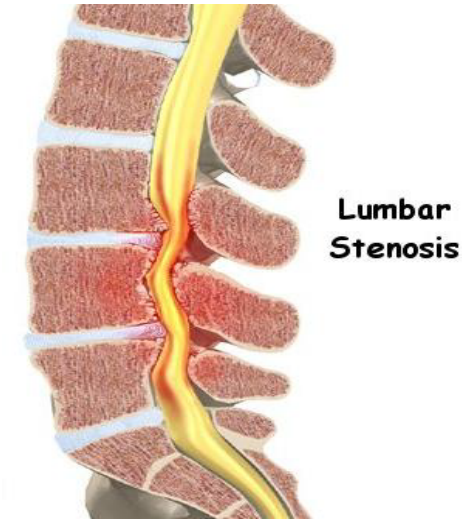
LUMBAR CANAL STENOSIS
RECENT ADVANCES



Source:
concordortho.com

Moderators

Dr Ashish Suri

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Presented by

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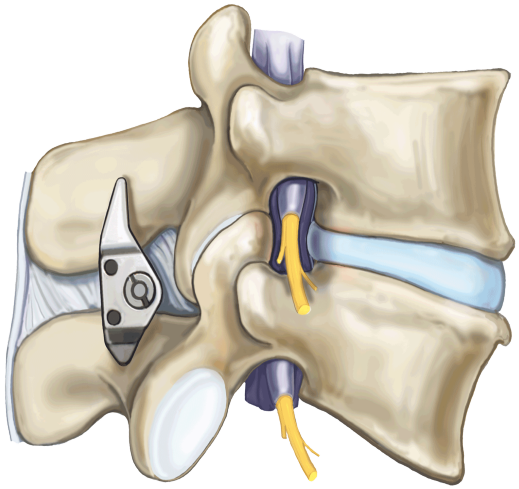


Source: musculoskeletalnetwork.com

LUMBAR CANAL STENOSIS (LCS)

- Definition: Narrowing of the spinal canal / lateral recess / intervertebral foramen.
- Sachs and Frankel (1900): 1st description of narrowing of lumbar canal.
- Henk Verbiest (Dutch surgeon):
  - First clinical description
  - Coined expression lateral spinal stenosis in 1940.

Henk Verbiest

EPIDEMIOLOGY/ BURDEN OF DISEASE

- Annual incidence: 5 cases/100,000. [1]
- 4 x higher than incidence of cervical spinal stenosis. [1]
- Myelographic evidence: 1.7–6% of adults by 65yrs of age [2]
- Stenosis in up to 80% of people >70 yrs [3]
- *Most common indication of spine surgery in patients > 65 years.* [4]

1.Johnsson K, et al. Lumbar spinal stenosis.A retrospective study of 163 cases in southern sweden. Acta Orthop. Scand. 1995;66, 403–405.

2. DeVilliers PD, Booysen EL . Fibrous spinal stenosis. A report on 850 myelograms with a water-soluble contrast medium. Clin Orthop Relat Res. 1976:140–4

3. Sasaki K. Magnetic resonance imaging findings of the lumbar root pathway in patients over 50 years old. Eur Spine J. 1995; 4:71–6.

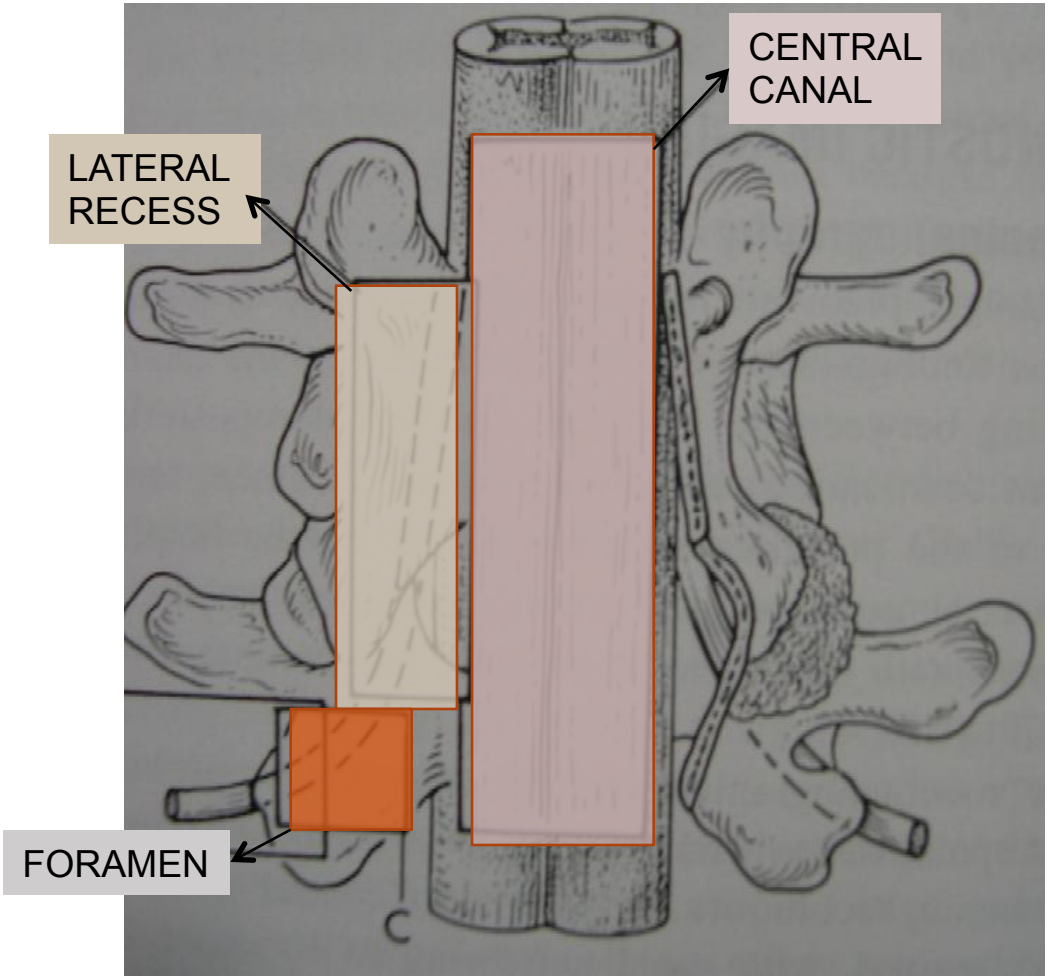
4. Postacchini F. Spine update: surgical management of lumbar spinal stenosis. Spine 1999; 24:1043-7

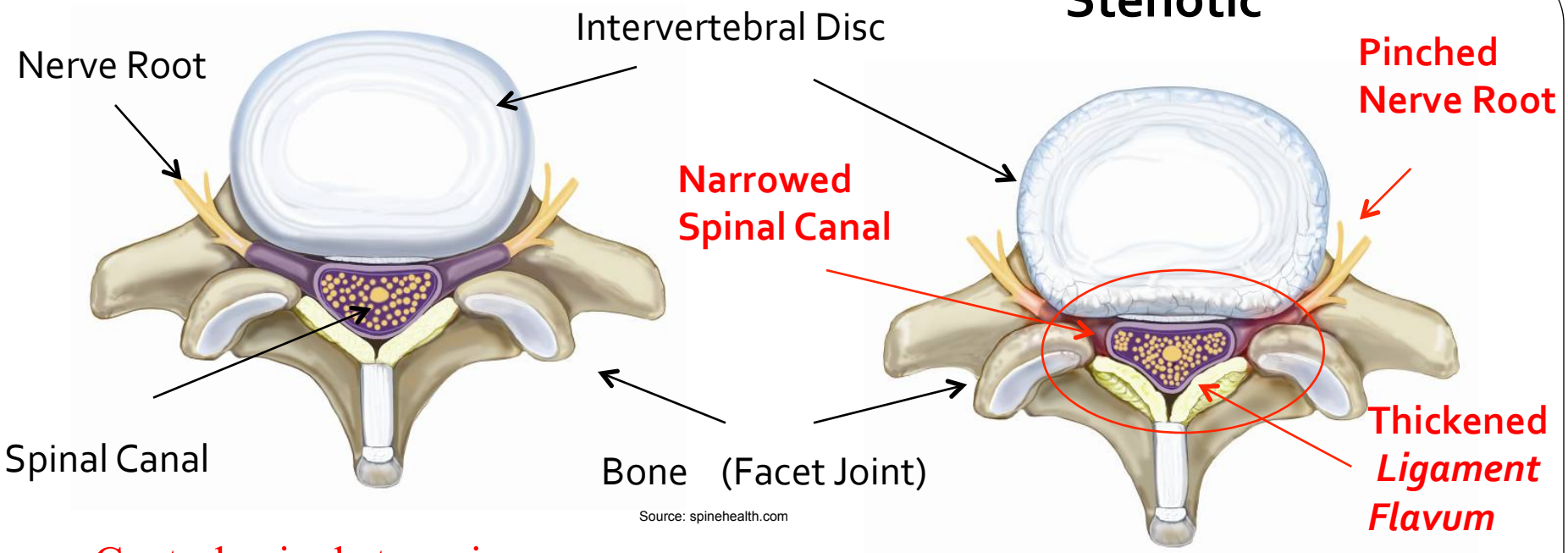
ETIOLOGICAL CLASSIFICATION

- *Congenital-developmental stenosis*
  - Idiopathic stenosis
  - Achondrodysplasia
- *Acquired stenosis*
  - Degenerative (for e.g., spondylosis, spondylolisthesis, scoliosis)
  - Ossification of the ligamentum flavum (OYL) & OPLL
  - Metabolic or endocrine causes (epidural lipomatosis, acromegaly, fluorosis)
  - Infections (discitis, osteomyelitis, Pott's disease [tuberculous spondylitis])
  - Neoplastic
  - Rheumatological conditions (for e.g., Paget disease, rheumatoid arthritis)
  - Posttraumatic or postoperative stenosis (for example, fracture of vertebrae, laminectomy, fusion, fibrosis)

ANATOMICAL CLASSIFICATION

- Central stenosis (with or without lateral stenosis)
- Isolated lateral stenosis
- Foraminal stenosis





Central spinal stenosis

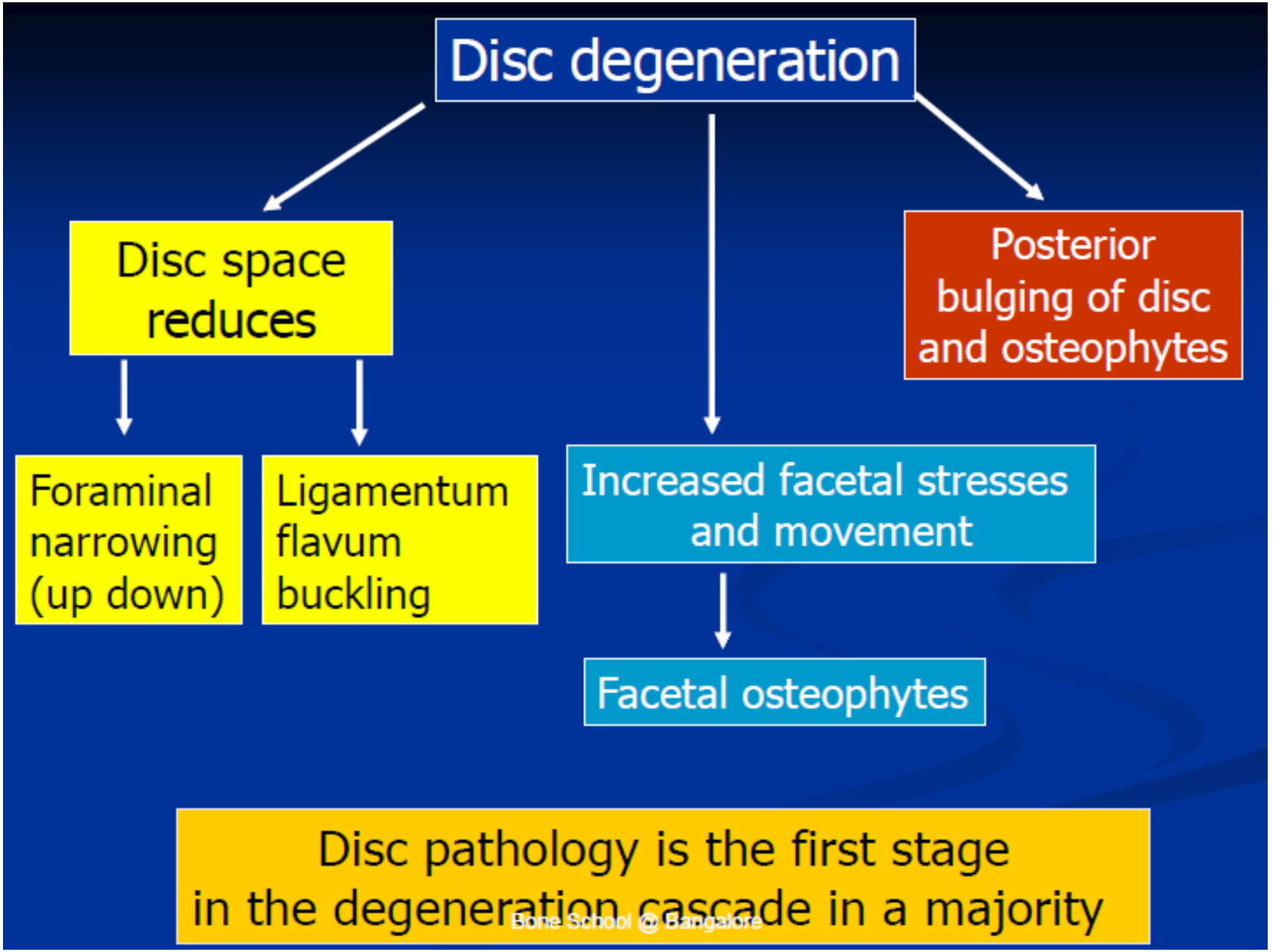
- Medially bulging/protruding disc.
- Hypertrophy of the yellow ligament: result of a compensatory mechanism to restabilize a segmental hypermobility

