I  NEUROSURGERY INITIATIVE

DEGENERATIVE SPINAL DISEASES

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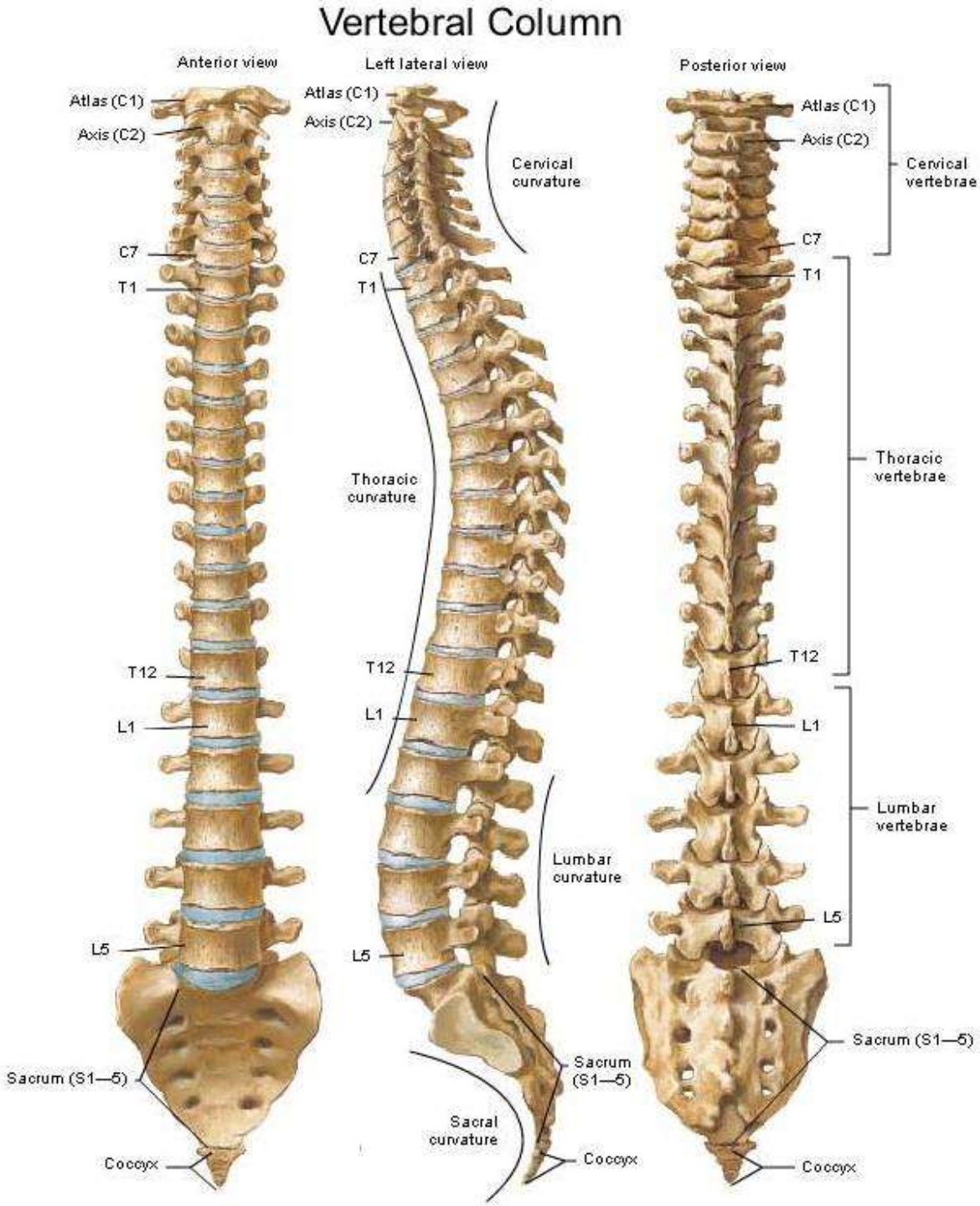
Normal Anatomy – Vertebral Column

