
- ▶ Cordless monitors

A sample of surgical techniques

- ▶ Microendoscopic discectomy
- ▶ Laminotomy and foraminotomy
- ▶ Arthrodesis and instrumentation
- ▶ Disc replacements
- ▶ Implantation of stimulators
- ▶ Sympathectomy
- ▶ Kyhoplasty ,vertebroplasty
- ▶ Indirect decompression,X-stop

Sequential Dilatation & Tube Placement



- ▶ Place sequential dilators over the initial dilator down to the lamina
- ▶ Utilize twisting motion to ensure dilators seated each time
- ▶ Use depth markings on outer dilator to determine the correct tubular retractor length

Exposure of Disc & Discectomy



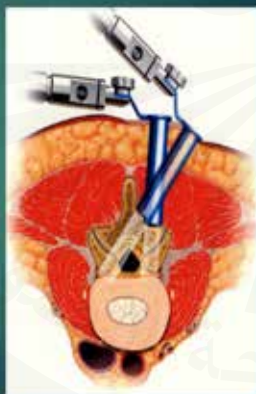
- ▶ Utilize nerve root retractor to retract dura or nerve root and expose disc or disc fragments
- ▶ Utilize pituitary to remove the free disc fragments OR perform annulotomy with sheathed knife
- ▶ Explore epidural space and cauterize epidural veins as needed

Claudication - Spinal Stenosis

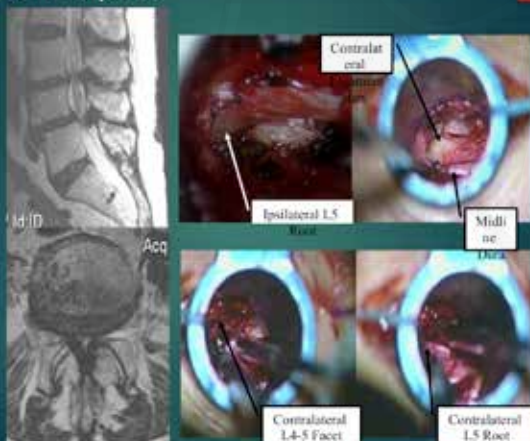
- ▶ One –two level central lateral recess or foraminal
- ▶ Unilateral
- ▶ Laminoplasty (unilateral approach bilateral decompression)
- ▶ Outpatient procedure



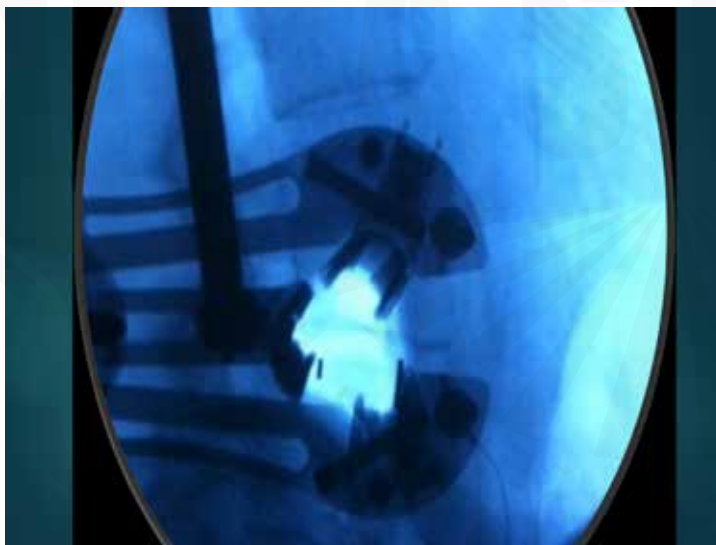
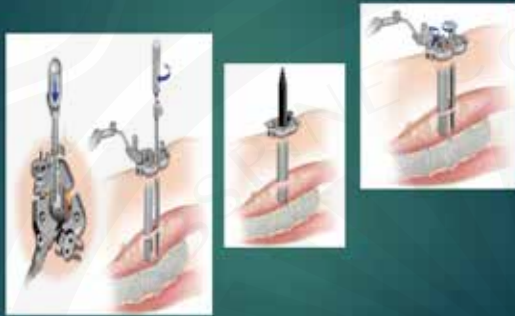
Minimal Access Muscle Splitting Technique (MAST)



Technique



Lateral Approach



Future Percutaneous

A diagram illustrating the early stages of embryonic development. It shows a cross-section of an embryo with a central neural tube (blue) and surrounding somites (yellow). The neural tube is shown differentiating into the brain (top) and spinal cord (bottom). The somites are shown differentiating into muscle (red) and bone (yellow). The diagram is labeled with 'Neural Tube', 'Somites', 'Brain', 'Spinal Cord', 'Muscle', and 'Bone'.



Multi-Level Instrumentation

- ▶ Different Screw Extender Assemblies
- ▶ Same arc
- ▶ Compatible with existing instruments (screwdrivers, taps, etc.)
- ▶ Same implants



(1) Freehand Method

Case 1



Courtesy of Najeeb M. Thomas, M.D.

Dr. Chedid 1/22/08



Pre expansion



Expanded to 11mm

Level: L5/S1
 Implants: 24mm XD Bilateral PLIF
 Wafers: 3/4 wafers per implant
 Height: 10mm & 11mm expansion
 Distraction: Scraped to 9mm



Lateral



A/P

- Pre expansion:
 - Rt 7mm trial;
 - Lt 9mm scraper;
 - hand placement/no mallet
- Lateral view: note anterior placement of XD implant & lordosis
- A/P view: bilateral placement; final implant heights: Rt 11mm, Lt 10mm

Dr. Chedid 3/17/08



Patient: Alsouaifet
 Level: L4/L5
 Implants: 26mm XD Bilateral PLIF
 Wafers: 7 wafers per implant
 Height: 14mm expansion
 Distraction: Scraped to 11mm

Epidemiology of Lumbar Spinal Stenosis (LSS)

- ▶ 8 - 11% Incidence of LSS in the U.S.¹
- ▶ LSS is the most common reason for spine surgery in older people²
- ▶ More than 125,000 laminectomy procedures were performed for LSS in 2003³
- ▶ Financial impact and lost work hours reaches billions of dollars each year in the U.S.⁴

1. Murphy et al. BMC Musculoskeletal disorders. 2006; Jeros et al. Spine 2000;
 2. Murphy et al. BMC Musculoskeletal disorders. Sepala, European Spine Journal, 2003
 3. The Orm FactBook™, U.S. 5th Edition; Bolocent, LLC and Vertigan, LLC
 4. Knowledge Enterprises, Inc.

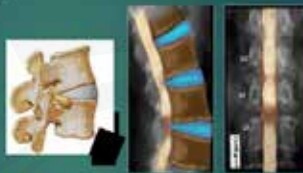
Degenerative Cascade of LSS



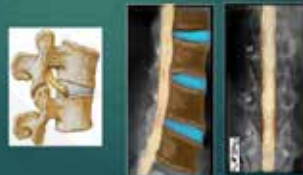
Pathoanatomy

Dimensions of spinal canal, lateral recess, and neural foramina

Decrease in Extension



Increase in Flexion



Where does MIS fit in deformity

- ▶ Used by itself
- ▶ Stand alone?
- ▶ In combination
- ▶ As adjunct for total correction

MIS in Deformity

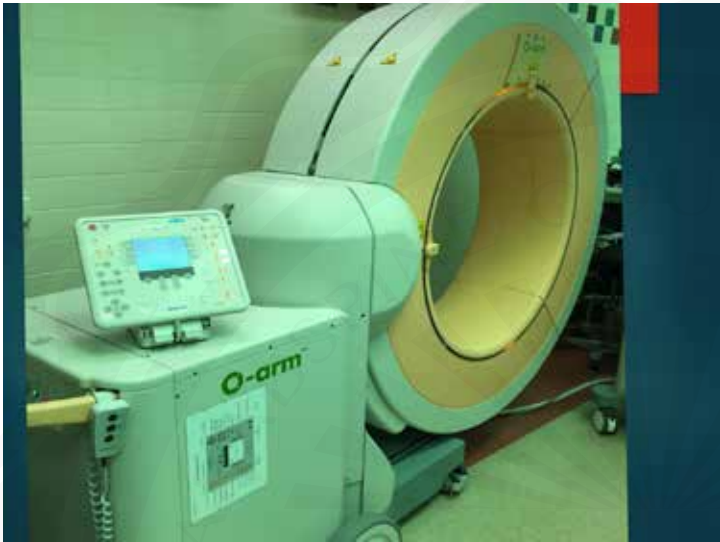
- ▶ Posterior like TLIF PLIF etc...
- ▶ Posterior instrumentation with muscle splitting techniques
- ▶ Lateral in different forms, for Vertebrectomy, discectomy, release, tumor resection, grafts implants etc
- ▶ Anterior approach
- ▶ Endoscopic, posterior anterior, lateral
- ▶ Most of the time in conjunction with other techniques to complete a task
- ▶ Limitations and skill
- ▶ Learning curve