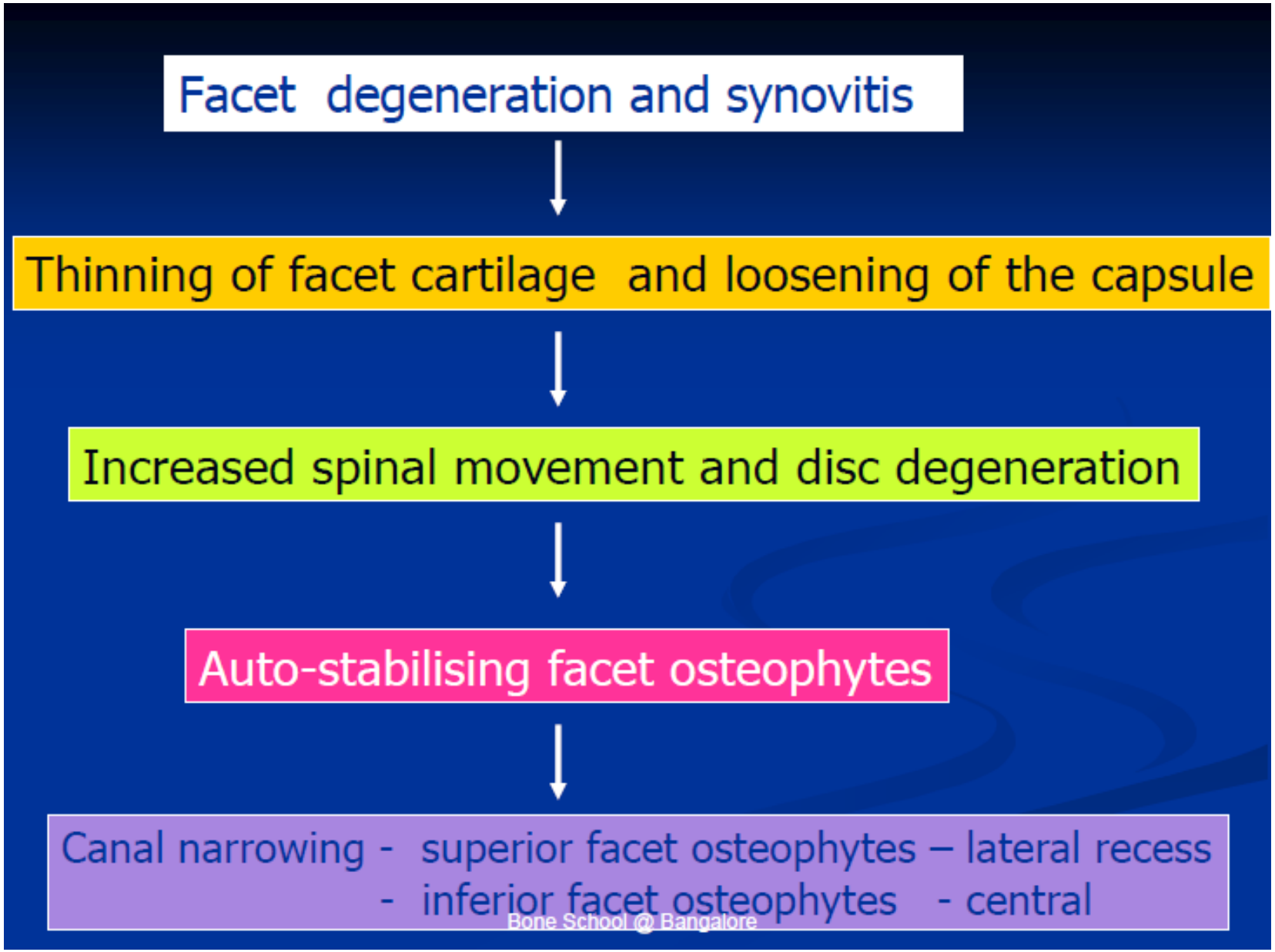
Lateral recess stenosis

- Disc height decrease
- Posterolateral disc protrusion
- Hypertrophy of the articular processes.

Foraminal stenosis

- Isthmic spondylolisthesis when the nerve root is compressed as a result of the listhetic vertebra and disc height loss


Disc degeneration
Disc space reduces
Posterior bulging of disc and osteophytes
Foraminal narrowing (up down)
Ligamentum flavum buckling
Increased facetal stresses and movement
Facetal osteophytes
Disc pathology is the first stage in the degeneration cascade in a majority
Bone School @ Bangalore


Facet degeneration and synovitis
Thinning of facet cartilage and loosening of the capsule
Increased spinal movement and disc degeneration
Auto-stabilising facet osteophytes
Canal narrowing - superior facet osteophytes – lateral recess
- inferior facet osteophytes - central
Bone School @ Bangalore

SPINAL CLAUDICATION SYNDROME

- *Neurogenic Compression Theory* [1,2]
  - Mechanical nerve root compression
    - Decreased nutrition
    - Microvascular changes
    - Edema
    - Fibrosis

- *Vascular Compression Theory* [3]
  - Venous congestion and inadequate arterial vasodilation impairs nerve root nutrition during walking.

1. Rydevik B, Holm S, Brown MD, Lundborg G (1990). Diffusion from the cerebrospinal fluid as a nutritional pathway for spinal nerve roots. Acta Physiol Scand 138:247–8
2. Rydevik B, Lundborg G, Skalak R (1989) Biomechanics of peripheral nerves. In: Nordin M,Frankel VH (eds) Basic biomechanics of the musculoskeletal system. Lea & Febiger, Philadelphia,pp 75–87
3. Ooi Y, Mita F, Satoh Y (1990) Myeloscopic study on lumbar spinal canal stenosis with special reference to intermittent claudication. Spine 15:544–9

SYMPTOMS OF LUMBAR SPINAL STENOSIS

Source: neurosurgical.com

- Standing / walking provokes symptoms
- Numbness/ Pain/ weakness in the legs

- Patients lean forward while walking to relieve symptoms

- Sitting or bending forward relieves symptoms

Distance required to develop these symptoms will decrease with increasing severity of the degenerative changes

Lateral canal stenosis may present with ***radicular claudication*****:** localized to a nerve root dermatome

LESS FREQUENT SYMPTOMS

- Mechanical low-back pain (worse on activity)
- Atypical leg pain (non-radicular distribution)
- Cauda equina syndrome (very rare)

Source: topnews.in

PHYSICAL FINDINGS

- Limited lumbar extension (66–100%)
- Sensory deficit (32–58%)
- Muscle weakness (18–52%)
- Straight leg raising (10–90%)
- Absent knee reflexes (10–50%)
- Absent ankle reflexes (50–68%)

➢ A reliable assessment of the walking distance is an important parameter for determining the outcome of surgical treatment.

(Katz JN, et al: Diagnosis of lumbar spinal stenosis. Rheum. Dis. Clin. North Am. 20:471-483, 1994)

- In 1977, Dyck and Doyle reported the ***bicycle test of van Gelderen.***
  - Patient pedals on a stationary bicycle.
  - Lumbar stenosis: symptoms relieved on leaning forward while bicycling.
  - Peripheral vascular disease: claudication

NEUROGENIC Vs VASCULAR CLAUDICATION

Signs and symptoms	Vascular	Neurogenic
walking distance	• fixed	• variable
type of pain	• cramps, tightness	• dull ache, numbness
relief at cessation of activity	• immediate	• delayed
back pain	• rarely	• occasionally
pain relief	• standing	• flexion and sitting
posture provocation	• uncommon	• common
walking up hill	• pain	• no pain
bicycle riding	• pain	• no pain
pulses	• absent	• normal
trophic changes	• likely	• absent
muscle atrophy	• rarely	• occasionally

GRADING OF LCS

- ***Grade I***

  Neurogenic intermittent claudication characterized by a reduced walking distance (caused by pain) and short intermittent sensory-motor deficits that at rest might be unremarkable, but can deteriorate while walking

- ***Grade II***

  Intermittent paresis refers to already persistent sensitivity deficits, loss of reflexes and intermittent paresis.

- ***Grade III***

  Persistent, progressing paresis accompanied by partial regression of pain

Hufschmidt, A. & Lücking, C. H (eds) *Neurologie Compact (Thieme, stuggart, 2006)*

DIFFERENTIAL DIAGNOSES

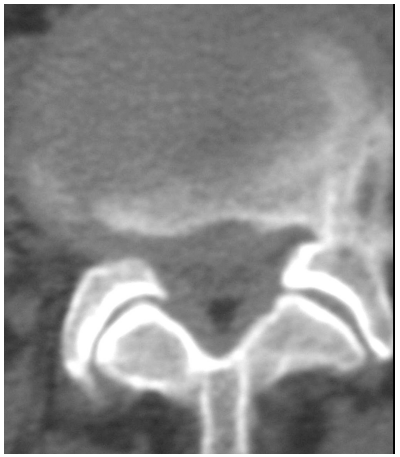
- Intermittent claudication or vascular claudication
- Radiculopathies or polyneuropathies
- Intraspinal synovial cyst
- Tethered cord or spina bifida
- Cox arthrosis or arthrosis of the iliosacral joint
- Abdominal aortic aneurysm
- Neoplasia (for e.g., tumor of myelon, spinal roots, meninges, bones)
- Inflammatory conditions (for e.g., spondylodiscitis, arachnoiditis)
- Dissociative syndromes

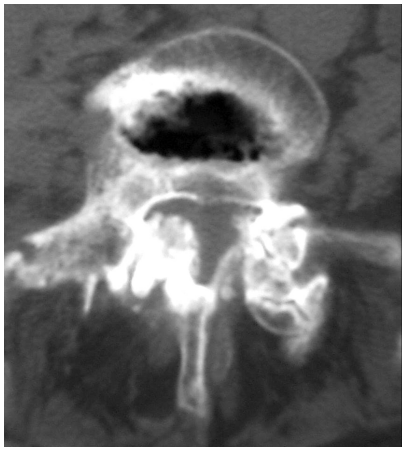
DIAGNOSTIC TESTS

X-Ray

- Screening exam
- Instability such as scoliosis or listhesis
- **Findings a/w stenosis**
  - Degenerative spondylolisthesis
  - Degenerative scoliosis
  - Congenitally narrow spinal canal
- **Less reliable findings implying lateral recess or foraminal stenosis :**
  - Disc space narrowing
  - Isthmic spondylolisthesis
  - Severe facet osteoarthritis

CT Scan



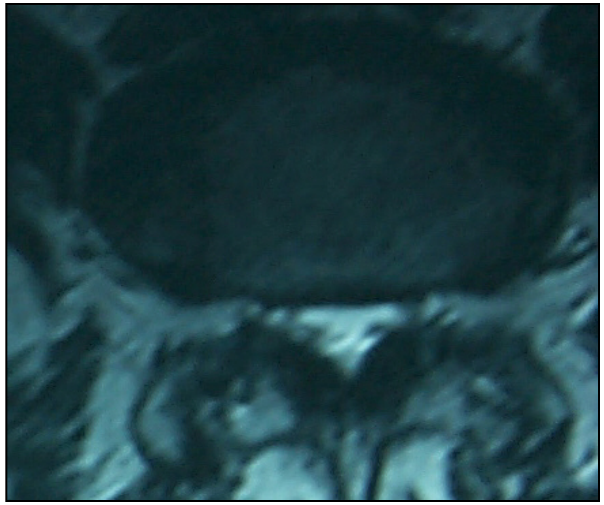


- Excellent bony detail
- May be useful for those who cannot have an MRI

- *Absolute stenosis*
  - Midsagittal lumbar canal diameters <10mm
- *Relative stenosis*
  - Midsagittal lumbar canal diameters <13mm