- Composed of 33 vertebrae:
  - 7 C, 12 T, 5 L, 5 S (fused) & 4 coccygeal (lower 3 commonly fused).
- Flexible structure, owing to:
  - Segmented (vertebrae)
  - Joints (articular processes)
  - Intervertebral disks (pads of fibro cartilage, forms around ¼ of the total length of the spine)



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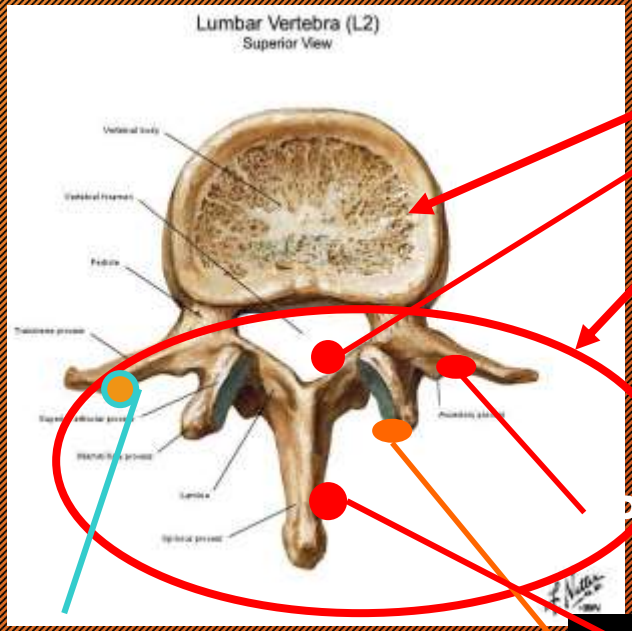
Development of the spinal Curvature

Normal Anatomy - The Vertebrae

- General features:
  - Typical vertebra consists of: body (anterior) + arch (posterior).
  - Vertebral arch: lamina + pedicle
  - Articulates typically via an intervertebral dis and articular facets.
  - Has 7 processes:
    - 1 spinous
    - 2 transverse
    - 4 articular