Final Thoughts

- ▶ What did we change
- ▶ What is next
- ▶ Philosophical quest

Other Tools of the trade

- ▶ C-arm
- ▶ O-Arm
- ▶ Intra op CT scan
- ▶ Image guided systems
- ▶ Stereotactic applications
- ▶ Monitoring
- ▶ 3-D thinking

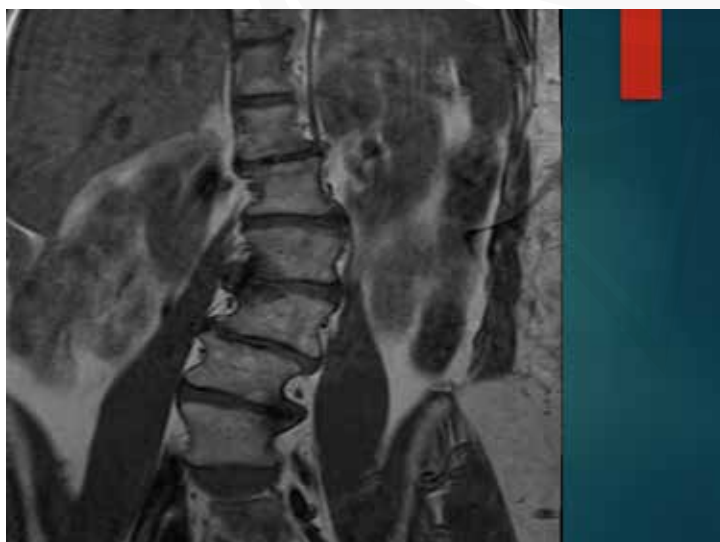




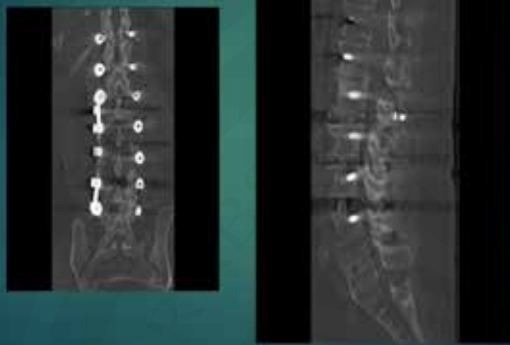








Actual Patient Cases



Is MIS the Answer

- ▶ NO, yes or may be
- ▶ Choose wisely
- ▶ Each patient is different
- ▶ Need to design treatment depending on situation
- ▶ No doubt MIS has a lot of applications, but also with a variety of limitations

References

- ▶ 1-Wang MY, Mummaneni PV : Minimally invasive surgery for thoracolumbar spinal deformity : initial clinical experience with clinical and radiographic outcomes . Neurosurg Focus 2010 Mar;28(3):E9.
- ▶ 2-Mummaneni PV,Shaffery CI, Lenke LG, Park P,Wang MY, LaMarca F,Smith JS,Mundis GM Jr., Okonkwo DO,Moal B,Fessler RG,Anand N,Uribe JS,Kanter AS,Akbarnia B, Fu KM: The minimally invasive spinal deformity surgery algorithm: a reproducible rational framework for decision making in minimally invasive spinal deformity surgery. Neurosurg Focus 2014 May; 36(5): E6
- ▶ 3- Bach K, Ashmadian A, Deukmedjian A, Uribe JS : Minimally invasive surgical techniques in Adult Degenerative Spinal deformity: A Systematic Review. Clin Orthop Relat Res. 2014 Jun; 472(6):1749-1761

Degenerative Spine Disease:

DIRECT LATERAL APPROACH IN LUMBAR FUSION

Vertebral Interbody Fusion

History

- Anterior Lumbar Interbody fusion (ALIF): first description Capener in 1930s
- Posterior Lumbar Interbody fusion (PLIF): Cloward in 1945
- Transforaminal Lumbar Interbody fusion (TLIF): Harms and Jerszensky in 1998
- XLIF (eXtreme Lateral Interbody Fusion) first paper (Ozgur and Pimenta) in 2006



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Technical Report

Extreme Lateral Interbody Fusion (XLIF): a novel surgical technique

for anterior lumbar interbody fusion

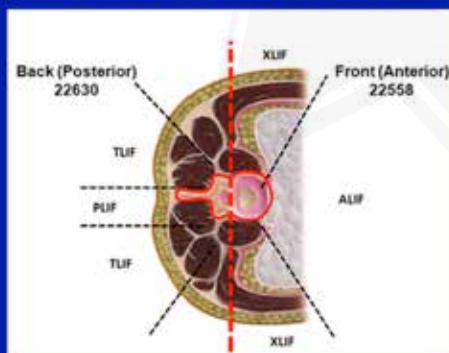
Burak M. Ozgur, MDa,* , Henry E. Aryan, MDa, Luiz Pimenta, MD, PhDc, William R. Taylor, MDb

The Spine Journal 6 (2006) 435–443



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Surgical approaches



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DLIF Concept

- Conventional surgery through small incisions
- Retroperitoneal Trans-psoas approach to Lumbar spine



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Lateral Interbody Fusion

- Advantages
 - Minimally invasive
 - Avoid major organs and vessels
 - Reduce surgery related morbidity
 - Better postop. pain control
 - Shorter hospital stay
 - Less operative time
 - Cosmetically more appealing



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Lateral Interbody Fusion

- Advantages
 - Access to all levels of the thoracolumbar spine (T12-L5)
 - Better access to concave side in deformity cases
 - No need for access surgeon



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- Compared to ALIF
 - Reduce the potential for vascular injury
 - Limit the potential for retrograde ejaculation
 - ALL is kept intact
 - Less traumatic abdominal soft tissue/muscle damage
 - No postop ileus
 - Multiple levels through same incision
- Compared to PLIF/TLIF
 - Does not disrupt posterior musculature or ligamentous structures
 - Allows for a more complete discectomy
 - No dura/root retraction
 - No nerve root scarring
 - Maximizes implant/end plate interface



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Lateral Interbody Fusion

Limitations

- No access to L5/S1
- Indirect decompression of neural element
- Potential injury to lumbar plexus and genitofemoral nerve. *Post op thigh pain & numbness (30%)*
- EMG monitoring is essential\mandatory
- Special equipment (lights, retractors, cages)
 - Initial cost and steep learning curve
- Radiation exposure



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Indications

As for all LIF

- DDD
- Degenerative scoliosis
 - Trauma
 - Tumour
 - Infection
 - instability



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Goals

- Restore disc height
- Restore foraminal dimension
- Restore coronal and sagittal balance
 - Achieve a solid fusion



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Surgical Technique

1. Patient positioning
2. Retroperitoneal access
3. Transpsoas access and disc exposure
4. Discectomy and disc space preparation
5. Implant placement



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Patient positioning



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Patient positioning



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Imaging

*Good Fluoroscopic
Images Are Critical*



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Imaging

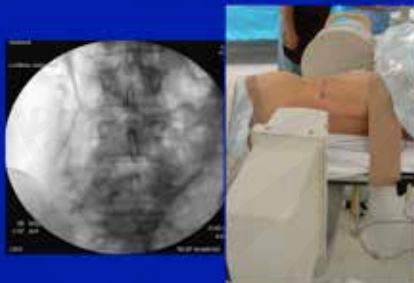
- True Lateral image
 - Linear endplates
 - Linear posterior cortex
 - Superimposed pedicles



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Imaging

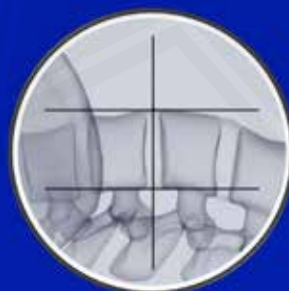
- True AP image
 - Midline spinous process
 - Symmetrical pedicles



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Landmark Identification

- Use a guidewire to mark the posterior and anterior margins and midline of the disc space on the skin.