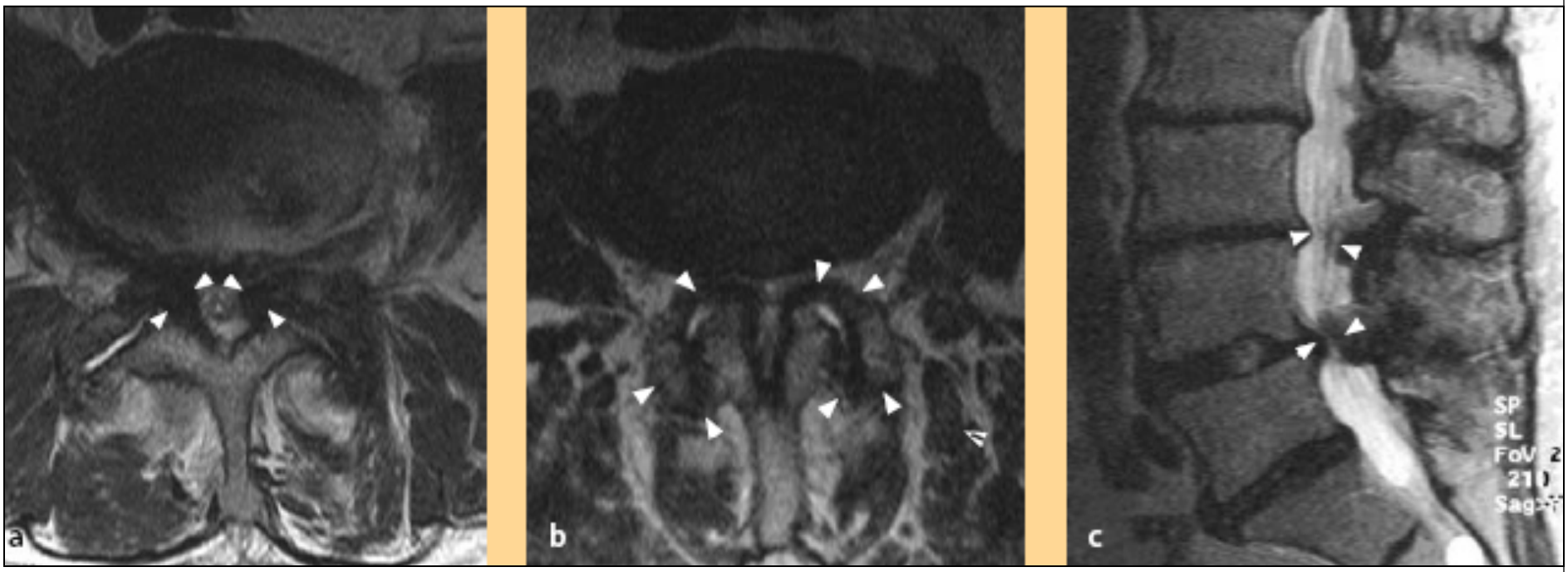
(Verbiest H The significance and principles of computerized axial tomography in idiopathic developmental stenosis of the bony lumbar vertebral canal. Spine 1979;4:369–78)

MRI



- *Gold standard*
- Non-invasive
- Soft tissue visualization

MRI CHARACTERISTICS OF SPINAL STENOSIS

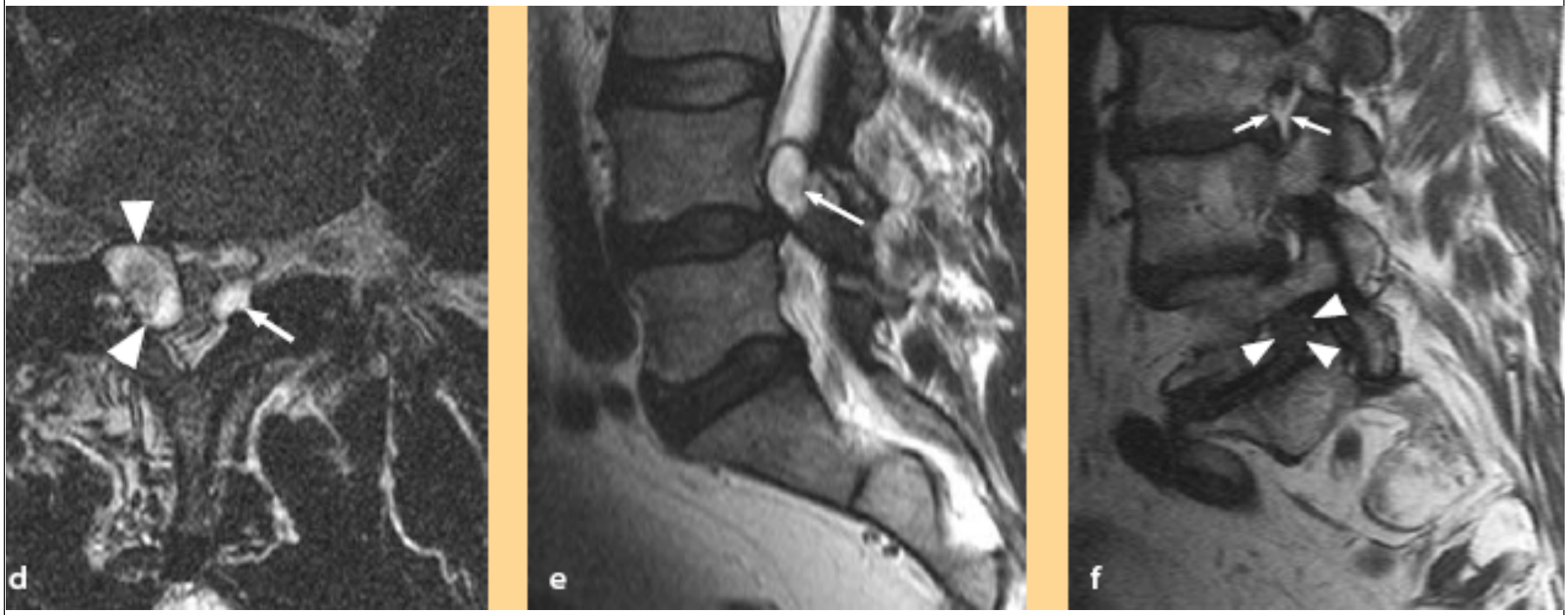


Hypertrophy of the yellow ligament on a T2W axial scan.

Facet joint hypertrophy with joint effusion on T2W axial image.

Hourglass appearance of the spinal canal on a sagittal T2W image.

MRI CHARACTERISTICS OF SPINAL STENOSIS

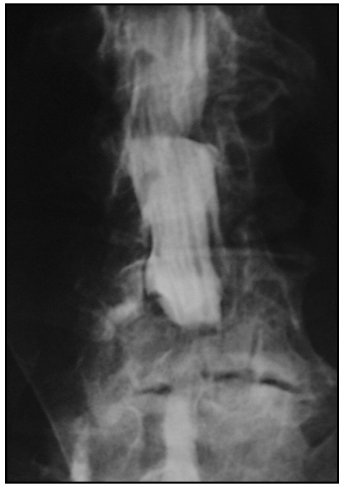


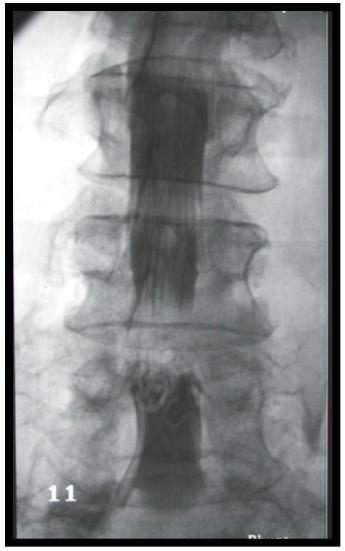
Large facet joint synovial cysts on right side (arrowheads) and a small cyst on left side (arrow).

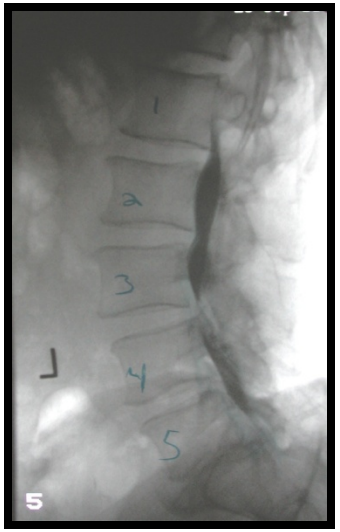
A large facet joint cyst compressing the thecal sac shown on T2W sagittal image.

Fat in the foramen appears with a bright signal on T1W (arrows). Obliterated perineural fat (arrowheads) in neural foramina indicating foraminal stenosis which is aggravated by a small disc protrusion

Myelography



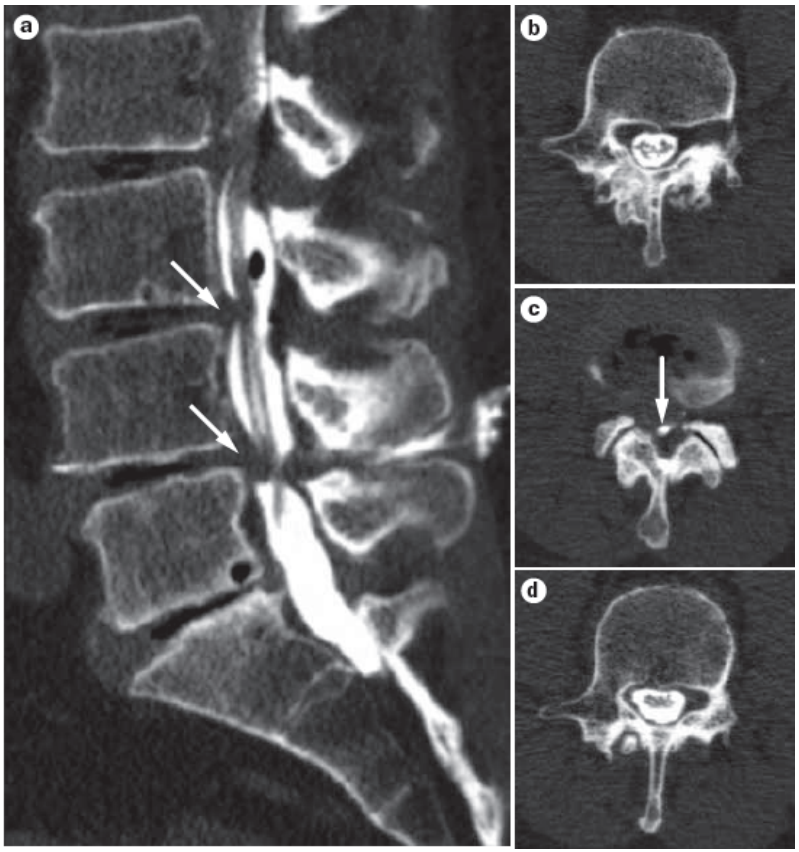




- Excellent for intra-canal pathology
- Poor for foraminal pathology
- Invasive
- 1% spinal headache
- Option if inability to obtain MRI
- Replaced by MRI

CT Myelography

- Excellent visualization of spinal canal



a | Sagittal reformatted CT myelograph : multisegmental severe disc degeneration, with disc space height reduction, vacuum phenomenon and endplate sclerosis of lower lumbar spine , thecal sac compressions at L3–4 & L4–5 (arrows).

b–d | Axial images : circumscribed severe LCS of L3–4, with typical hourglass constriction of thecal sac (arrow) adjacent to relatively normal areas.

Radiographics 2005:15; 122-29

NON_SURGICAL TREATMENT OPTIONS

- Rest and education
- Oral medication
- Cognitive behavioural therapy
- Multidisciplinary rehabilitation
- Immobilisation and supports
- Exercise therapy
- Physical therapy/massage therapy
- Manipulation
- Traction
- Injections
- Orthoses (Braces/ Corsets/ unloading corsets)
- Transcutaneous electric nv stimulation

Shen FH et al. J Am Acad Orthop Surg 2006.

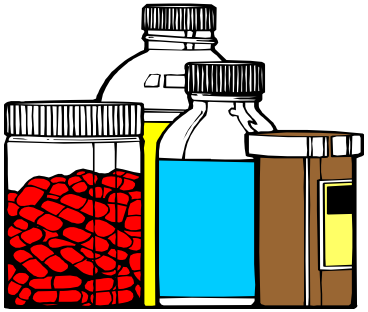
INDICATIONS FOR NON SURGICAL RX

- Mild claudication symptoms
- Concomitant back pain
- Mild to moderate radiculopathy
- Minimal interference with lifestyle
- Absence of motor deficits

Rest

Source: neurosurgical.com

- Short term activity modification for acute pain.
- Long term activity modification is not recommended



Medication

- Paracetamol
- NSAIDS
- Narcotics
- Muscle relaxants
- Gabapentin/pregabalin

Koes BW et al. Eur Spine J 2010; Savigny P et al. NICE guidance. BMJ 2009:

- Paracetamol : 1st line
- NSAIDs/ weak opioids/ both: 2nd line
- Effective for short term pain relief
- Persistent pain: strong opioids for short term

Djurasovic M, Glassman SD, Carreon LY, Dimar JR. Contemporary management of symptomatic lumbar spinal stenosis. Orthop. Clin. North Am 2010;41:83–91.

- Evidence of efficacy of NSAIDS, Muscle relaxants and opioid analgesics is lacking and they should have a limited role in treatment

Franklin GM et al. Spine 2008;Webster BS Scand JWork Environ Health 2007:

- Early use of opioids : ↑ work disabiilty, poor outcomes.

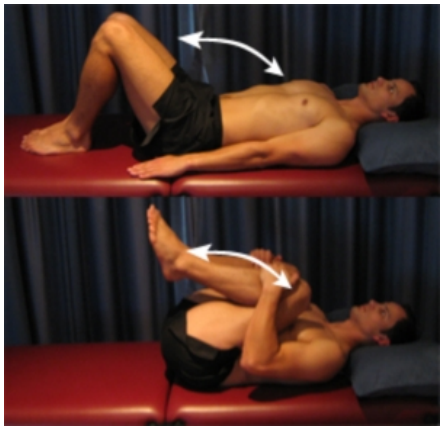
Exercise therapy

Hayden JA et al. Cochrane database Syst Rev 2005.

- Effective at decreasing pain and improving function

Kellar A et al. Eur Spine J 2007.

- Only modest efficacy



Source: physioadvisor.com.au

Hayden JA et al. Cochrane et al. Ann Intern Med 2005.

- Individually designed programmes
- Stretching or strengthening type
- Under supervision

Jensen TS et al. Eur Spine J 2008.