Body
Vertebral Foramen

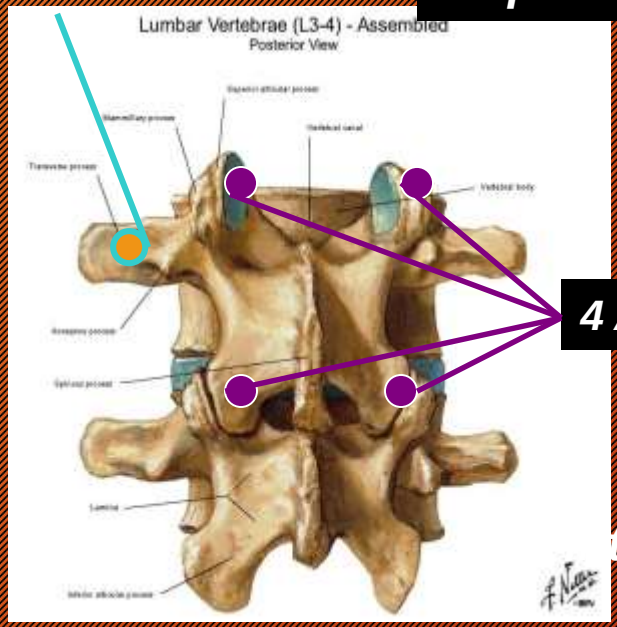
Arch

Pedicle

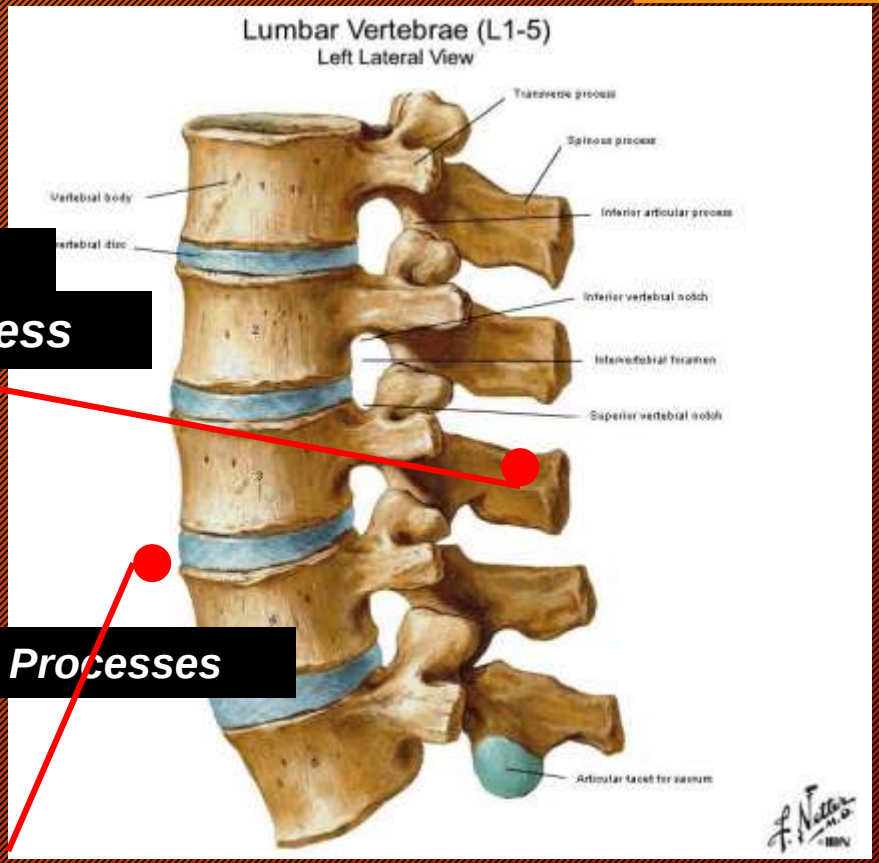
2 Transverse Processes

Lamina

1 Spinous Process



4 Articular Processes



tervertebral Disk

Normal Anatomy - The Joints

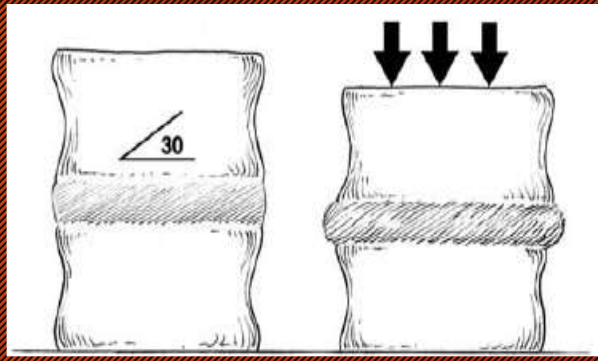
- Intervertebral Disks: **fibro-cartilaginous** joints *between 2 vertebral bodies*.
  (more details later)
- Joints *between 2 vertebral arches:* **synovial** joints, between superior & inferior articular processes.

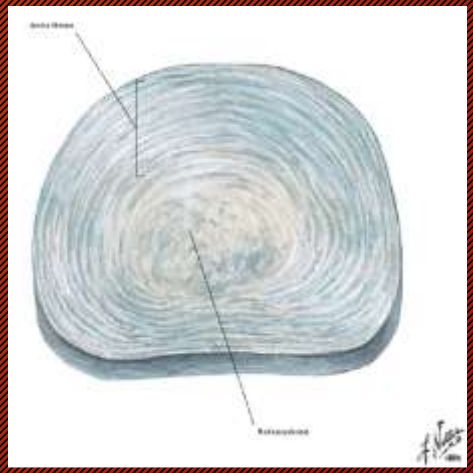
Intervertebral disc – Normal anatomy

- Intervertebral disks form ¼ of the length of the spinal column.
- Thickest in the areas of greatest movement: cervical & lumbar regions.
- No disks are found between the 1st and 2nd cervical vertebrae or in the sacrum & coccyx.
- The upper & lower surfaces of vertebrae are covered with a thin layer of hyaline cartilage, between them lies the intervertebral disk: which is mainly formed from:
  - Anulus fibrosus
  - Nucleus pulposus