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Retroperitoneal access



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Transpsoas access and disc exposure



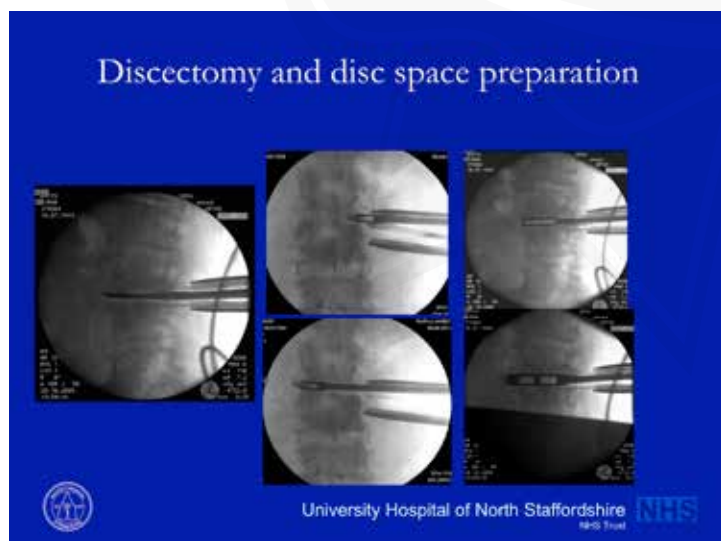
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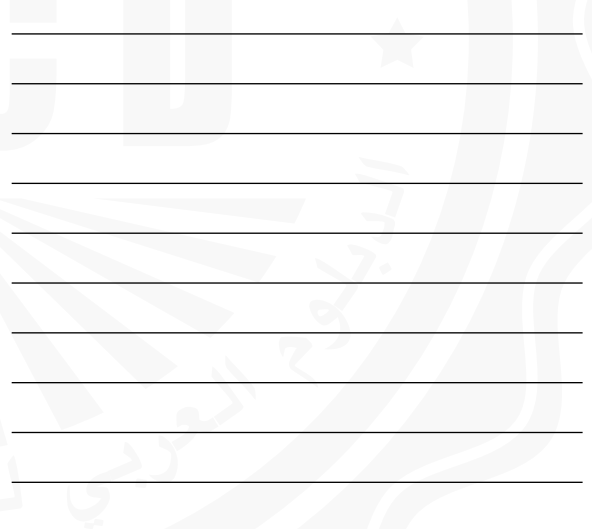
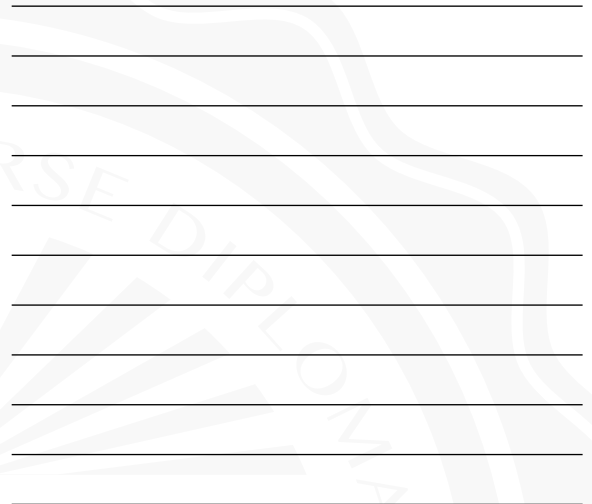


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Degenerative Spine Disease:

LBP AND SYSTEMIC DISEASES

Back Pain

- Leading cause of work disability in those < 45 years.
- Up to 84% of adults have LBP at some time in their lives.
- Prevalence:
 - Activity-limiting LBP >1 day was 12%.
 - > 1month prevalence was 23%.
- Most episodes are self-limited.
 - Acute period (4weeks).
 - Subacute back pain (between 4-12 weeks).
 - Chronic back pain (persists for > 12 weeks).



Non-Specific Low Back Pain

- Majority of patients in primary care will have nonspecific LBP
- Definition:
 - “the patient has back pain in the absence of a specific underlying condition that can be reliably identified”
- Many may have musculoskeletal pain.
- Most will improve within a few weeks.



Risk Factors

- Risk factors associated with back pain complaints:

- Age
- Female gender
- Obesity
- Job:
 - Physically strenuous
 - Sedentary
 - Psychologically strenuous
 - Compensation – Insurance
 - Dissatisfaction
- Psychologic factors
 - Somatization disorder
 - Anxiety
 - Depression



Back Pain Evaluation

- Initial evaluation:

- A history and physical to evaluate for signs or symptoms that indicate the need for immediate imaging and further evaluation.
- For most patients with acute back pain (<4 weeks), laboratory tests and imaging are not indicated in the initial evaluation.



History

- Pain:

- Location
- Duration
- Severity
- Radiation
- prior back pain and how current symptoms compare with previous pain.

- Constitutional Symptoms (weight, fever)
- Hx of Malignancy or Infection
- Precipitating events
- Therapies attempted
- Neurologic symptoms
- Social or psychological stress.



Physical Examination

- Purpose is to identify features that suggest the need for further evaluation rather than to make a primary diagnosis.
 - Inspection of back and posture
 - Palpation / Percussion of the spine
 - Neurologic exam
 - Systemic exam (incl. Gait)
 - Nonorganic signs (Waddell's signs)
 - Waddell's signs may indicate non-organic or psychological back pain



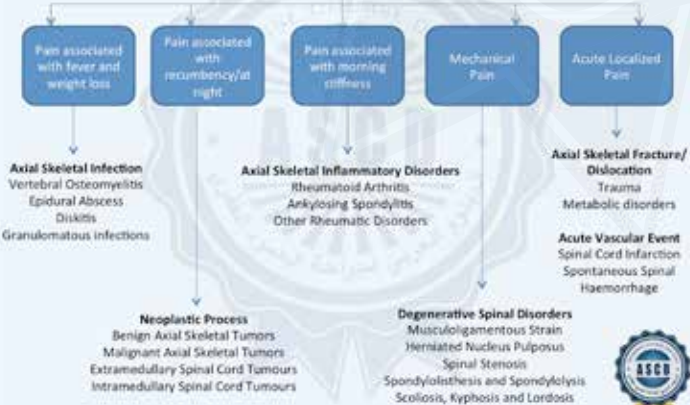
Waddell's signs

- Tenderness tests
- Simulation tests
- Distraction tests
- Regional disturbances
- Overreaction

When three or more categories are positive, the finding are considered clinically significant

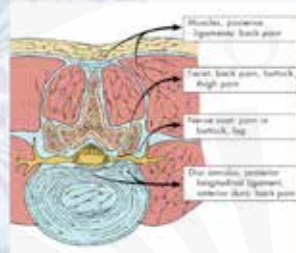


Spinal or Radicular Pain



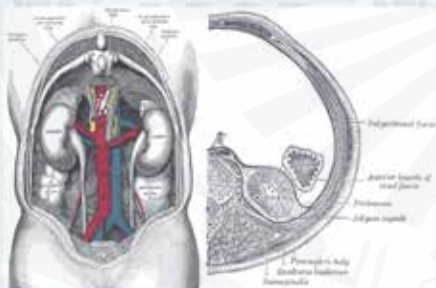
Systemic Causes Of Back Pain

- Pathologies outside the Spine
- Rheumatoid Arthritis
- Ankylosing Spondylitis
- Osteoarthritis
- Other Rheumatological diseases
- Metabolic disorders
- Tumours of the axial spine
- Spine Infections



Etiologies Outside The Spine

- Pancreatitis
- Nephrolithiasis
- Pyelonephritis
- Abdominal Aortic Aneurysm
- Herpes Zoster



Rheumatoid Arthritis

- One of the most common disabling diseases.
- Prevalence 0.8 – 1% of those older than 15 years.
- RA of the cervical spine was first described as a clinical entity by Garrod in 1890
- According to Conlon and coworkers, if lateral cervical radiographs were obtained among the general population, cervical spine involvement compatible with RA would be detected in about 6%.



Rheumatoid Arthritis

- chronic relapsing inflammatory arthritis
- usually affects multiple diarthrodial joints with varying degree of systemic involvement.
- worldwide in all racial groups.
- Affects females 2 to 4 times more frequently than males.
- 50% of patients are unable to work within 10 years of onset.
- Joints, articular tissues, serosae and the eyes are commonly affected. Vasculitis – organ damage
- The axial skeleton, with the exception of the cervical spine, is affected later and less frequently.



Rheumatoid Arthritis

The frequency of radiographic signs of cervical spine involvement is in the range of 40 – 85% depending on the duration of the disease.

83% of patients in prospective studies develop anterior atlantoaxial subluxation within 2 years of disease onset.



Rheumatoid Arthritis

- Atlantoaxial (C1–2) instability, or subluxation.
- Erosive pannus formation at C1–2 articulation.
- Destruction of its skeletal and ligamentous supports.
- Atlantoaxial subluxation follows in 50% to 70% of patients.
- Pannus may exhibit a mass effect.