- May not be tolerated by all patients of degenerative disc disease

Choi BK et al. Cochrane database Syst Rev 2010

- Additional exercise programmes after formal treatment are beneficial.

BEHAVIOURAL THERAPY

TYPE	DEFINITION
OPERANT	Removes positive reinforcement of pain behaviour.
COGNITIVE	Modifies harmful cognitions (maladaptive thoughts, feelings, beliefs), uses cognitive restructuring techniques (imagery & attention diversion).
RESPONDENT	Modifies physiological responses to pain through reduction of ms tension using relaxation techniques.

Sorenson PH et al. BMC Musculoskelet Disord 2010.

• Cognitive intervention as good outcomes as exercise therapy despite fewer treatment sessions

Lamb SE et al.Lancet 2010.

• Improvement in back-specific function sustained over 1-yr follow-up

MULTIDISCIPLINARY REHABILITATION

- *Definition:* Multidisciplinary biopsychosocial rehabilitation coupled with a minimum of 1 physical dimension (i.e., psychological or social or occupational).

Guzman J et al. BMJ 2001.

- 'Moderate evidence that multidisciplinary rehabilitation with functional restoration more effective in reducing pain than less intensive treatments.'

Lambeek LC et al. BMJ 2010

- 'Multidisciplinary outpatient work-related intervention effective in return to work.'

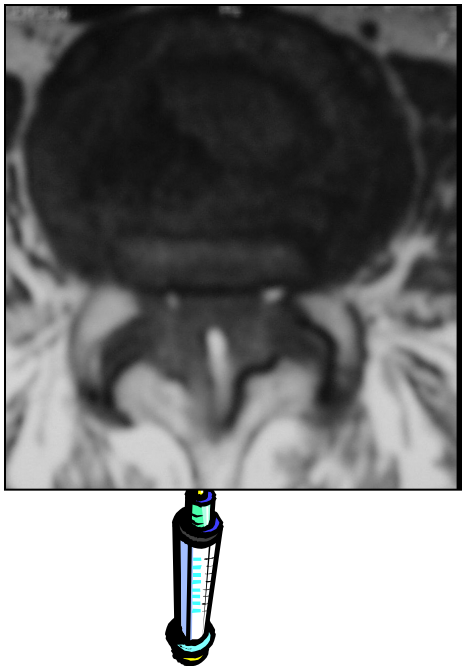
Buijis PC et al. J Back Musculoskeletal Rehabil 2009.

- 'Programme successful in changing patients' goal setting from pain-oriented toward function restoration and return to work.'

INJECTION THERAPY

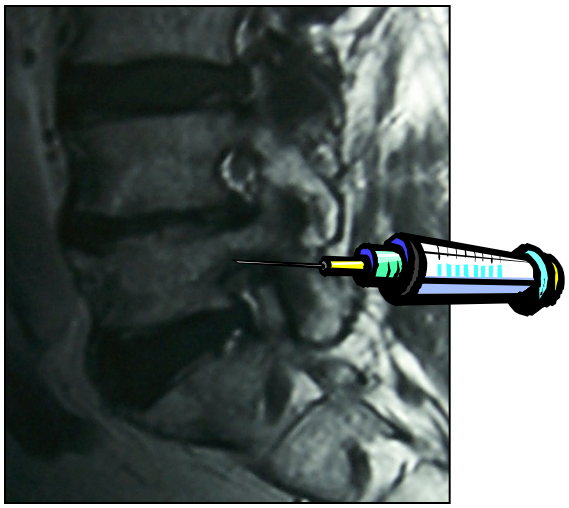
- Steroid injections:
  - Epidural
  - Transforaminal
  - Facet joint
  - Intradiscal
- Nerve blocks
- Provocative Discograms (intradiscal injections of contrast under fluoroscopy or CT imaging)
- Intradiscal TNF α antagonists
- Intradiscal fibrin injection
- Intradiscal methylene blue injection
- Calcitonin injection
- Growth factors and stem cell therapies

EPIDURAL STEROID



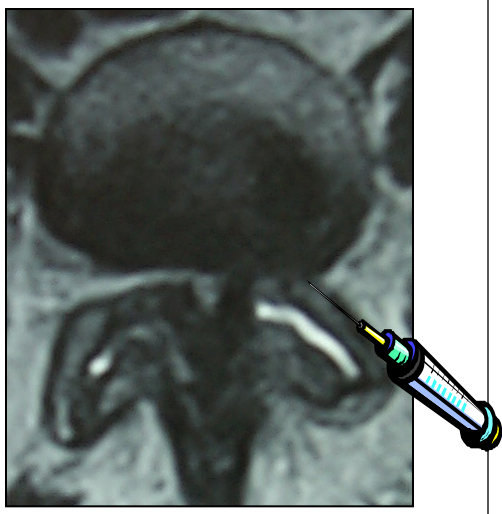
- Commonly prescribed
- 50% short-term efficacy
- Not as selective
- May not require fluroscopy

TRANSFORAMINAL ROOT BLOCK



- Highly selective
- Diagnostic as well as therapeutic
- Delivers medicine to the floor of spinal canal

FACET INJECTION



- Facet for back pain
- Not for radicular pain
- May act as epidural in 40% of cases

Chou R et al. Spine 2009.

- Epidural or transforaminal steroid injection recommended in patients with persistent radiculopathy: moderate short-term benefits.
- *STRONGLY RECOMMENDS AGAINST* provocative discography.

Djurasovic M et al. Orthop. Clin. North Am 2010.

- Epidural steroid injection: efficacy is contradictory.

Tran de QH, Duong S, Finlayson RJ. Can J Anaesth 2010.

- Epidural blocks may transiently decrease pain, but there is no evidence of long-term effect.

Parr AT, Diwan S, Abdi S. *Pain Physician* 2009.

- Adding steroids to these injections does not improve result.

- **TNF α ANTAGONIST INJECTION (ETANERCEPT)**
  - *More potent anti-inflammatory agent than steroids*
  - *Eagerly evaluated in tt of sciatica*[1]
- Cohen SP et al. Anaesthesiology 2007;107:99-105.
  - *Not yet proven in degenerative disc disease*

- **INTRADISCAL FIBRIN INJECTION**
- Buser Z et al.Spine 2011.
  - *Fibrin injection into experimentally damaged discs ↓ TNF α synthesis.*

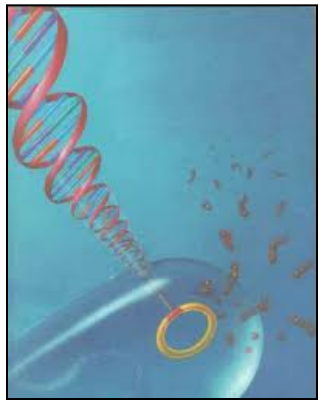
- **CALCITONIN INJECTION**
- Tran de QH, Duong S, Finlayson RJ. Lumbar spinal stenosis: a brief review of the nonsurgical management. *Can J Anaesth 2010;*57 (7): 694–703
  - *Injectable calcitonin may be useful for short term pain relief*

1. Karppinen J. New perspectives on sciatica. In: DeLeo JA, Sorkin LS, Watkins LR, ed. Immune and glial regulation of pain. Seattle (WA): IASP Press;2007. p. 385-406

INTRADISCAL METHYLENE BLUE INJECTION

- *Peng et al. Pain 2010.*
  - RCT comparing efficacy of methylene blue vs placebo
  - 24-month post injection follow-up
  - Significant ↓ in mean pain & Oswestry Disability Index Score with methylene blue
- However, study has not been replicated; benefits remain speculative
- *O'Neill et al. Toxicity of methylene blue in the epidural space. Presented at: International society for the study of the Lumbar Spine. Gothenburg. Sweden, 2011.*
  - Animal study
  - Extreme neurotoxicity l/t paralysis if dye leaked out of disc into epidural space
  - Never to be used in case of disrupted annulus fibrosus
  - Best to be avoided till further experiments

GENE THERAPY



Source: cmcweb.lr.k12.nj.us

- Current treatment methods address clinical symptoms but not underlying pathology
- *Molecular and gene therapy: potential to augment or reverse course of disease*
- Nishida 1998*: first successful in vivo transfer of adenoviral-mediated LacZ marker gene in rabbit models
  - Evidence of sustained transgene expression after 1 yr
  - No systemic side effects
- EFFECTS:
- ↑ TGF-β1
- ↑ proteoglycans
- paracrine effect on adjacent nontreated cell

*Nishida et al.Spine 1998;23: 2437-42.

STUDY	YEAR	FACTOR USED	RESULT
Wallach et al	2003	Tissue Inhibitor of metalloproteinase 1 (TIMP-1)	↑ proteoglycan synthesis
Paul et al	2003	Adenoviral Sox9 complex	↑ Type-II collagen
Yoon et al	2004	Adenoviral LMP-1 (LIM Mineralisation Protein)	↑ BMP-2 & 7 mRNA
Moon et al	2008	Growth factors (BMP-2 & IGF-1)	↑ proteoglycan synthesis

SAFETY ISSUES:

- Potential dangers due to viral vector usage
- Tumorigenesis

STEM CELL THERAPY

Source: topnews.in

- *BASIS OF THERAPY:*
- Disc degeneration is a cell-mediated response to progressive structural failure: causes instability of vertebral motion
- Most disc cells in adults are in senescent stage

- *Sakai et al. Biomaterials: 2003.* first transplantation of MSCs into rabbit disc degeneration
- Animal studies confirming efficacy:
  - Crevensten et al 2004
  - Zhang et al 2005
  - Himaya et al 2008
  - Leung et al 2006
  - Hoogendoorn et al 2008
  - Ganey et al 2009


Source: ibnlive.in.com

➢ ***Human studies:***

- *Yoshikawa et al. Disc degeneration therapy using marrow mesenchymal cell transplantation: a report of two case studies. Spine 2010;35: E475-80.*
- 2 cases undergoing decompression surgery for spinal stenosis
- Transplant autologous bone marrow stem cells into discs showing vacuum phenomenon and instability
- 2-yr follow-up MRI & Xray: high moisture content, less instability, less vacuum phenomenon

➢ **Dangers and limitations**

- Cell leakage l/t osteophyte formation *(Vadala et al 2011 J. tissue eng regen med)*
- Tumorigenesis
- Currently: focus only on nucleus pulposus (because it is a cavity with easier application of stem cells)
- Need for application to annulus fibrosus & vertebral end plate

CONSERVATIVE V/S SURGERY

Spine Patient Outcome Research Trial (SPORT)

- In patients with imaging-confirmed spinal stenosis without spondylolisthesis and leg symptoms persisting for at least 12 weeks, ***surgery was superior to nonsurgical treatment*** in relieving symptoms and improving function.

James N. Weinstein et.al. Surgical v/s Nonsurgical Therapy for LSS.
NEJM 2008; 358:794-810;Feb 21, 2008

MAINE LUMBAR STUDY GROUP

- Surgery group: more severe symptoms
- *1 year f/u* (p=0.003)
  - 55% surgery improved
  - 28% non-op improved
- *4 year f/u* (p=0.05)
  - 70% surgery improved
  - 52% non-op improved
- *10 year f/u* (p<0.05)
  - 54% initial surgery pts improved
  - 42% initial non-op pts improved

- ***Leg pain relief and back related functional status favoured surgical treatment, although benefits of surgery declined over time***

- Atlas SJ et al. Surgical and nonsurgical management of lumbar spinal stenosis: outcomes from the Maine Lumbar Spine Study. Spine 2000;25:556-62.

American Association of Neurological Surgery/ Congress of Neurological Surgery joint section

- 'Fusion recommended for LCS and associated degenerative spondylolisthesis which requires decompression'
- 'Wide decompression of facet joints a/w poorer outcome'
- *Thus, less invasive means of decompression and fusion needed.*

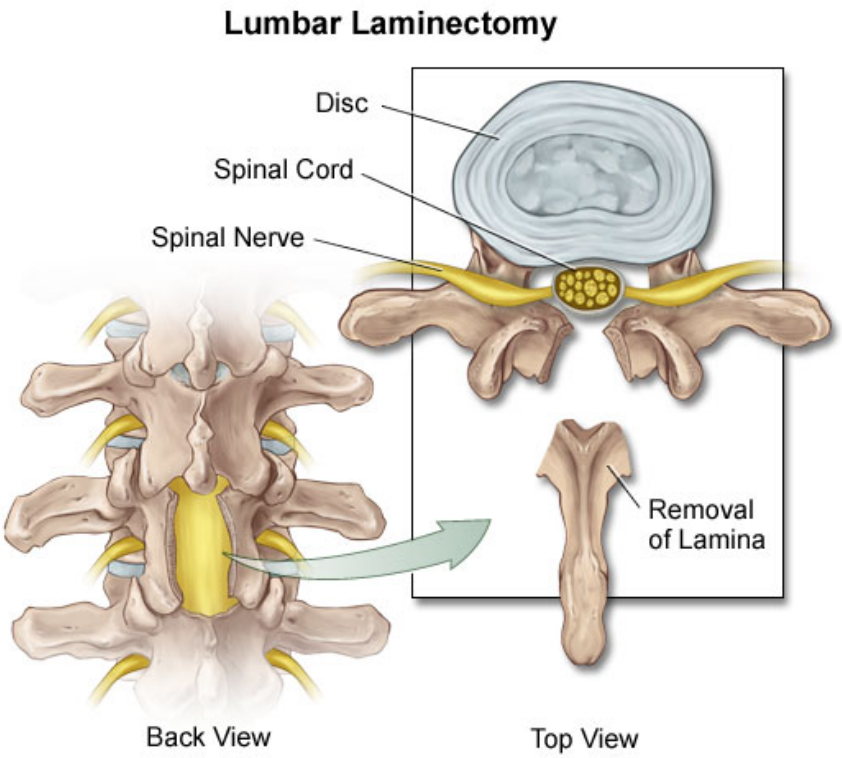
Resnick D et al. J Neurosurg Spine 2005;2:679-85.

