LUMBAR CANAL STENOSIS
RECENT ADVANCES

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Presented by
Dr Avijit Sarkari

Source: concordortho.com
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

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
- Foraminal narrowing (up down)
- Ligamentum flavum buckling

Posterior bulging of disc and osteophytes

Increased facetal stresses and movement
- Facetal osteophytes

Disc pathology is the first stage in the degeneration cascade in a majority
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
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.

SYMPTOMS OF LUMBAR SPINAL STENOSIS

- 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.

Source: neurosurgical.com
LESS FREQUENT SYMPTOMS

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


- 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
<table>
<thead>
<tr>
<th>Signs and symptoms</th>
<th>Vascular</th>
<th>Neurogenic</th>
</tr>
</thead>
<tbody>
<tr>
<td>walking distance</td>
<td>fixed</td>
<td>variable</td>
</tr>
<tr>
<td>type of pain</td>
<td>cramps, tightness</td>
<td>dull ache, numbness</td>
</tr>
<tr>
<td>relief at cessation of activity</td>
<td>immediate</td>
<td>delayed</td>
</tr>
<tr>
<td>back pain</td>
<td>rarely</td>
<td>occasionally</td>
</tr>
<tr>
<td>pain relief</td>
<td>standing</td>
<td>flexion and sitting</td>
</tr>
<tr>
<td>posture provocation</td>
<td>uncommon</td>
<td>common</td>
</tr>
<tr>
<td>walking up hill</td>
<td>pain</td>
<td>no pain</td>
</tr>
<tr>
<td>bicycle riding</td>
<td>pain</td>
<td>no pain</td>
</tr>
<tr>
<td>pulses</td>
<td>absent</td>
<td>normal</td>
</tr>
<tr>
<td>trophic changes</td>
<td>likely</td>
<td>absent</td>
</tr>
<tr>
<td>muscle atrophy</td>
<td>rarely</td>
<td>occasionally</td>
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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.

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
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 nerve stimulation

INDICATIONS FOR NON SURGICAL RX

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

- Short term activity modification for acute pain.

- Long term activity modification is not recommended

Source: neurosurgical.com
Medication

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


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


- 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 J Work Environ Health 2007:

- Early use of opioids: ↑ work disability, poor outcomes.
Exercise therapy

- Effective at decreasing pain and improving function
- Only modest efficacy
- Individually designed programmes
- Stretching or strengthening type
- Under supervision
- 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

<table>
<thead>
<tr>
<th>TYPE</th>
<th>DEFINITION</th>
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<tr>
<td>OPERANT</td>
<td>Removes positive reinforcement of pain behaviour.</td>
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<td>COGNITIVE</td>
<td>Modifies harmful cognitions (maladaptive thoughts, feelings, beliefs), uses cognitive restructuring techniques (imagery &amp; attention diversion).</td>
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<tr>
<td>RESPONDENT</td>
<td>Modifies physiological responses to pain through reduction of ms tension using relaxation techniques.</td>
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Sorenson PH et al. BMC Musculoskelet Disord 2010.  
• Cognitive intervention as good outcomes as exercise therapy despite fewer treatment sessions  

• 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).
  

- ‘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.’


- ‘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

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


- Epidural steroid injection: efficacy is contradictory.


- 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\(^1\)

  - Not yet proven in degenerative disc disease

**INTRADISCAL FIBRIN INJECTION**

  - Fibrin injection into experimentally damaged discs ↓ TNF α synthesis.

**CALCITONIN INJECTION**

  - Injectable calcitonin may be useful for short term pain relief

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INTRADISCAL METHYLENE BLUE INJECTION

  • 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

  • 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

• 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

<table>
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<tr>
<th>STUDY</th>
<th>YEAR</th>
<th>FACTOR USED</th>
<th>RESULT</th>
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<tbody>
<tr>
<td>Wallach et al</td>
<td>2003</td>
<td>Tissue Inhibitor of metalloproteinase 1 (TIMP-1)</td>
<td>↑ proteoglycan synthesis</td>
</tr>
<tr>
<td>Paul et al</td>
<td>2003</td>
<td>Adenoviral Sox9 complex</td>
<td>↑ Type-II collagen</td>
</tr>
<tr>
<td>Yoon et al</td>
<td>2004</td>
<td>Adenoviral LMP-1 (LIM Mineralisation Protein)</td>
<td>↑ BMP-2 &amp; 7 mRNA</td>
</tr>
<tr>
<td>Moon et al</td>
<td>2008</td>
<td>Growth factors (BMP-2 &amp; IGF-1)</td>
<td>↑ proteoglycan synthesis</td>
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**SAFETY ISSUES:**
- Potential dangers due to viral vector usage
- Tumorigenesis
STEM CELL THERAPY

**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
- **Human studies:**
  - 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
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

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.