American Rheumatism Association Criteria for Classic or Definite Rheumatoid Arthritis

- Morning Stiffness
- Pain on motion or tenderness in at least one joint
- Swelling of at least one joint
- Symmetrical joint swelling of the same joint, right and left
- Subcutaneous nodules
- Radiological changes typical of rheumatoid arthritis
- +ve serum RF
- Poor mucin clotting of synovial fluid
- Characteristic histological changes

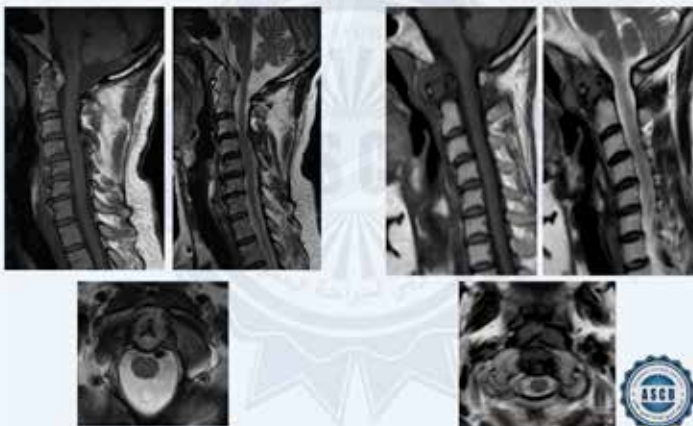


Rheumatoid Arthritis

- Cervical spine is the most common site affected.
- Predilection for involvement of the craniocervical junction.
- Atlantoaxial dislocation, followed by cranial settling and then rheumatoid granulation tissue.
- Subaxial subluxation occurs in 12% to 22% of individuals and is seen predominantly at the C4 and C5 levels.
- Higher risk of multiple thoracic and lumbar compression fractures.
- Spontaneous (nontraumatic) odontoid fractures in RA patients.



Cervical spine in Rheumatoid Arthritis



Rheumatoid arthritis of the cervical spine



Rheumatoid Arthritis

- **Extra-articular Manifestations**
 - Pericarditis
 - Myocarditis
 - Coronary vasculitis
 - Pleural effusion and pleuritis
 - Intraparenchymal rheumatoid nodules
 - Caplan's syndrome
 - Pharyngeal dysfunction



Rheumatoid Arthritis

- **Treatment**
 - Medical
 - NSAID
 - Corticosteroids
 - DMARDs
 - Synthetic eg, methotrexate, leflunomide, sulfasalazine
 - Biologic eg, infliximab, etanercept, adalimumab
 - Surgery
 - Reducible: Traction? (contraindicated in complex rotary luxation or posterior occipitoatlantoaxial dislocation)
 - Irreducible



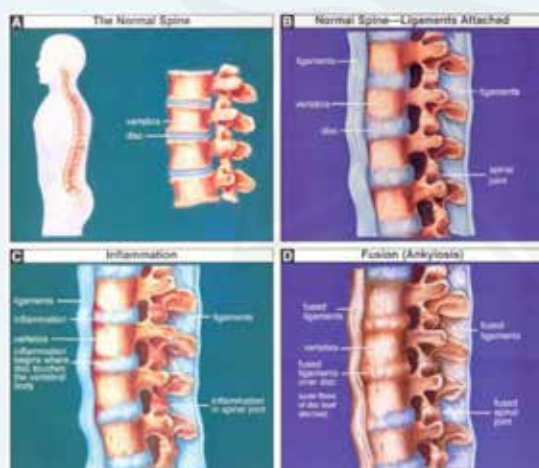
Ankylosing Spondylitis

- Pathogenesis is unclear but linked to immunologic association with HLA-B27
- Most prevalent seronegative spondyloarthropathy
- 2% incidence in the white population
- 0.5% of patients presenting with back pain will have ankylosing spondylitis.
- Most common in men under the age of 40



Ankylosing Spondylitis

- Axial skeleton is most commonly affected, with a milder degree of peripheral involvement.
- Pain has characteristics suggesting an inflammatory etiology
 - morning stiffness
 - improvement with exercise
 - pain at night
- Three stages:
 - Inflammation
 - Bone erosion
 - Syndesmophyte (bony growth originating inside a ligament, commonly seen in the ligaments of the spine)



Ankylosing Spondylitis

- Insidious LBP in 80%-90% of patients
- Peripheral joint pain in the hip or shoulder joint in 20%-40% of patients.
- Characteristic pathological changes:
 - Vertebral body osteoporosis
 - Ankylosis of the apophyseal joints
 - Intervertebral disk calcification
 - Ligamentous ossification
- Sacroiliitis is one of the earliest manifestations of the disease

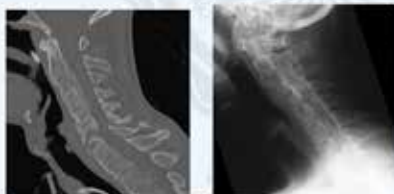


Ankylosing Spondylitis

- It takes 3-7 years for radiographic evidence of ankylosing spondylitis to appear.
- Chronic spondylitis:
 - Kyphosis
 - Fractures
 - Stenosis
 - Rotary instability



Ankylosing Spondylitis



Ankylosing Spondylitis

- Treatment Options:
 - Medical
 - Anti-inflammatory drugs
 - TNF blockers (eg, Infliximab)
 - Physical Therapy
 - Pain relief, improve strength and flexibility and preserve good posture.
 - Surgery
 - For severe kyphotic deformities or fracture (osteotomies with instrumentation and fusion)



Osteoarthritis

- Most commonly presents in patients over the age of 40
- LBP may be a symptom of osteoarthritis of the facet joints.
- Pain is typically exacerbated by activity and relieved by rest
- Osteoarthritis can lead to spinal stenosis.



Other Rheumatic Disorders

- Psoriatic Arthritis
- Reiter's Syndrome
- Behcet's disease
- Whipple's disease
- Enteropathic arthritis
- Gout
- Pseudogout
- The clinical presentation of spondyloarthropathies overlap and in general these syndromes cause instability or axial deformity



Metabolic Disorders

- Affect bone mineralization or density and may predispose patients to benign pathologic fractures
- Patients usually present with systemic symptoms and signs of the disease before the discovery of any spine pathology.
- Most common bone diseases:
 - Osteoporosis
 - Osteomalacia
 - Paget's disease

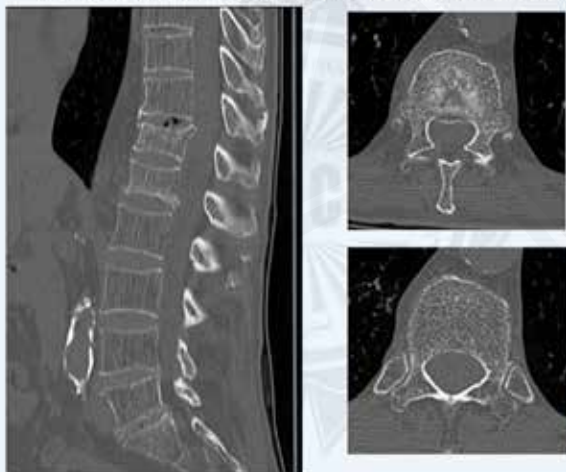


Fig. CP 1

Section of a normal vertebral body with dense and well calcified trabeculae (left) and osteoporotic vertebra with rarefaction of trabeculae which weakens the mechanical properties of the vertebral body



Vertebral insufficiency fractures in severe osteoporosis





Rugger jersey spine describes the prominent sub-endplate densities at multiple contiguous levels to produce an alternating dense-lucent-dense appearance. This simulates the transverse bands of **rugby sweater**.

Although this vertebral sign is relatively specific for hyperparathyroidism, a similar appearance may be seen in [Paget disease](#) and [osteopetrosis](#).



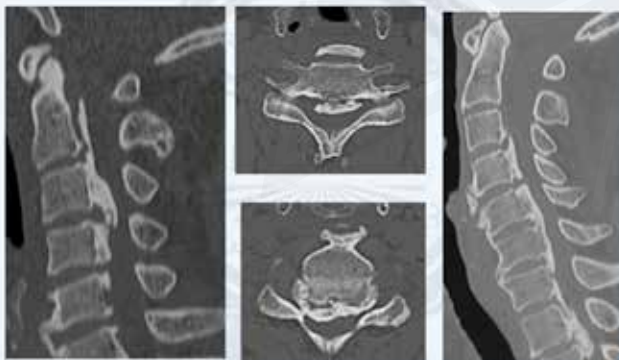
Metabolic Disorders

- Others:

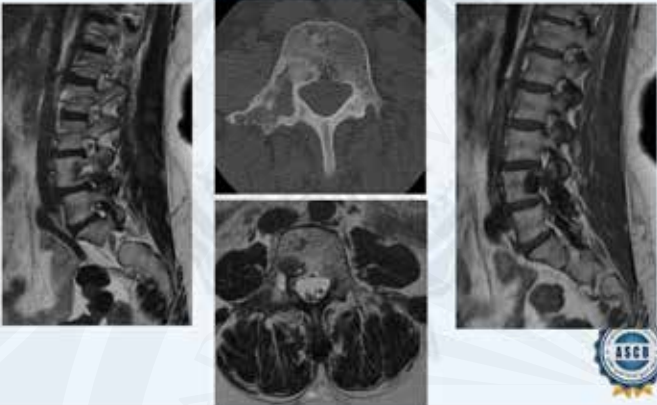
- Ossification of the PLL
- Diffuse idiopathic skeletal hyperostosis
- Calcium pyrophosphate arthropathy
- Amyloidosis
- Acromegaly
- Fibrous dysplasia
- Dialysis-associated spondyloarthropathy



OPLL



Fibrous dysplasia of lumbar spine
(Expansile, lucent lesion within the right transverse process and pedicle L4)