Intervertebral disc – Normal anatomy

- Anulus fibrosus:
  - Composed of concentric layers of fibrocartilage, arranged obliquely.
  - Mainly resists out “ward thrusts” or extension movements.
- Nucleus pulposus:
  - Ovoid mass of gelatinous material: large amounts of water + few collagen fibers & cartilage cells.
  - Normally situated slightly to the posterior of the disc.
  - Mainly resists compression load.
- Advancing age:
  - Decrease water content of nucleus pulposus, replaced by fibrocartilage.
  - Collagen fibers of anulus fibrosis degenerate.
  - Discs become thin & less elastic.





Terminology used in back pain

Spondylosis: arthritis of the spine. Seen radiographically as disc space narrowing and arthritic changes of the facet joint.

Spondylolisthesis: anterior displacement of a vertebra on the one beneath it. A radiologist determines the degree of slippage upon reviewing spinal x-rays. Slippage is graded I through IV:

- Grade I - 1 percent to 25 percent slip
- Grade II - 26 percent to 50 percent slip
- Grade III - 51 percent to 75 percent slip
- Grade IV - 76 percent to 100 percent slip

Generally, Grade I and Grade II slips do not require surgical treatment and are treated medically. Grade III and Grade IV slips might require surgery if persistent, painful, slips are present.

Spondylolysis: a fracture in the pars interarticularis where the vertebral body and the posterior elements, protecting the nerves are joined. In a small percent of the adult population, there is a developmental crack in one of the vertebrae, usually at L5.

Spinal stenosis: local, segmental, or generalized narrowing of the central spinal canal by bone or soft tissue elements, usually bony hypertrophic changes in the facet joints and by thickening of the ligamentum flavum.

Radiculopathy: impairment of a nerve root, usually causing radiating pain, numbness, tingling or muscle weakness that corresponds to a specific nerve root.

Sciatica: pain, numbness, tingling in the distribution of the sciatic nerve, radiating down the posterior or lateral aspect of the leg, usually to the foot or ankle.

Cauda equina syndrome: loss of bowel and bladder control and numbness in the groin and saddle area of the pelvis, associated with weakness of the lower extremities. This condition can be caused by abnormal pressure on the bottom-most portion of the spinal canal and spinal nerve roots, related to either bony stenosis or a large herniated disc.

LUMBAR DISC PROLAPSE

- Extrusion (herniation) or protrusion (bulge) of nucleus pulposus through the annulus fibrosis
- Can occur at any age in adults
- 90% occur at L4/L5 and L5/S1
- Why?
  - 75% movement occurs at lumbosacral junction, 20% at L4/L5, 5% at upper lumbar region