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%


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

• Modalities
  • Somatosensory evoked potentials (SEPs)
  • Electromyography (EMG)
  • Motor evoked potentials (MEPs)

changes noted within 30 s of the untoward “event”; reproduced within 60 s


• 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

  - 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
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


  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.


  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 $2/3^{rd}$ of cephalad spinous process and lamina and $1/3^{rd}$ of caudal 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

**APPROACHES:**
- Standard posterior (interlaminar)
- Translaminar
- Transforaminal
- Extraforaminal

Source: brainspine.com, 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
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 approach
- 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

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
• 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.

MED: LATERAL, EXTRAFORAMINAL APPROACH

- **Indications**
- Extraforaminal disc herniations located at least $2/3$rd lateral to the pedicle

- **Contraindications**
- Foraminal disc herniations located $>2/3$rd 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

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


- 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)

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

<table>
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<th>2 YEAR FOLLOW-UP</th>
<th>X-STOP GRP</th>
<th>CONTROL GRP</th>
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<tbody>
<tr>
<td>IMPROVEMENT OVER MEAN BASELINE SYMPTOM SEVERITY SCORE</td>
<td>45.45</td>
<td>7.4%</td>
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<tr>
<td>MEAN IMPROVEMENT IN PHYSICAL FUNCTION</td>
<td>44.3%</td>
<td>-0.4%</td>
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<tr>
<td>PATIENT SATISFACTION</td>
<td>73.1%</td>
<td>35.9%</td>
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- 1-yr outcome in 24 patients of X-Stop: 29% sufficiently severe residual pain or neurogenic claudication to warrant caudal epidural injections


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


- 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 lead to iatrogenic instability)
  - Recurrent disc herniations
Mini - TLIF

- Blume & Rojas (1981): described 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

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

MIDLINE TRANSPERITONEAL APPROACH TO L5-S1: Mini-ALIF
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 1/3\(^{rd}\) 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

EXTREME LATERAL INTERBODY FUSION (XLIF)

Source: spartanburgregional.com

Source: southfloridaspine.com

Source: drjohnmasciale.com

Source: sdspineinstitute.com

Source: nycneurosurgery.com

Source: nycneurosurgery.com

The XLIF® technique uses the XLIF® plate to achieve effective fixation through a single approach.

Spondylolisthesis (Malalignment) before XLIF®

Restoration of Alignment and Disc Height after XLIF®
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 instrumentation along long axis have appeal from a biomechanical standpoint d/t ability to place instrumentation 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

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

Source: ispub.com
• **Advantages**
  • No disruption of post musculature, ligaments or elements
  • No entry into abdominal cavity
  • No mobilisation of vasculature or intra-abdominal viscera
  • Plane easy to dissect once identified because sacrum separated from rectum by mesorectum and covered by visceral fascia

• **Disadvantages:**
  • Not comfortable for spine surgeons
  • Injuries to surrounding 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 fluoroscopic 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
  • Can be used to correct or derotate spinal deformities without encroachment into spinal canal

Percutaneous and mini-open techniques have been developed for the placement of pedicle screw/rod constructs.

Most based on cannulated screws, placed over a small-diameter guide wire.

Others designed to be placed through small, expandable ports or retractors that allow direct exposure to pedicle screw entry site.

**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.

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\(^1,^2\)

ADJUNCTIVE DEMINERALISED BONE MATRIX


- 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 $\beta$-TRICALCIUM PHOSPHATE

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

  - Epstein NE: *Spine J* 2008; 8:882-887.

• 60 patients (avg 70 years): multilevel lumbar laminectomies (average, 5.4 levels) with 1- or 2-level noninstrumented fusion using lamina autograft in a 50-50 mix with $\beta$-TCP (Vitoss/$\beta$-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.
• Bone deposited posterolaterally over the transverse processes.

• In this case, the noninstrumented fusion was performed using autologous bone graft and $\beta$-tricalcium phosphate.

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

THANK YOU