Metabolic Disorders

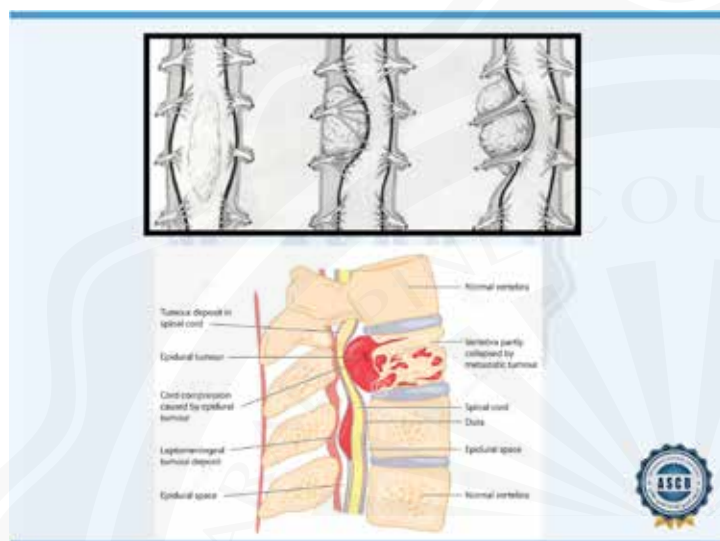
- Present to the neurosurgeon with
 - Localized spine pain
 - Pathologic vertebral column fractures
 - Symptoms from neural entrapment
- Treatment:
 - Most are managed medically
 - External Bracing may help in relieving pain in the acute phase of a vertebral fracture
 - Surgery is reserved for fractures resulting in:
 - Gross deformity
 - Instability
 - Neurological impairment

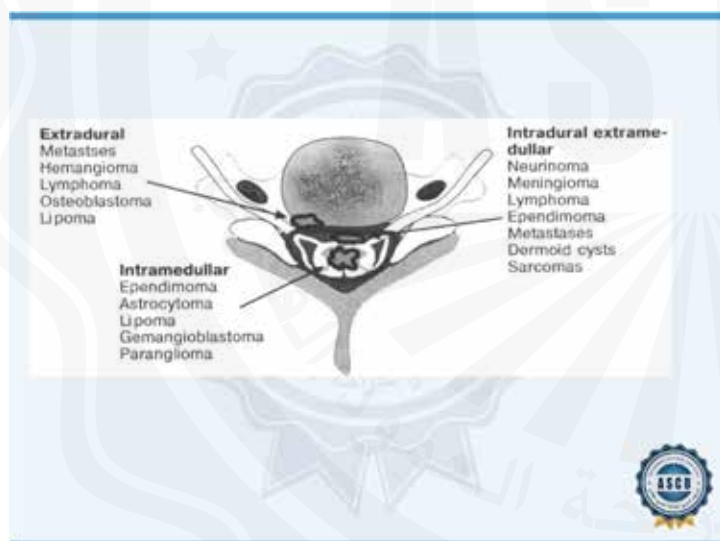


Tumors of The Axial Skeleton

- Metastatic or Primary
- Malignant tumors of the axial skeleton are 25-40 times more likely to be metastatic than primary
- Most common metastatic spinal tumours are the breast, lung and prostate malignancies
- Most common primary malignant neoplasms:
 - Multiple myeloma
 - Chordoma
 - Chondrosarcoma
 - Osteogenic sarcoma
 - Ewing's sarcoma







Tumors of The Axial Skeleton

- Thoracic metastases tend to become symptomatic most often
- Cervical lesions are symptomatic in 6%-8% of patients
- The vertebral body is the structure most often involved

Surgery is reserved for:

- Neurological compromise
- Radiation failure
- Spine instability
- Uncertain diagnosis

Goals of Surgery:

Pain Control

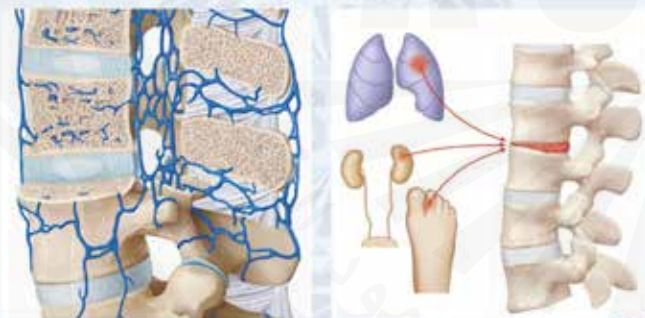
Preservation of function and stability

Spine Infections

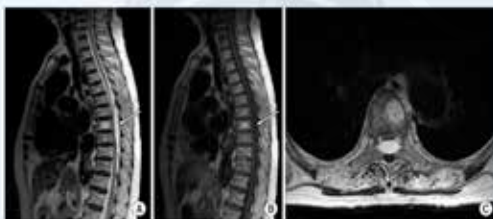
- Delayed diagnosis (elderly)
- Progressive onset
- Continuous pain exacerbating in the night
- Fever and septic patterns might be absent
- Predisposing factors
 - Diabetes,
 - Immunodeficiency,
 - Peripheral infections,
 - Drug abusers
- The most frequently found **organisms** are Staphylococcus aureus (30–55%), E. coli, Salmonella, Enterococcus, Proteus mirabilis, Pseudomonas aeruginosa (in 65% of drug abusers), Streptococcus viridans, and epidermatitis



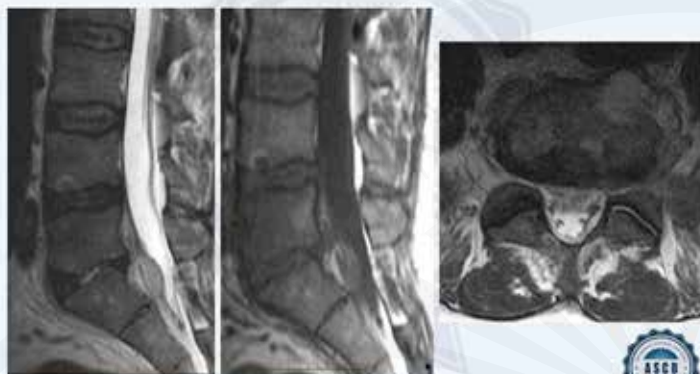
Spread of microorganisms via the blood vessels



Epidural Abscess



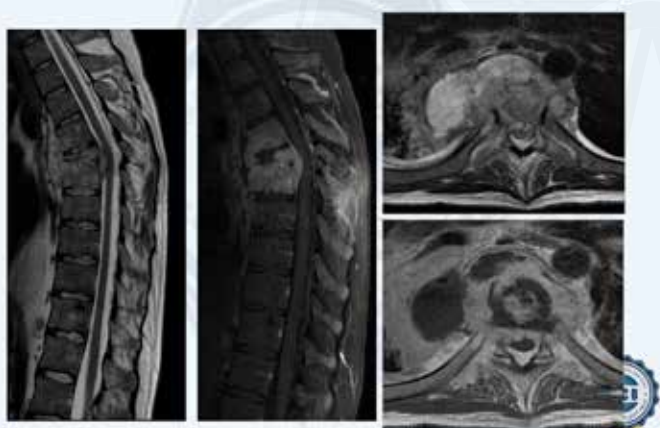
L5/S1 endplate osteomyelitis/discitis with epidural abscess



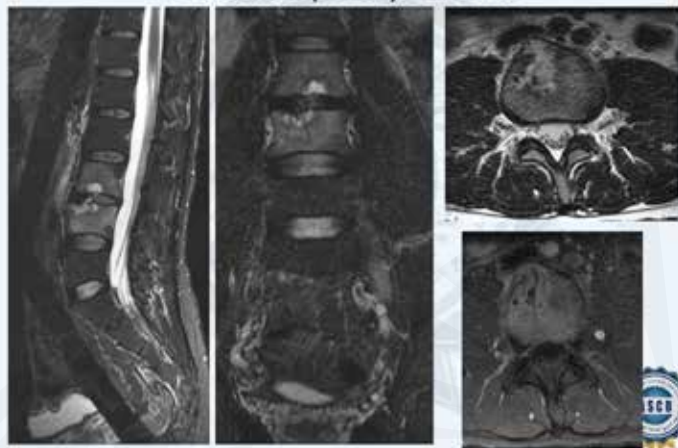
Discitis osteomyelitis L2/3 – Candida Albicans



Tuberculous discitis, osteomyelitis and paravertebral abscess



Brucella spondylodiscitis



Conclusion

- Adequate history and physical examination can minimize and direct further investigation
- Spinal Disorders often require multi-disciplinary management
- Early diagnosis can modify disease prognosis for some disorders
- Many spinal disorder have non-surgical treatments



Degenerative Spine Disease:

ACUTE SPINAL CORD COMPRESSION AND CAUDA EQUINA SYNDROME

Introduction

- Various lesions can compress the spinal cord, causing segmental sensory, motor and sphincter deficits.
- Compression is caused far commonly by extramedullary than by intramedullary lesions
- Extradural lesions.....80%
- Intradural extramedullary.....15%
- Intradural intramedullary 5%
- Compression may be:
 - Acute (develops within minutes to hours).
 - Subacute (develops over days to weeks)
 - Chronic compression (over months to years)



Acute Spinal Cord Compression

Etiology

- Trauma
 - Displaced fracture fragment
 - Acute disk herniation
 - Hematoma
 - Vertebral subluxation or dislocation
- Abscess / Diskitis
- Spontaneous Epidural Hematoma
- Tumor or metastatic deposits



Epidemiology

- Can affect all age groups and different causes vary with different patient groups.
- Patients with known disk disease, osteoporosis and malignancies are at increased risk
- Malignancy: cord compression occurs in 2.5% of total cancer cases



Complete vs Incomplete

- Complete:
 - Absence of sensory and motor function below the level of injury
 - Loss of function to lowest sacral segment
 - Minimal chance of functional motor recovery
- Incomplete:
 - Sensory, motor or both functions are partially present below the neurologic level of injury
 - Some degree of recovery
 - Incomplete syndromes:
 - Anterior spinal cord syndrome
 - Anterior spinal artery syndrome
 - Posterior column syndrome
 - Brown-Sequard(Hemicord) syndrome
 - Central Spinal cord syndrome



Anterior Cord Syndrome

- Damage to the corticospinal and spinothalamic tracts
- Dorsal column function is intact
- Loss of:
 - Motor function
 - Pain and temperature sensation
- Vibration, position and crude touch are maintained



Central Cord Syndrome

- Older patients
- Preexisting central spondylosis
- Hyperextension injury
- Injury affects central cord> peripheral cord
- Damage to corticospinal and spinothalamic tracts
- Upper extremities>thoracic >lower extremities>sacral

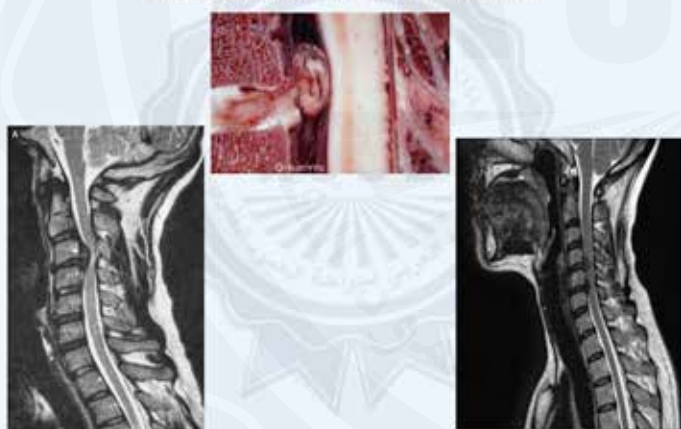


Brown-Séquard Syndrome

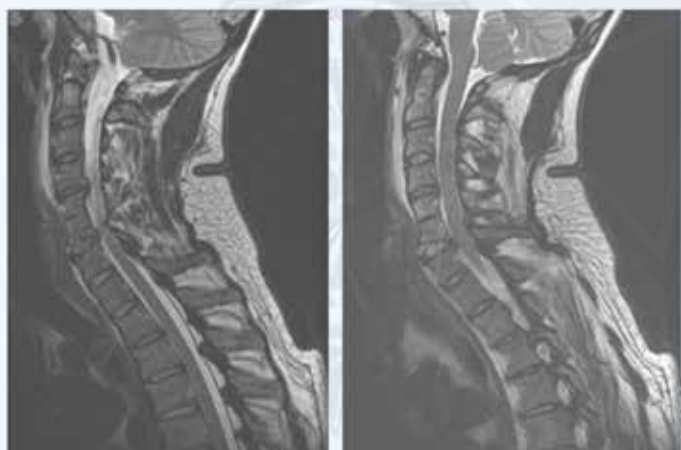
- Hemisection of the cord
- Ipsilateral loss of:
 - Motor function
 - Proprioception and vibration sense
- Contralateral loss of:
 - Pain and temperature sensation



Acute Disk Herniation



Hyper-extension injury of the neck with ALL disruption



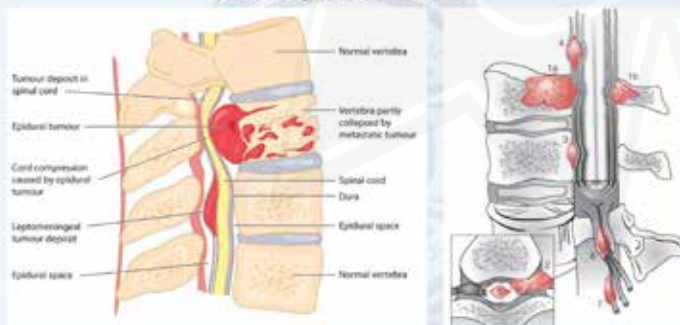
Thoracic Disk Herniation



Thoracic Disk Herniation



Malignancies



Malignancies



Metastatic parotid squamous cell carcinoma, presented following fall with lower limb deficit



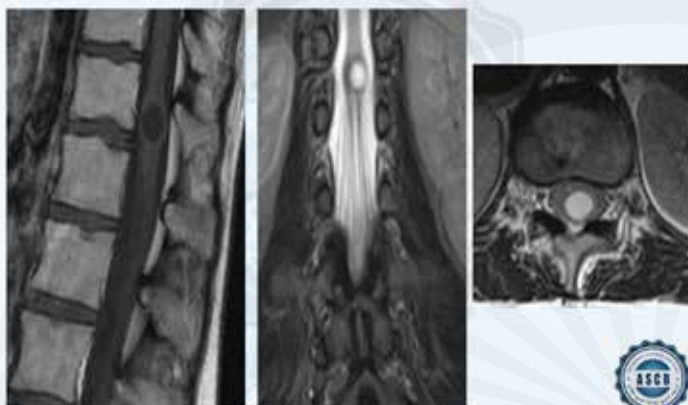
Malignant spinal cord compression from glioblastoma drop metastasis



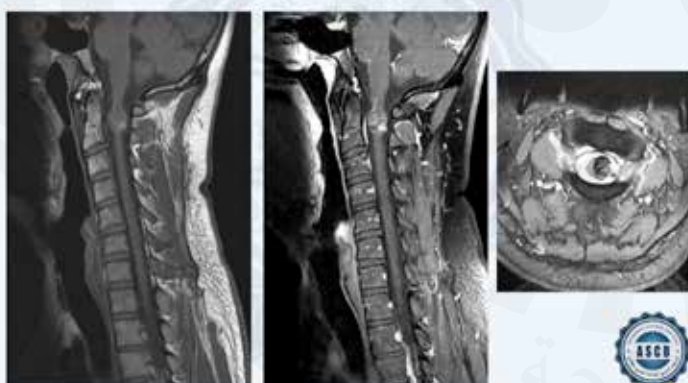
Spinal cord compression from epidural prostate metastases



Intramedullary cyst of the lumbar spinal cord



Cervical spinal cord cavernoma



Spinal Meningioma



Discitis



Discitis, osteomyelitis with epidural phlegmon



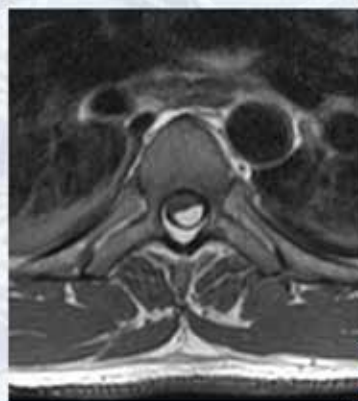
Lumbar Epidural Abscess



History of IV Drug Use



Intradural Lipoma



Epidural Hematoma (warfarin use)

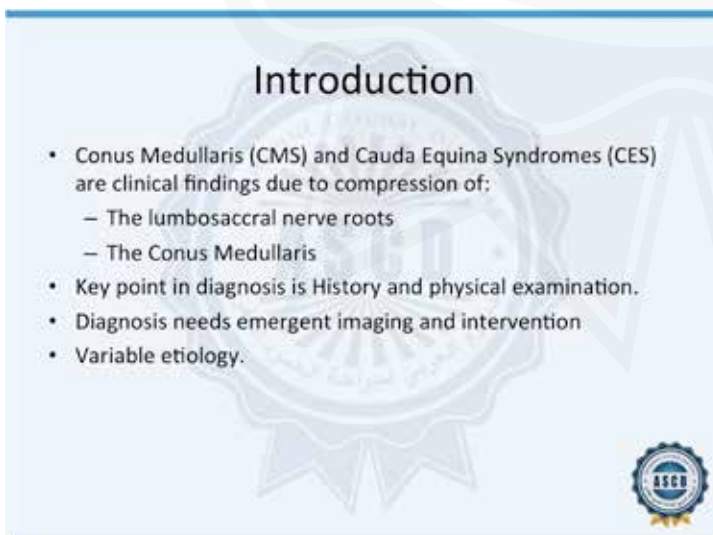
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Fractures