INDICATIONS FOR SURGERY

- Moderate to severe claudication symptoms
- Significant interference with lifestyle
- Progressive neurological deficits
- Cauda equina syndrome

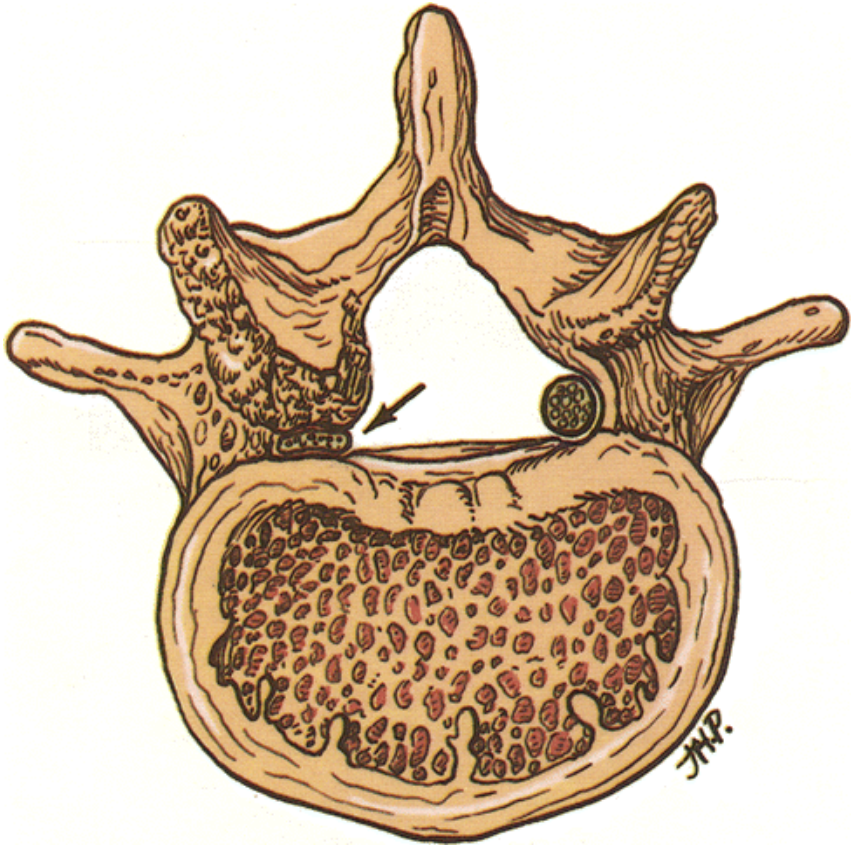
SURGICAL TECHNIQUES

- Decompression (uni-/bilateral laminotomy or laminectomy)
- Decompression with non-instrumented fusion
- Decompression with instrumented fusion



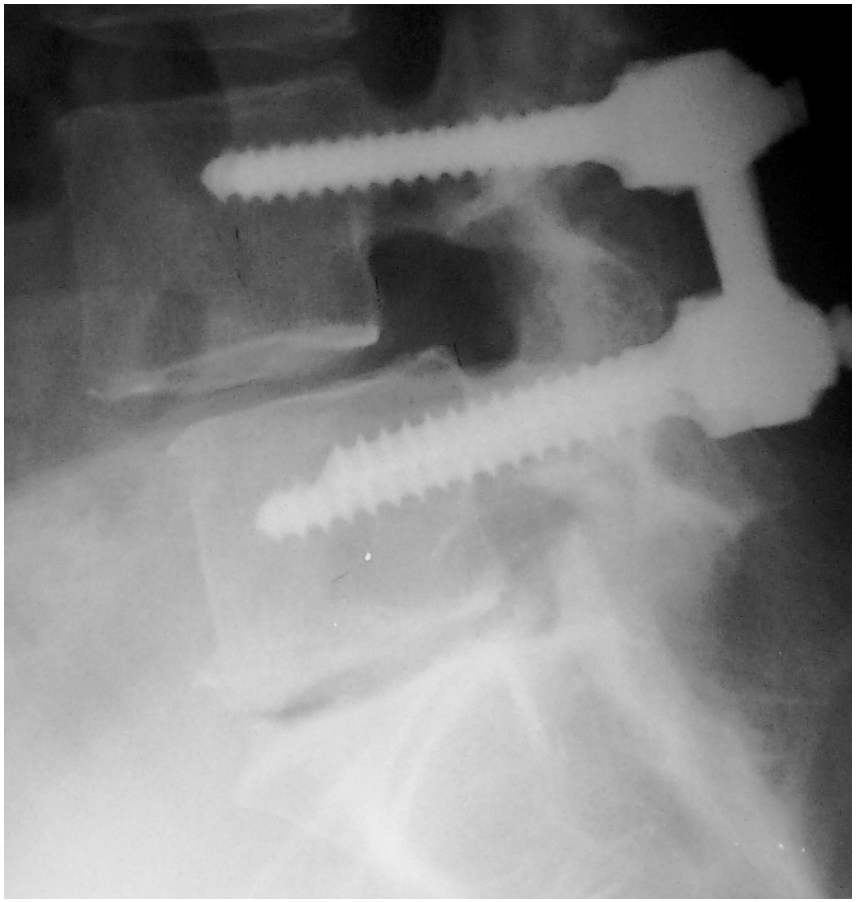
Source: yalemedicalgroup.org

- DECOMPRESSION OF LATERAL RECESS
  - Undercutting the ventral aspect of the facet joints and the associated ligamentum flavum.
  - Medial facetectomy if necessary
  - The traversing nerve root underneath the facet joint must be visualized



Source: yalemedicalgroup.org

- FUSION
  - Sagittal instability
  - Scoliosis
  - Iatrogenic pars defect
  - Greater than 50% facet joint resection



TOTAL LAMINECTOMY

- *Indication*

  - thecal sac cannot be sufficiently decompressed or access to the foramen is obliterated (foraminal stenosis).

- *Contraindication (laminectomy alone)*

  - pre-existing instability such as:
    - Degenerative spondylolisthesis
    - Isthmic spondylolisthesis with secondary degenerative changes
    - Degenerative scoliosis

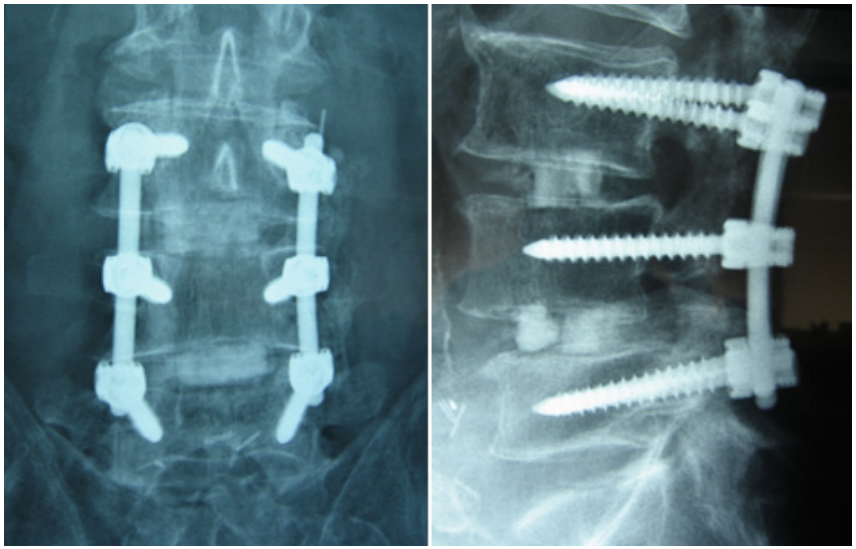
- Clinical results :
  - Patient satisfaction : 57% - 81%

Iguchi T,Wakami T, Kurihara A, Kasahara K, Yoshiya S, Nishida K (2002) Lumbar multilevel degenerative spondylolisthesis: radiological evaluation and factors related to anterolisthesis and retrolisthesis. J Spinal Disord Tech 15:93–9

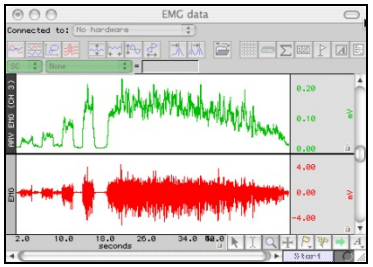
Iguchi T, Kurihara A, Nakayama J, Sato K, Kurosaka M, Yamasaki K (2000) Minimum 10- year outcome of decompressive laminectomy for degenerative lumbar spinal stenosis. Spine 25:1754–9

DECOMPRESSION AND FUSION

- Segmental instability (degenerative spondylolisthesis and scoliosis)
- Concomitant moderate to severe back pain
- Necessity for a wide decompression
- Recurrent spinal stenosis



INTRAOPERATIVE MONITORING



Source: biopac.com

- ***Modalities***
  - Somatosensory evoked potentials (SEPs)
  - Electromyography (EMG)
  - Motor evoked potentials (MEPs)

➢ Changes noted within 30 s of the untoward "event"; reproduced within 60 s

- All modalities ↓ complications during complex spine procedures *(Egli D et al. J Neurol 2007; Krassioukov AV et al. J Neurosurg Spine 2004)*
- Majority of clinical postoperative root injuries positively correlates with intraoperative SEP *(Resnick DK. J Neurosurg Spine 2005)*
- Both SEPs and EMG be used to provide immediate feedback during surgery regarding the sensory and motor function of the nerve tissue, cord, and cauda equina. *(Balzer JR. Neurosurg 1998)*

TRADITIONAL SURGERY

- *DISADVANTAGES*
- Extensive resection of posterior spinal elements & muscular complex: pain, disability and morbidity
- Loss of midline supra/interspinous lig complex: loss of flexion stability
- ↑ blood loss
- Paraspinal muscle denervation and atrophy; chronic pain and "failed back syndrome"
- Patients are elderly: higher comorbidity
- ↑ DVT and other systemic complications
- ↑ hospital stay

OPEN DECOMPRESSION PROCEDURES

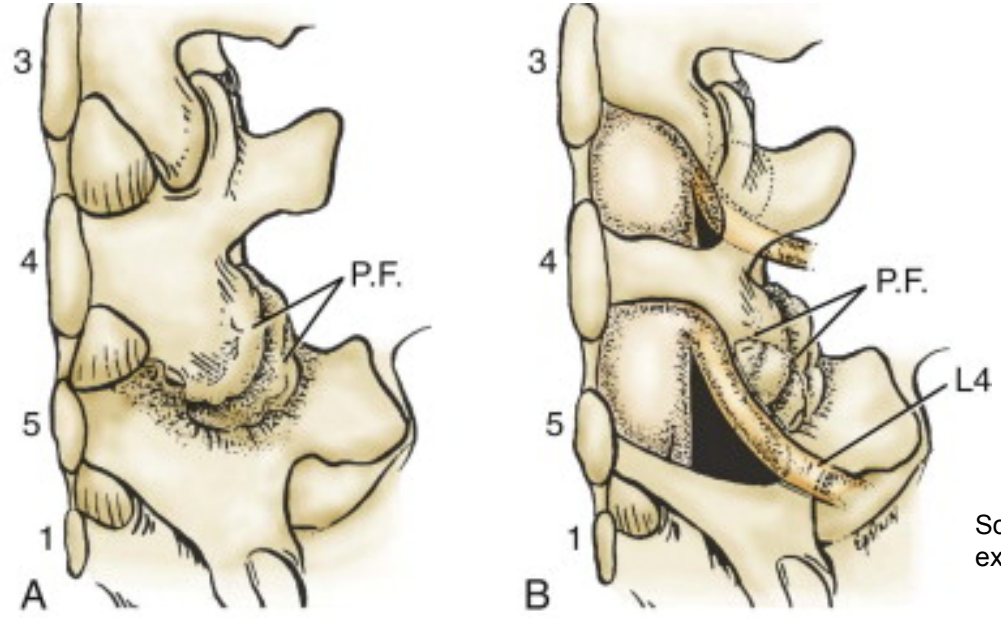
- *Laminotomy:*
- Unilateral laminotomy - for decompressing focal one-sided spinal stenosis

➢ *Oertel MF et al. Long-term results of microsurgical treatment of lumbar spinal stenosis by unilateral laminotomy for bilateral decompression. Neurosurgery 2006; 59:1269-1279.*

- 102 patients
- 92.2% improved
- 11.7% secondary operations – recurrent stenosis (7 cases); instability (2 cases)

➢ *Costa F et al. Unilateral Laminotomy for bilateral microdecompression. JNS-Spine 2007;7(6):579-586*

- 374pts
- 88% improved
- 0.8% instability
- None reoperated



Source:
expertconsult.com

A. Unilateral lateral recess stenosis at L4-5 + marked focal hypertrophy of L4-5 facet.

B. Mild lateral recess stenosis at L3-4 was decompressed using an interlaminar laminotomy + medial facetectomy + foraminotomy. However, at L4-5 , the greater degree of lateral recess stenosis warranted a partial L4-5 facetectomy to decompress the inferiorly exiting L5 nerve root. (P.F. - Posterior facets)

BILATERAL LAMINOTOMY (FENESTRATION PROCEDURE)

- Moderate central stenosis
- Adv: preservation of spinous processes, interspinous ligament, and lateral 2/3rd of facet joints: continued stability.