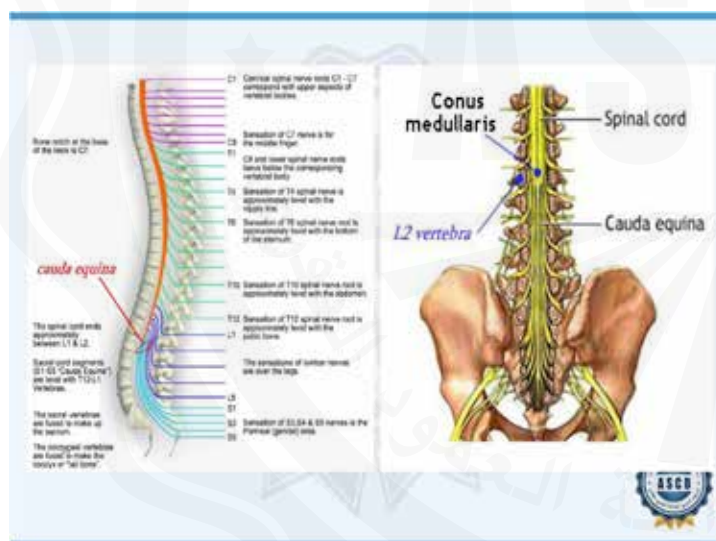
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- There is no precise definition of CES
 - Diversity of possible etiologies and myriad clinical presentations
- Literature consensus that the diagnosis of CES must involve
 - Bladder dysfunction
(Domen et al, 2009, Fraser et al, 2009, Sun J et al, 2012)
- The clinical definition of CES by proposing
 - bladder or bowel dysfunction
 - perianal dysesthesia, or sexual dysfunction
 - possible neurologic deficits in the LE: motor, sensor



The Cauda Equina

- The Cauda Equina (i.e., “horse’s tail”) is the name given the group of nerve roots that arise from the culmination of the spinal cord (the conus medullaris) and extend inferiorly in the intradural space towards the coccyx.



The Cauda Equina

- The “Cauda Equina” was so-named by French anatomist Andreas Lazarius in the 1600’s.
- Generally considered to be comprised of nine pairs of nerve roots, starting with L2 and extending to and including S5 (ok, and the coccyx root as well).
- Provides motor innervation to the hips, knees, ankles, and feet...as well as sphincter innervation, sensory innervation to the “saddle region,” and parasympathetic innervation to the bladder (and distal bowel).



Aetiology

- Trauma
- Herniated IV disc
- Spinal Stenosis
- Neoplasms
- Inflammatory Conditions
- Infectious Conditions
- Developmental defects
- Causes related to medical intervention (iatrogenic)
- Much rarer causes include the following:
 - Intravascular lymphomatosis
 - Multiple sclerosis
 - Spinal arteriovenous malformations
 - Neurosarcoidosis
 - Deep venous thrombosis of the spinal veins (propagated)
 - Inferior vena cava thrombosis



Herniated Disc



Burst fracture with cauda equina syndrome



Pott disease causing cauda equina syndrome



Cauda Equina Tumors



CES

- Cauda Equina Syndrome was first described by Mixter and Barr in 1934.
- A *variable* presentation consisting of a constellation of symptoms which includes lower back pain, asymmetrical LE paralysis, variable sensory deficits, and loss of bowel and bladder control.



CES

- Major point to keep in mind is this: Cauda Equina Syndrome has a variable presentation and is widely thought to be regularly misdiagnosed or just plain missed.
- Failure to recognize the syndrome (especially in the emergency setting) is an ongoing issue and the subject of continued litigation in patients who were eventually recognized to have this, but in whom deficits remain after surgery.



CES signs/symptoms

- **The most common symptom in patients presenting with CES is Low Back Pain (LBP).**
 - >90% of patients
- Nonspecific, yes, but index of suspicion should be high and appropriate history should be elicited, especially if coexisting symptoms/complaints are present.



CES signs/symptoms

- **The most consistent sign in cauda equina syndrome is urinary retention (incidence approaches 90%).**
 - Check post-void residual – normal is between 50 and 100 mL and >200 is positive for retention.
 - Overflow incontinence can be seen as the bladder fills.
- **Anal sphincter tone is diminished in 50-75% of patients with CES.**
 - Fecal incontinence can be seen.



CES signs/symptoms

- **“Saddle anesthesia” is the most commonly observed sensory deficit in patients with CES.**
 - Roughly 75% of pts.
- Sensory loss seen around the anus, lower genitalia, perineum, buttocks, sometimes even the posterior thighs.



CES signs/symptoms

- LBP is a nonspecific finding.
- New LBP is rarely seen in cases of CES without other symptoms being present.
- Sciatica, when present, is usually bilateral (but can be unilateral).



CES signs/symptoms

- Motor weakness – can be severe, and usually involves *more* than a single nerve root.
- May be bilateral, but is rarely symmetric (one side is usually weaker/stronger than the other).
- Untreated motor weakness can become permanent disability, and can progress to complete paralysis/paraplegia.
- Reflexes are HYPO-active; no long tract signs.



	Conus Medullaris Syndrome	Cauda Equina Syndrome
Presentation	Sudden and bilateral	Gradual and unilateral
Reflexes	Knee jerks preserved but ankle jerks affected	Both ankle and knee jerks affected
Radicular pain	Less severe	More severe
Low back pain	More	Less
Sensory symptoms and signs	Numbness more localized to perianal area; symmetrical and bilateral; sensory dissociation occurs	Numbness more localized to saddle area; asymmetrical, may be unilateral; no sensory dissociation
Motor strength	Typically symmetric, hyper-reflexic distal paresis of lower limbs that is less marked; fasciculations may be present	Asymmetric a-reflexic paraplegia that is more marked; fasciculations rare; atrophy more common
Impotence	Frequent	Less frequent; erectile dysfunction, lack of sensation in pubic area, and inability to ejaculate
Sphincter dysfunction	Urinary retention and atonic anal sphincter cause overflow urinary incontinence and faecal incontinence; tend to present early in course of disease	Urinary retention; tends to present late in course of disease



Onset of CES

- Acute presentation is most common, and is most commonly seen in patients with a prior history of LBP.
- Acute presentation in patients with no prior history of LBP and/or sciatica *occasionally* seen.
- Insidious onset and progression of symptoms is rare, but is associated with better chance of return of function (*especially* bladder function).



Incidence of CES

- Incidence of CES in U.S. is estimated between 2 and 4 cases per 10,000 patients with chief complaint which includes LBP.
- Estimated to be present to some degree in as many as 2% of patients undergoing surgery for HNP.
- High clinical suspicion must be kept in patients presenting with LBP and other symptoms. Good history and physical exam-taking is key!



Pathophysiology of CES

- Nerve roots of the Cauda Equina are susceptible to injury from compression partly due to a poorly developed epineurium (less protection from “outside stresses” or tension).
- Proximal nerve roots are relatively hypovascularized and are supplemented by increased vascular *permeability* in this area as well as diffusion from surrounding CSF (which is thought to contribute to swelling and edema in irritated nerve roots).
- Unmyelinated, smaller parasympathetic/pain fibers are more susceptible to compression and injury from compressive forces.



Surgical Issues with CES

- The major point of contention with Cauda Equina surgical intervention revolves around timing – when is it most appropriate to operate on these lesions? IS THIS AN EMERGENCY???



Prognosis

- Shapiro et al noted that patients who underwent surgery within 48 hrs of symptom onset, 95% recovered continence and normal function within six months. Conversely, 63% of those patients whose surgery was delayed beyond 48 hrs still required catheterization after 6 months.
- Generally, patients show improvement first in pain, then with motor function – while autonomic signs are last to improve (and the least likely).

[illegible]

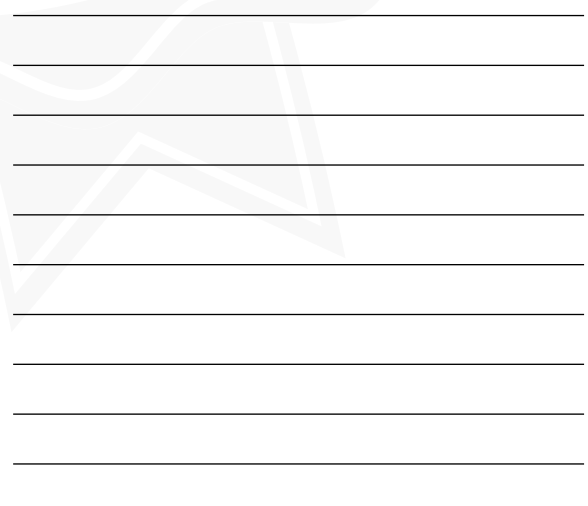
When to operate

- A meta-analysis that came out of Johns Hopkins University in 2000 (total 332 patients) that looked at patients with CES secondary to lumbar disc herniations, Ahn et al determined a significant improvement in outcome for patients operated on within 48 hours of onset of symptoms when compared with those operated on more than 48 hours after onset of symptoms.
- Within those respective groups, there was no significant difference in outcomes for earlier or later times.