- *Nakai O, Okawa A, Yamaura I: Long-term roentgenographic and functional changes in patients who were treated with wide fenestration for central lumbar stenosis. J Bone Joint Surg Am 1991; 73:1184-1191.*

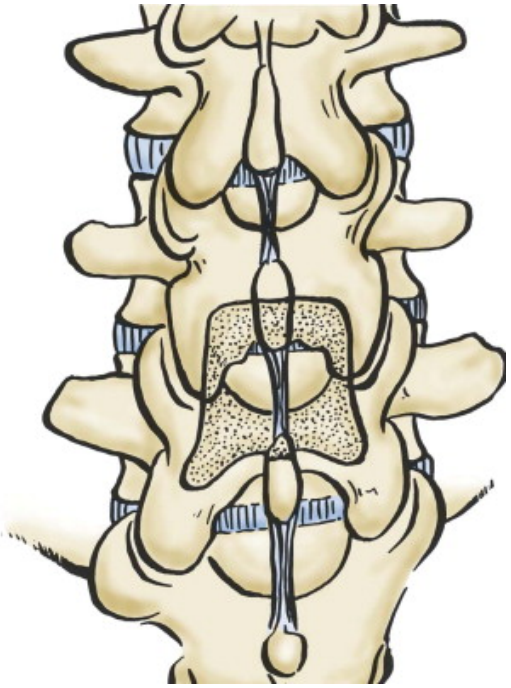
➢ Provided symptomatic relief for up to 5.5 postoperative years; although new bone deposition contributed to stability, there was no significant evidence of recurrent stenosis.

- *Caspar W, Papavero L, Sayler MK, et al: Precise and limited decompression for lumbar spinal stenosis..Acta Neurochir (Wien) 1994; 131:130-136*

➢ Adequately decompressed nerve roots and preserved stability, yielding a 71% incidence of good or excellent results on surgeon-based outcome measures and 76% good or excellent results on patient-based outcome questionnaires.

CORONAL HEMILAMINECTOMY

- Alternative to fenestration procedure, esp for one-level stenosis
- Removal of 2/3rd of cephalad spinous process and lamina and 1/3rd of caudad spinous process and lamina + medial facetectomy and foraminotomy
- Excellent decompression of central and lateral recess stenosis
- Better access to remove foraminal OYL *under operating microscope* from opposite side of table, without being limited by the presence of residual midline elements
- Useful: older patients more severe stenotic changes: maximizes safety & efficacy of decompression while minimizing instability by undercutting facet joints and avoiding more extensive facet disruption.



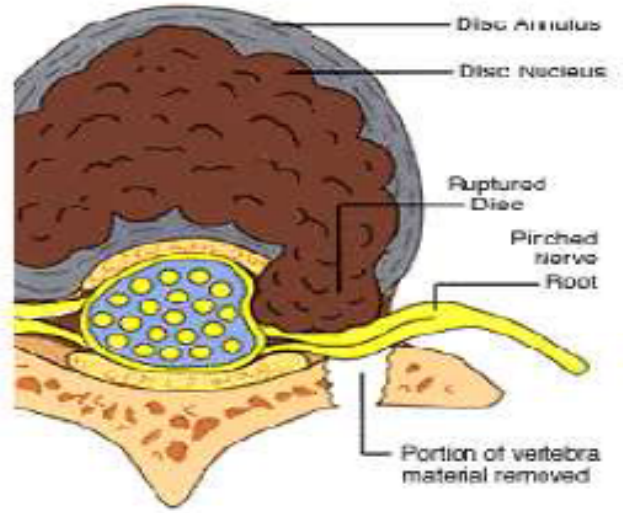
Source: expertconsult.com

SURGICAL ADVANCES

- Better microendoscopic visualization techniques :
  - MED (microendoscopic-assisted discectomies)
  - MEDL (microendoscopic decompressive laminotomy)
- B/L decompression via U/L approach
- Fusion by minimally invasive techniques
  - Percutaneous screw fixation
  - Post lumbar arthroplasty devices

Microendoscopic-assisted discectomies (MED)

- First developed in 1997
- Muscle splitting approach with serial tubular dilators
- Tubular retractor and special endoscope used to perform discectomy

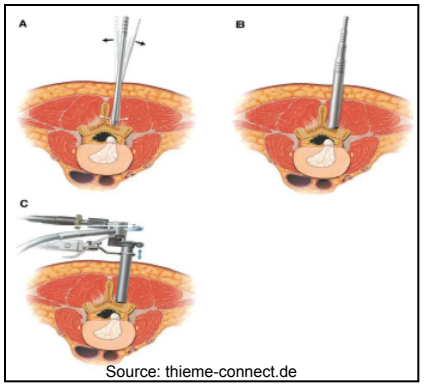


surgeon has removed a small portion of the bone to expose the pinched nerve.

Source: brainspine.com

APPROACHES:

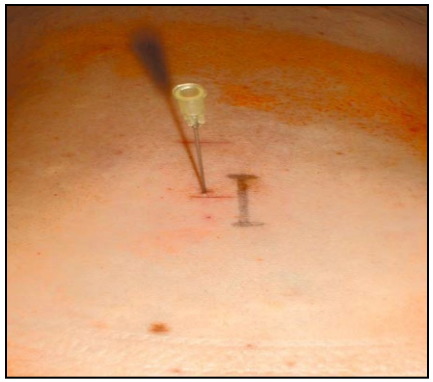
- Standard posterior (interlaminar)
- Translaminar
- Transforaminal
- Extraforaminal



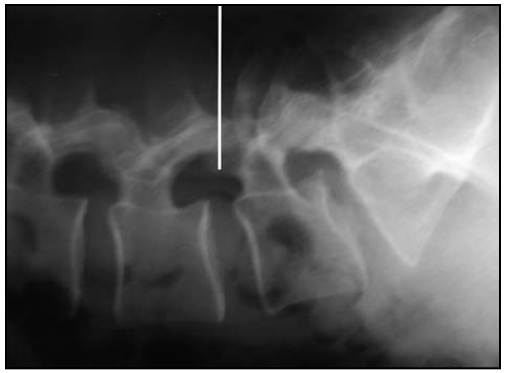
Source: thieme-connect.de

MED INTERLAMINAR : INDICATIONS

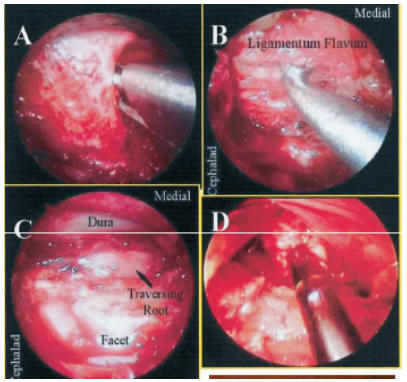
- All forms of disc herniation including associated pathology (e.g., lateral or central spinal stenosis)
- In disc herniations extending to the lateral third of the foramen a combined approach (paramedian- interlaminar and extraforaminal recommended.



Localization of the disc space with a needle



Lateral fluoroscopy showing the needle at the level of the disc space



Source: thieme-connect.de

Mayer HM. Minimally invasive Spine Surgery, 2nd ed; Editor:Mayer HM. 2006, Heidelberg, Germany: Springer publication.

MED : INTERLAMINAR

- ADVANTAGE
- Small skin incision (2.5–3 cm)
- Epidural fibrosis minimized by preserving the ligamentum flavum and epidural fat.
- Nerve root manipulation minimized.
- Excellent visualisation
- Preservation of muscle insertions
- Preservation of lamina and facet joint by only limited osteoclastic extension of the approachIn selected cases (e.g., at L5/S1) preservation of the yellow ligament
- Preservation of epidural fat and epidural venous plexus
- Limited blood loss (avg < 50 cc)
- Surgery possible as OPD procedure
- Short rehabilitation period

DISADVANTAGES

- Long learning curve
- Complications like dural tear

*Mayer HM. Principles of microsurgical discectomy in lumbar disc herniation. In: Minimally invasive Spine Surgery, 2nd ed; Editor:Mayer HM. 2006, Heidelberg, Germany: Springer publication.

MED: TRANSLAMINAR APPROACH

- **Indications**
  - Extruded disc fragment, ideally when it pushes the exiting root upward against the lower border of the pedicle
  - Some huge and caudally dislocated, so called "mid-vertebral body" fragments can also be approached
  - When previous disc surgery has been performed via an interlaminar access

- **Advantages**
  - Facet joint and yellow ligament are mostly preserved
  - Bypassing of the scar tissue when dealing with a cephalad recurrent herniation in a case operated previously via an interlaminar route
  - May be used in recurrent disc herniation in a case previously approached via the TLA

MED: TRANSLAMINAR APPROACH

- **Contraindications**

  - Severe spinal canal stenosis.
  - Malformations, such as spina bifida.
  - In the case of a foraminal disc herniation: the bulk of the fragment should be between two lines marking the medial and lateral borders of the superior facet.
  - Disc material located more laterally - approached through a paraspinal approach.

Papavero L.The translaminar approach.In: Minimally invasive Spine Surgery, 2nd ed; Editor:Mayer HM. 2006, Heidelberg, Germany: Springer publication.

MED : LATERAL, EXTRAFORAMINAL APPROACH

- **Indications**
- Extraforaminal disc herniations located at least 2/3rd lateral to the pedicle
- **Contraindications**
- Foraminal disc herniations located > 2/3rd inside the intervertebral root canal.
- **Advantages**
  - Straightforward approach to the herniation
  - Excellent exposure of the extraforaminal compartment
  - Microscopic dissection of the nerve and its vessels
  - Bony resection usually limited to hypertrophied facets and to the L5/S1 level
- **Disadvantages**
  - Long learning curve, especially at the L5/S1 level

Papavero L.The lateral extraforaminal approach.In: Minimally invasive Spine Surgery, 2nd ed; Editor:Mayer HM. 2006, Heidelberg, Germany: Springer publication.

MICROENDOSCOPIC DECOMPRESSIVE LAMINOTOMY (MEDL)

- U/l Hemilaminotomy + MED
- Effectively decompresses central, lateral recess, proximal part of I/L neural foramen
- So radiculopathy d/t foraminal stenosis or disc herniation addressed
- When nv compression +nt, do on the same side to provide maximum surgical exposure
- B/l radicular symptoms: b/l MEDL or open sx

➢ *Asgarzadie F, Khoo LT. Orthop Clin N Am 2007;38: 396-7.*

- 48 MEDL patients
- Av op time = 55min
- Bld loss = 25ml (open 193)
- No intra/postop transfusions
- Dural tear 4%
- No neural injury, no instability
- Av hosp stay = 36hrs (open 94 hrs)
- Patient satisfaction at 4 yr = 78%

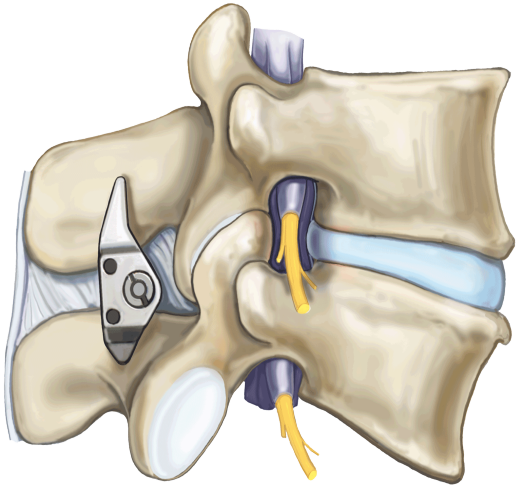
POSTERIOR LUMBAR ARTHROPLASTY DEVICES

- Placed b/w bases of spinal processes
- Mild distraction or blockade of the functional middle column
- Mimics bending or sitting
- Symptomatic relief without direct decompression
- Outpatient surgery < 1 hr
- No manipulation of nerves
- No entry into spinal canal
- Used only in select patients: symptoms must be relieved on sitting or bending forwards

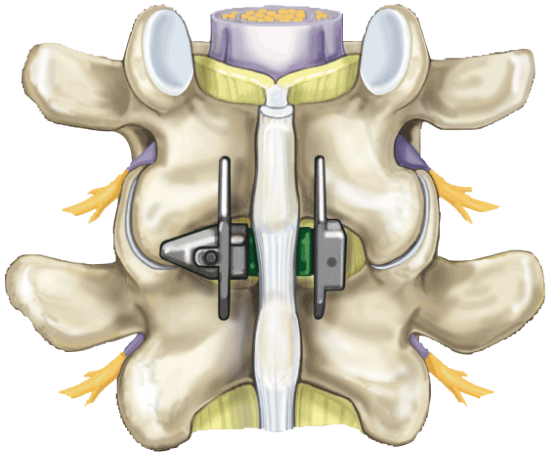
- *Examples:*

- X-stop (Saint Francis Medical Alameda, California)
- Wallis system (Abbott Spine, Austin, Texas)
- Diam Device (Medtronics, Memphis, Tennessee)
- Coflex system (Paradigm Spine, New York)

X-STOP



Source: musculoskeletalnetwork.com



Source: musculoskeletalnetwork.com

Zuchermann JF et al. A multicentre, prospective randomised trial evaluating the X-STOP interspinous process decompression system for the treatment of neurogenic intermittent claudication: two-year follow-up results. Spine 2005;30:1351-8.

- 191 patients
- 100 in X-STOP group, 91 controls (non-surgical)

2 YEAR FOLLOW-UP	X-STOP GRP	CONTROL GRP
IMPROVEMENT OVER MEAN BASELINE SYMPTOM SEVERITY SCORE	45.45	7.4%
MEAN IMPROVEMENT IN PHYSICAL FUNCTION	44.3%	-0.4%
PATIENT SATISFACTION	73.1%	35.9%

- *Siddiqui M, Smith FW,Wardlaw D. One-year results of X-Stop interspinous implant for the treatment of lumbar spinal stenosis. Spine. 2007;32: 1345-1348*

- 1-yr outcome in 24 patients of X-Stop : 29% sufficiently severe residual pain or neurogenic claudication to warrant caudal epidural injections

- *Brussee P, Hauth J, Donk RD, et al. Self-rated evaluation of outcome of the implantation of interspinous process distraction (X-Stop) for neurogenic claudication. Eur Spine J. 2008;17:200-203.*

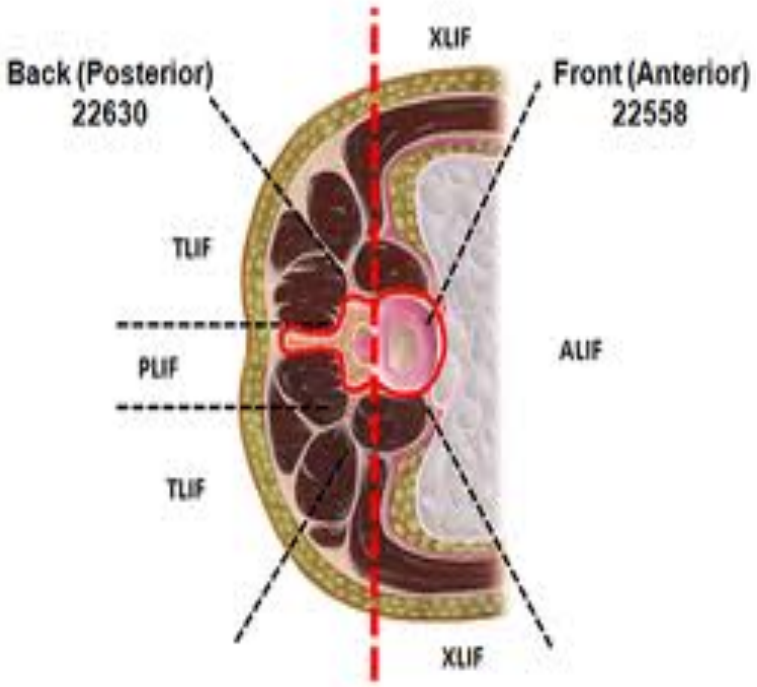
- 65 patients of X-Stop : only 31.1% had good outcome

- Verhoof O, Bron JL, Wapstra FH, et al. High failure rate of the interspinous distraction device (X-Stop) for the treatment of lumbar spinal stenosis caused by degenerative spondylolisthesis. *Eur Spine J. 2008;17:188-192.*

- 2 yr follow-up of 12 patients of X-Stop: 7 patients needed additional surgery
- Recommended not to use for severe stenosis attributable to degenerative spondylolisthesis

Minimally Invasive Techniques for lumbar interbody fusion

- ***TLIF*** (Transforaminal lumbar interbody fusion)
- ***ALIF*** (Anterior lumbar interbody fusion)
  - Retroperitoneal
  - Transperitoneal
- ***XLIF*** (Extreme lateral interbody fusion)
- ***Axial LIF*** (Axial lumbar interbody fusion)



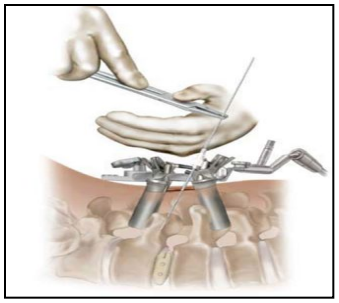
Source: phx.corporate-ir.net

INDICATIONS OF MISS IN LCS

- Same as those for open lumbar interbody fusion
  - Preoperative segmental instability
  - Stenosis with deformity that may worsen after decompression alone
  - Wide decompression needed (that may l/d iatrogenic instability)
  - Recurrent disc herniations

Mini - TLIF

- Blume & Rojas (1981): described TLIF
- Harms et al (1998): popularised TLIF
- U/l approach to disc through intervertebral foramen
- Designed to preserve facet joints
- Required nerve root retraction for adequate disc excision and placement of graft/cage



Source: orthopaedia.com

Source: mytwitterexperiment.com

•*Advantages:*

–Familiarity due to *posterior approach*

–Circumferential fusion possible

–Preservation of c/l facet & post laminar arch: lower risk of adjacent segment disease

–Uses u/l facetectomy: less dural retraction

–Can address post element pathology concurrently with interbody fusion through single posterior incision

–No risk of c/l scar as seen with traditional b/l PLIF open approach

•Although typically u/l, excessive facet removal l/t instability; so commonly combined with percutaneous / limited open screw fixation

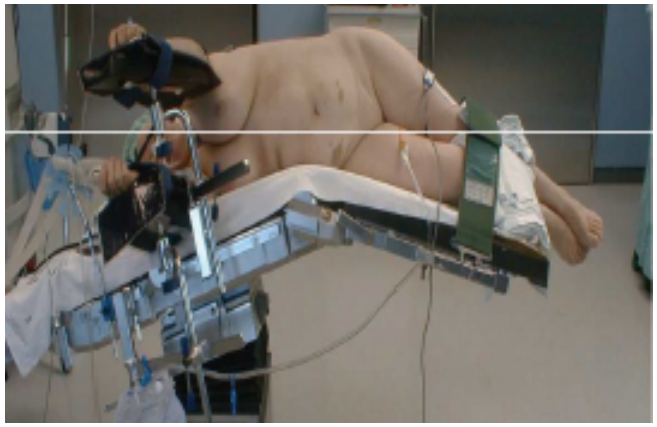
Mini - ALIF

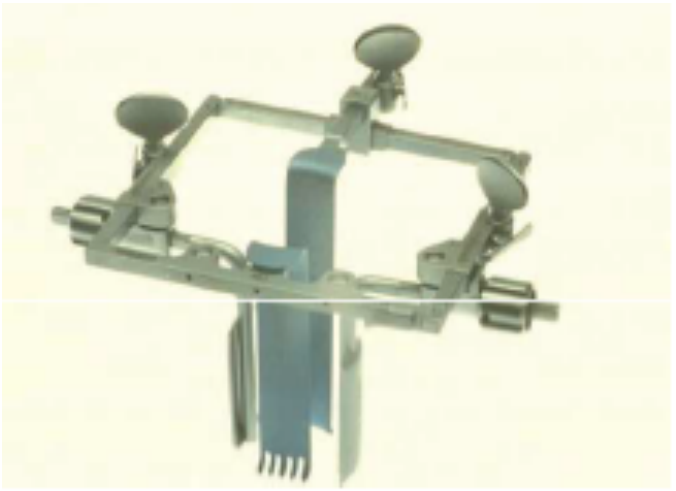
- *RETROPERITONEAL ALIF*: Modified with minimally invasive techniques to use smaller incisions with muscle-splitting [1,2]
- *TRANSPERITONEAL LAPAROSCOPIC* approach also described [3] but spine surgeons not well-versed

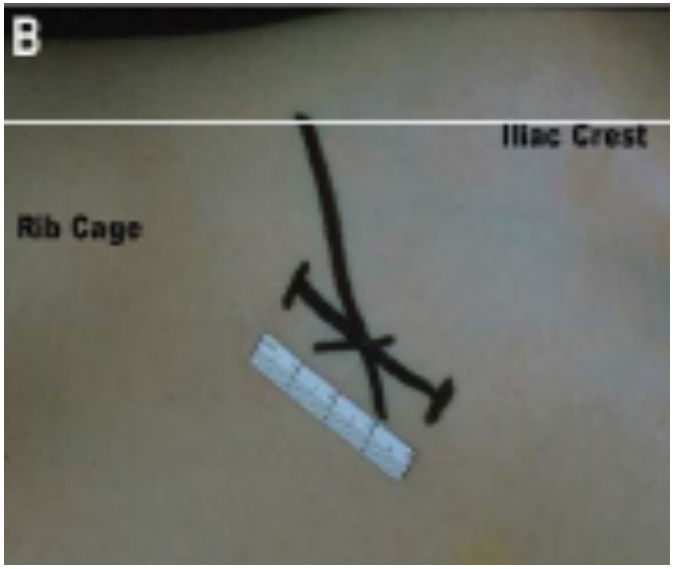
- Advantage:
  - Direct visualisation
  - Thus more complete discectomy and better fusion
  - Others common to MISS : no retraction of nv roots, no entry into canal
- Disadv:
  - Iatrogenic injury to superior hypogastric plexus : retrograde ejaculation
  - Retroperitoneal: retraction of psoas ms posteriorly l/d ms swelling and weakness

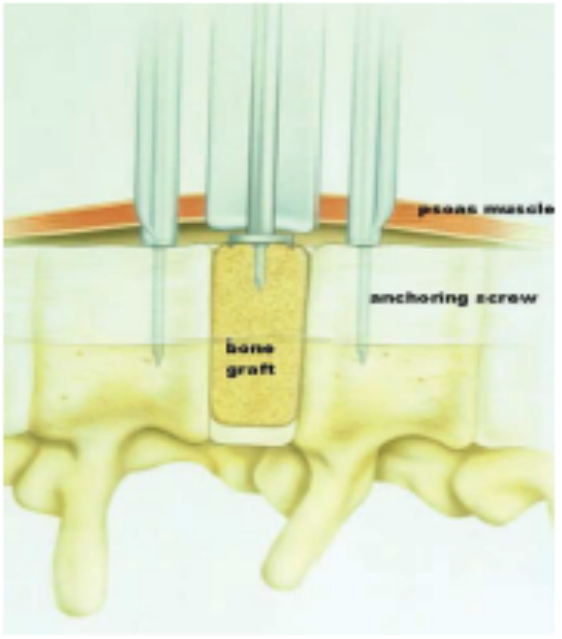
1.McAfee PC et al. Minimally invasive anterior retroperitoneal approach to the lumbar spine. Emphasis on the lateral BAK. Spine 1998;23: 1476-84.
2. Mummaneni PV et al. Lumbar interbody fusion: state-of-the-art technical advances. J Neurosurg Spine 2004;1: 24=30.
3. Regan et al. Laparoscopic fusion of the lumbar spine in a multicente series of the first 34 consecutive patients. Surg Laparosc Endosc 1996;6: 459-468.

RETROPERITONEAL MINI-ALIF









Source: orthopedia.com

MIDLINE TRANSPERITONEAL APPROACH TO L5-S1 : Mini - ALIF

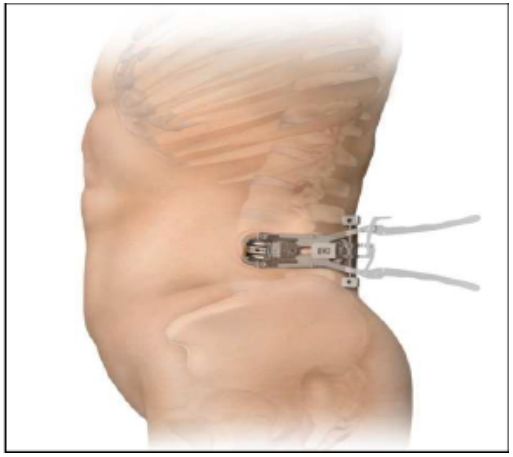
Source: orthopedia.com

EXTREME LATERAL INTERBODY FUSION (XLIF)

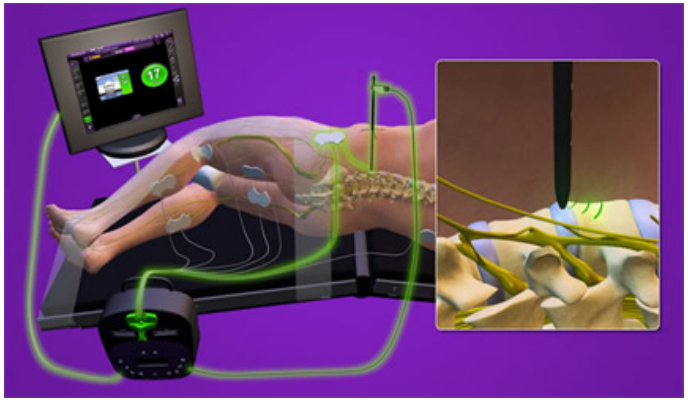
- Ozgur (2006): XLIF
- Developed to overcome disadvantages of retroperitoneal ALIF (psoas ms swelling and weakness)[1,2]
- Lateral flank incision
- Disadv:
  - Anatomic location of ribs and iliac wing can limit exposure to L1-2 down to L4-5
  - Superior edge of iliac crest can limit exposure to L5-S1
  - Lumbar plexus damage risk
  - Direct trauma to psoas can l/t weakness
- EMG monitoring intraop recommended to reduce risk of nv root injury[3]
- Dissecting within ant 1/3rd of psoas : reduce risk of nv root injury[2] but this limits ability to reach posterior aspect of disc and directly manage intracranial pathology
- May need separate post fusion and/or instrumentation

1. Bergey DL et al. Endoscopic lateral transpsoas approach to the lumbar spine. Spine 2004;29: 1681-8.
2. Pimenta L. Lateral endoscopic transpsoas retroperitoneal approach for lumbar spine surgery. Paper presentation at the VIII Brazilian Spine Society Meeting, Belo Horizonte, Minas Gerais, Brazil, May 2001.
3. Bose B, Wierzbowski LR et al. Neurophysiologic monitoring of spinal nerve root function during instrumented posterior lumbar spine surgery. Spine 2000;27: 1444-50.