[illegible]

When to operate

- There is still debate about this in the literature. In 2004, Radulovic et al published a retrospective analysis of their own series of patients (47) where they found no significant difference in outcome regardless of time to operation. This study, however, did not focus on onset of symptoms; but rather, time from presentation.



Time to surgery - Outcome

- More recently, McCarthy et al published their series of 42 patients with CES secondary to disc herniation and found no significant improvement in patients' outcome regardless of time to surgery after onset of symptoms.



Current recommendations

- Current recommendations outline a goal of performing surgery within 24 hours of presentation if at all possible.
- A major line of thinking behind this plan lies in the medical-legal pitfalls of dealing with CES and the residual deficits dealt with by the patients.



Operating for CES

- The goal of the operation is to decompress the nerve roots of the cauda equina.
- Instrumentation is rarely used for acute disc herniations, but is more commonly used in cases of CES caused by trauma or severe degenerative disease of the spine from which CES has been the result of instability.



SERIOUS SPINAL CONDITIONS

Serious Spinal Conditions



Colorado

Come for winters/stay for summer



Disclosures

David A. Wong MD, MSc, FRCS(C)

Conflict of Interest:

- Stockholder
 - Denver Integrated Imaging
 - Huron Shores Investments LLC
- Research Funding (Group)
 - Mesoblast
- Consultant
 - United Healthcare
- Royalties
 - Lippincott



Serious Spinal Conditions

- Inherited Arthritis
 - Ankylosing spondylitis
 - Rheumatoid
- Osteoporosis
 - Post menopausal vs 2°
- Neoplasm
 - Primary / Hematopoietic
 - Secondary
- Infection
 - Discitis/ osteomyelitis
 - Spinal Tuberculosis



Is it the Spine???

Back & Buttoch/Leg

- Hip
- SI Joint
- Vascular – AAA
- GI/GU
- Neoplasm/1°/mets
- Vascular Claudication
- Peripheral Neuropathy



Hip-Spine Syndrome

C. M. OFFERKIL, MD, and J. MACIAS, M.D., CH.B.

Ankylosing Spondylitis

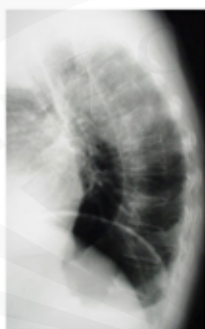
- 0.1%-0.5% adults
- Esp men teens/20's
- SI/LBP
 - Joints/tendonitis
- X-Ray
 - SI
 - Bamboo Spine
- HLA- B27



Osteoporosis Risk Factors

Medical Conditions

- Hyperthyroidism
- Chronic Lung Disease
- Cancer
- Inflammatory Bowel
- Chronic Hepatic Dis
- Chronic Renal Dis
- Hyperparathyroid
- Cushing's Disease
- Multiple Sclerosis
- Rheumatoid Arthritis



Osteoporosis Risk Factors

Medications

- Oral Steroids
- Cancer Treatments
 - Chemotherapy
 - Radiation
- Thyroid Medication
- Anti-Epileptic Meds
- Gonadal Hormone Suppression
- Immunosuppression



WHO Diagnostic Criteria

Classification	T-score
Normal	-1.0 and higher
Osteopenia	Between -1.0 and -2.5
Osteoporosis	-2.5 and lower
Severe osteoporosis	-2.5 and lower with history of fragility fracture

From Lewiecki E, AAOS online course

World Health Organization (WHO). Prevention and management of osteoporosis. Report of a WHO Scientific Group. http://whqlibdoc.who.int/trs/who_trs_921.pdf. Accessed December 26, 2011.

Diet (mg. Calcium)

Person A	Person B
Breakfast - Cereal + milk - 300 - Orange Juice - 300 - Yogurt - 450	Breakfast - Dry corn flakes - 0 - Diet Coke - 0
Lunch - Grilled cheese - 370 - Milk - 300	Lunch - French fries - 70 - Diet Coke - 0
Dinner - Cheese pizza - 140 - Broccoli - 90 - Milk - 300	Dinner - Cheese pizza - 140 - Diet Coke - 0
Total = 2150	Total = 210
DAILY REQUIREMENT = 1300 MG/D	

Osteoporosis Resources

- US Surgeon General's Report
 - www.surgeongeneral.gov
- NIH
 - www.osteoporosis.nih.gov
- National Osteoporosis Fdn
 - www.nof.org
- NASS
 - www.spine.org
- AAOS
 - www.aaos.org



Compression Fracture

vs.
Burst

- Three Column Concept Stability
 - Anterior
 - Middle
 - Posterior
- Compromise
 - 1 Column – stable (compression #)
 - 2 Column – unstable (burst #)
 - 3 Column – unstable (Chance #)



Compression Fracture

VS. Burst



- = who needs a CT
- Measurements
 - Vertical posterior body
 - Interpedicular distance

Spinal Neoplasm-Location



- Arch/Posterior Body
 - Osteoid Osteoma
 - Osteoblastoma
 - Aneurismal Bone Cyst-ABC
- Body
 - Metastases
 - Myeloma
 - Lymphoma
 - Eosinophilic Granuloma
 - Hemangioma
- Sacrum
 - Giant Cell
 - Chordoma



Spinal Neoplasm- Benign



	Age	Sex	Location	Characteristics
Osteoid Osteoma	<30	M > F	posterior	nidus/sclerosis
Osteoblastoma	<30	M > F	posterior	lucent
Osteochondroma	10-20	M > F	posterior	calcified
Aneurismal Bone Cyst ABC	<25	M=F	posterior	Lytic/expansile
Eosinophilic Granuloma	<20	M > F	body	Lucent/collapse
Giant Cell	>20	M > F	Body sacrum	lytic
Hemangiomas	>30	M < F	Body	Vertical trabeculae Specding on CT

Spine Neoplasm - Malignant

	Age	Location	Characteristics
Neuroblastoma	<3	Body	Rosette on histology
Osteosarcoma	10-20	body	Destructive
Chordoma	30-70	Sacrum/C1-2	Lucent/destructive
Chondrosarcoma	50-70	Body	Destructive/calcification
Lymphoma	>20	Body	Osteopenia
Multiple myeloma	>50	Body	Osteopenia
Metastases	>40	Body/pedicle	Destructive/Sclerotic Disc Spared

Spinal Neoplasm - Intraspinal

Intradural - Extradural

	Age	Sex	Characteristics
Neurolemmoma	30-40+	M = F	Schwannoma
Neurofibroma	30-40+	M = F	Dumbell or circular
Meningioma	50-60+	M > F	Thoracic 80%

Intradural Intramedullary

	Age	Sex	Characteristics
Ependymoma	20-60+	M > F	50% in filum terminale
Astrocytoma	20-50+	M > F	
Syringomyelia	> 20	M = F	Cystic
Arachnoid Cyst	> 20		Cystic esp Thoracic
Perineural Cyst	> 20		Cystic esp Sacrum/ Tarlov

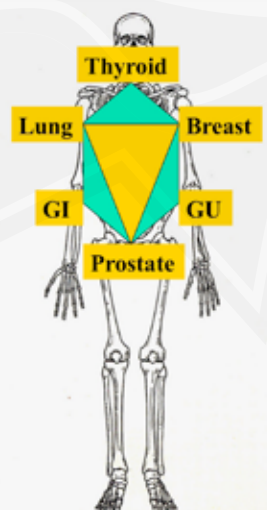
Skeletal Metastases

Hexagon

- Thyroid
- Lung
- Breast
- GI
- GU
- Prostate

Blastic

- Lung
- Breast
- Prostate



Septic Discitis/Osteomyelitis

- Very painful upright/OK flat
- Systemic symptoms
 - Fever/chills
- Immune Compromise
 - Diabetes/Chemo/RA/IBS
- Imaging
 - Involve disc-T2 hyperintense/narrow
 - Endplate enhancement/erosion
 - Epidural/paraspinous/psoas
 - Enhance with contrast



Spinal Tuberculosis-TB (Pott's)

- Children/young adults
- Most common extrapulmonary
- Start ant inf corner vert body
- Destruct disc sp/body
- Most common T/T-L
- Often spread mult levels
- Gibbus/ neurologic



Who Needs Investigation?

- Red Flags
 - Cauda Equina/B&B
 - Progressive neuro
 - Acute incapacitating symptoms
 - Esp acute pain upright/relief flat
 - Hx systemic symp
 - Fever/chills/night sweats
 - Fatigue/weight loss
 - Hx
 - Cancer
 - Osteoporosis
 - trauma



THANK YOU



www.arabspinediploma.org