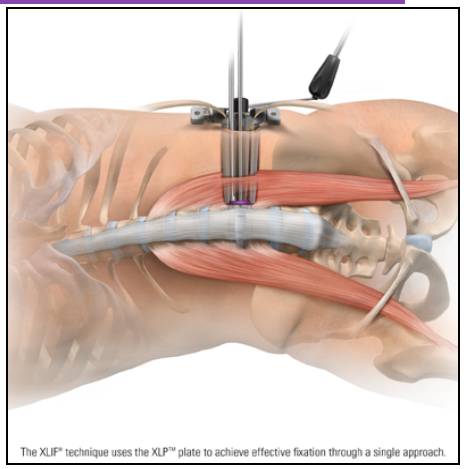
EXTREME LATERAL INTERBODY FUSION (XLIF)



Source: spartanburgregional.com

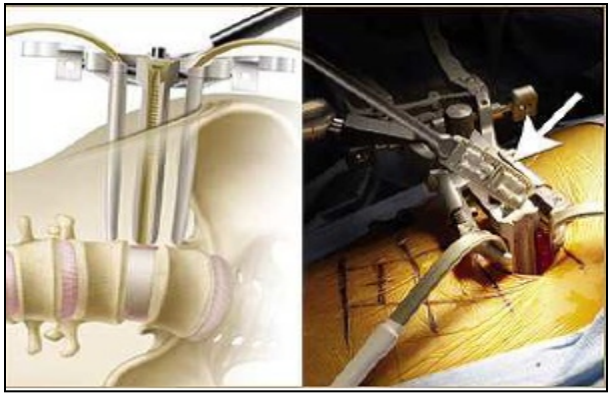


Source:southfloridaspine.com

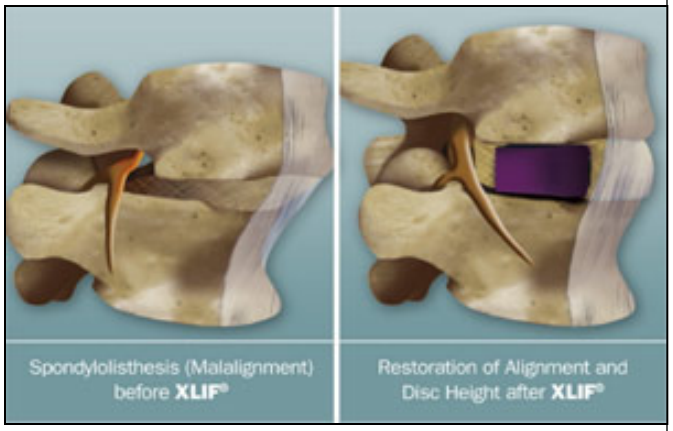


Source: drjohnmasciale.com

Source:sdspineinstitute.com



Source: nycneurosurgery.com



Source: nycneurosurgery.com

AXIAL LUMBAR INTERBODY FUSION

- To address disadvantages & limitations of previous approaches
- Developed by Cragg 2004[1]
- Addresses spine axially: *perpendicular to the vertebral endplate along long axis of spine*
- Conceptually, interbody fusion with instumentation along long axis have appeal from a biomechanical standpoint d/t ability to place place intrumentation close to the bending axis of spine and in line with the compression moments of the vertebral bodies
- Para-axial approaches were attempted but a true axial approach limited by availability of appropriate techniques and implants
- Thus percutaneous access through presacral space introduced[1,2,3]
- L5-S1 disc space accessed

1. Cragg A et al. New percutaneous access method for minimally invasive anterior lumbosacral surgery. J Spinal Disorder Tech 2004;17: 21-8.
2. Marotta N et al. A novel minimally invasive presacral approach and instrumentation technique for anterior L5-S1 intervertebral discectomy and fusion. Neurosurg Focus 2006;20: E1-8.
3. Yuan PS et al. Anatomy of percutaneous presacral space for a novel fusion technique. J Spinal Disorder Tech 2006;19: 237-41.

Source: ispub.com

PRESACRAL APPROACH FOR AXIAL LUMBAR INTERBODY FUSION

- Annulus remains intact
- Restoration of disc height
- Immediate rigid segmental fixation and stability of L4-S1
- Virgin corridor for a previously operated segment
- Enables fusion of L5-S1 without removing implants from rostral previously implanted

- *Advantages*
  - No disruption of post musculature, ligaments or elements
  - No enty into abd cavity
  - No mobilisation of vasculature or intraabd viscera
  - Plane easy to dissect once identified because sacrum seperated from rectum by mesorectum and covered by visceral fascia
- *Disadvantages:*
  - Not comfotable for spine surgeons
  - Injuries to surounding structures
  - Limited experience, complication rates unknown
  - Need for intraop fluoroscopy to ensure proper midline approach and implant trajectory
  - No direct visualisation of the intracranial pathology or discectomy; only under fluroscopic guidance

PERCUTANEOUS LUMBAR INSTRUMENTATION

- Major milestone, allowing complex reconstructions with less morbidity
- ***Pedicle screws***: most commonly used for secure fixation
- Adv:
- Secure fixation
- Can be used despite deficient or absent lamina[1]
- Can be used to correct or derotate spinal deformities without encroachment into spinal canal

1. Schmidt R et al. Pedicle screws enhance primary stability in multilevel cervical corpectomies: biomechanical in vitro comparison of different implants including constrained posterior instrumentation. Spine 2003;28: 1821.

- Percutaneous and mini-open techniques have been developed for the placement of pedicle screw/rod constructs[1]
- Most based on ***cannulated screws***, placed over a small-diameter guide wire.[2]
- Others designed to be placed through small, ***expandable ports or retractors*** that allow direct exposure to pedicle screw entry site.[3]

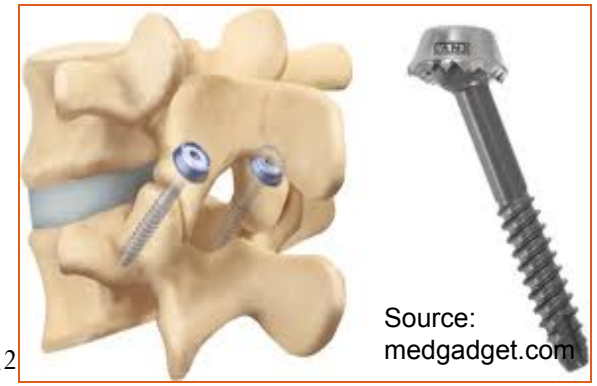
Sextant- An instrument used to measure the altitude of an object above horizon
The scale has a length of 1/6 of a full circle
Principle: Any two points in proximity can be considered part of a circle

source: spinalist.com.tr

1. *Foley KT, Gupta SK. Percutaneous pedicle screw fixation of the lumbar spine: preliminary clinical results. J Neurosurg 2002;97:7.*
2. *Friedl W.Chirurg 1992;63: 980.*
3. *Joseffer SS et al. Neurosurgery 2006*

Facet screws

- Magerl : Mini-open technique for translaminar facet screws
- Resurgence of interest with minimally invasive techniques
- Can be applied through
  - Base of spinous process and lamina (translaminar facet fixation)
  - Directly across facet joint
- Shim et al. Spine 2005:
  - An entirely percutaneous approach for translaminar facet screws with fluoroscopic guidance
- Adv:
  - Quick, simple
  - Inexpensive (relative to pedicle screws)
  - Similar segmental rigidity b/w facet screws and pedicle screws[1,2]



1. Best NM, Sasso RC. Efficacy of translaminar facet screw fixation in circumferential interbody fusions as compared to pedicle screw fixation. J Spinal Disorder Tech 2006;19:98.
2. Jang JS, Lee SH. Clinical analysis of percutaneous facet screw fixation after anterior lumbar interbody fusion. J Neurosurg Spine 2005;3:40.
3. Tuli SK, Eichler ME, Woodard EJ. Comparison of perioperative morbidity in translaminar facet versus pedicle screw fixation. Orthopedics 2005;28:773.

ADJUNCTIVE DEMINERALISED BONE MATRIX

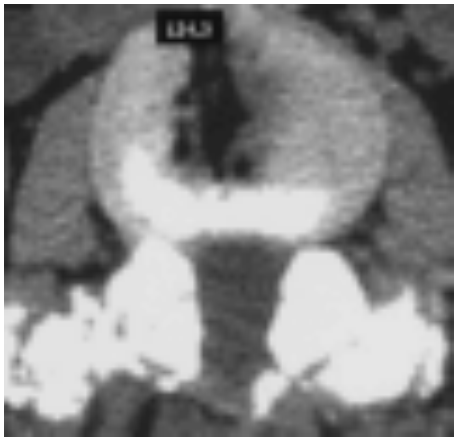
- Epstein NE: *J Spinal Disord Tech* 2008; 21:159-164.

- 75 cases : multilevel laminectomies (avg 4.9 levels) with an average 2-level noninstrumented posterolateral fusion

- 50-50 mix of lamina autograft and demineralized bone matrix (Osteofil/ICM; Medtronic, Memphis, TN)

- High fusion rates and excellent / good outcomes

- 1- and 2-year outcomes nearly comparable; patients exhibited maximal recovery on 6 out of 8 health scales



Source: expertconsult.com

ADJUNCTIVE β- TRICALCIUM PHOSPHATE

- Established role in performing noninstrumented posterolateral lumbar fusion with autograft.

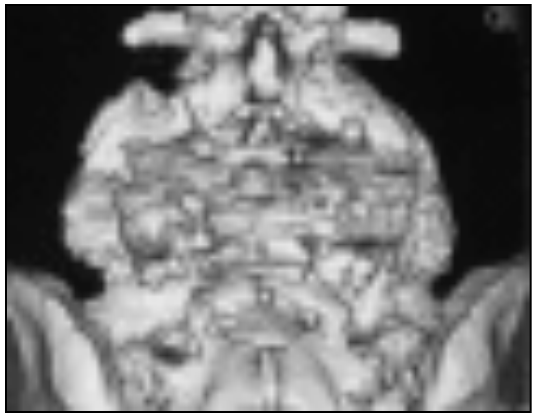
- *Epstein NE: Spine J 2008; 8:882-887.*
- *Epstein NE: Spinal Surg 2006; 20:219-231.*

- 60 patients (avg70 years). : multilevel lumbar laminectomies (average, 5.4 levels) with 1- or 2-level noninstrumented fusion using lamina autograft in a 50-50 mix with β -TCP (Vitoss/ β -TCP, Malvern, PA).

- Fusion in 85% of patients

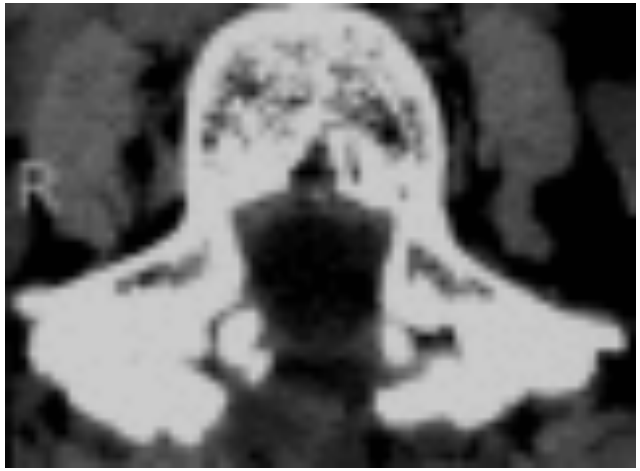
- 2 years postop: Odom's criteria revealed 51 good or excellent results; SF-36 outcomes showed maximal improvement on 6 out of 8 health scales.

Fusion mass overlying the transverse processes of L4-5 appears continuous, consistent with a solid noninstrumented fusion.



Source: expertconsult.com

- Bone deposited posterolaterally over the transverse processes.
- In this case, the noninstrumented fusion was performed using autologous bone graft and β-tricalcium phosphate.



Source: expertconsult.com

- Study obtained 6 weeks after an L4-5 posterolateral noninstrumented fusion demonstrates a cloud of autograft bone fragments and β-tricalcium phosphate. Here, the discontinuous bone fragments indicate that the fusion is not yet complete

Source: expertconsult.com

SILVER-IMPREGNATED DRESSINGS

- For post-op wound dressings
- Effectivity demonstrated in multilevel lumbar laminectomies for stenosis with instrumented (one- or two-level) lumbar fusions *
- Mechanism:
  - Binds to negatively charged proteins.
  - Sustained release of nanocrystals (up to 7 days).
  - ↓ proinflammatory cytokines
  - ↑ zinc metabolism &
  - Effective against resistant organisms (MRSA, *Staph.epidermidis, P.aeruginosa,* vancomycin-resistant enterococcus)
- Reuse each dressing, washing it daily ,up to 7 days, unless the drainage is purulent
- Alcohol, iodine compounds, saline, and peroxide to be avoided

* *Epstein NE: Technical note: do silver impregnated dressings limit infections following lumbar laminectomy with instumented fusion? Surg Neurol 2007; 68:483-485*

THANK
YOU