THE EXTENT AND DESCRIPTION

LUMBAR DISC

Bulge

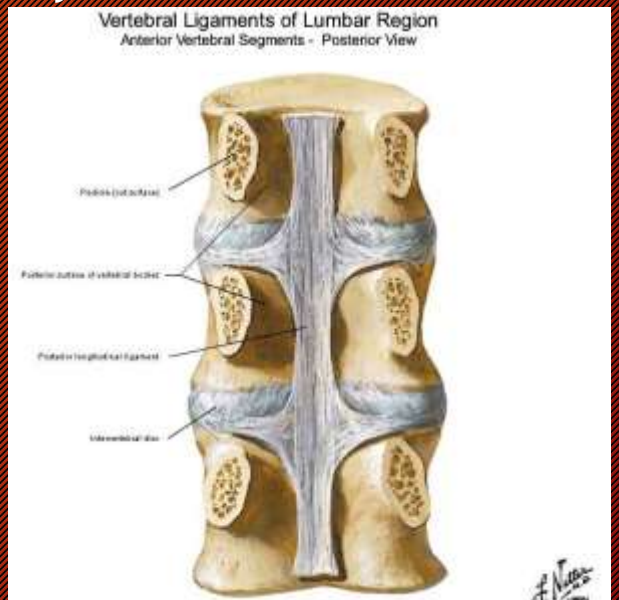
Prolapse

Extrusion

Migration

Pathophysiology

- Mostly **posterolateral**; the posterior longitudinal ligament prevents direct posterior herniation
  - Posterolateral:
    - Compression of nerve root of the numerically lower vertebra
  - Lateral:
    - Compression of nerve root of the upper vertebra
  - Central:
    - Cauda Equina



WHICH ROOT?

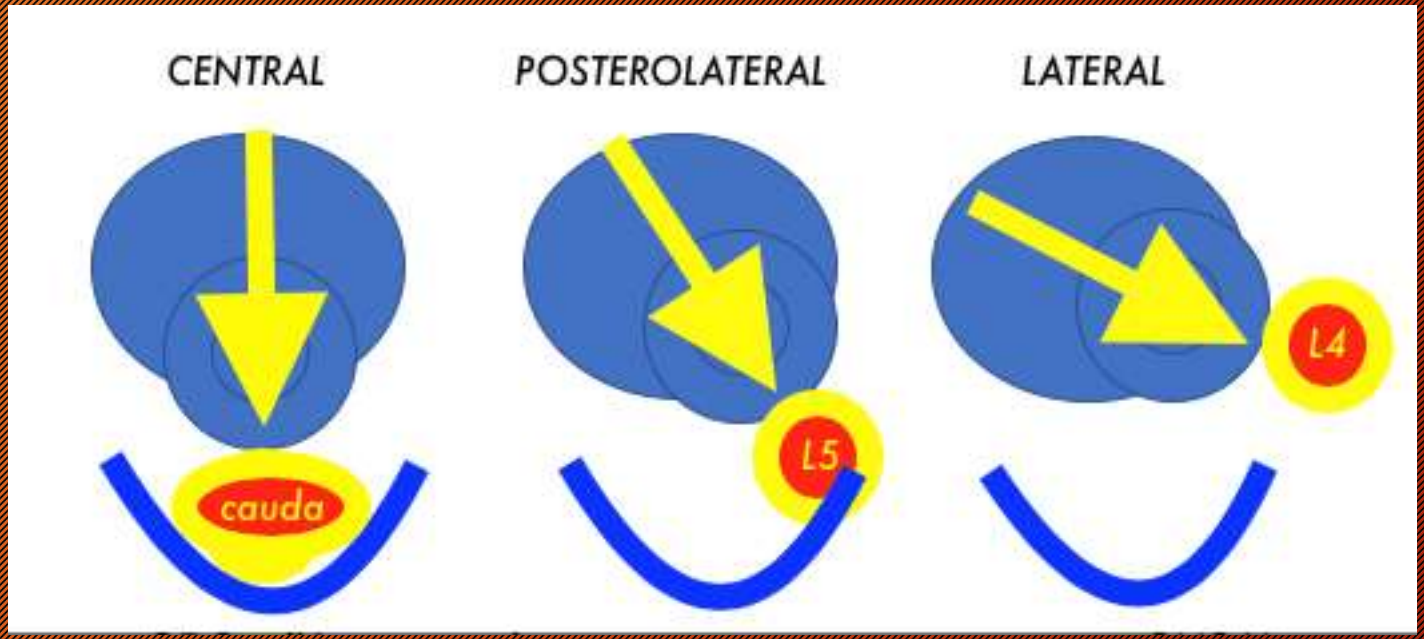
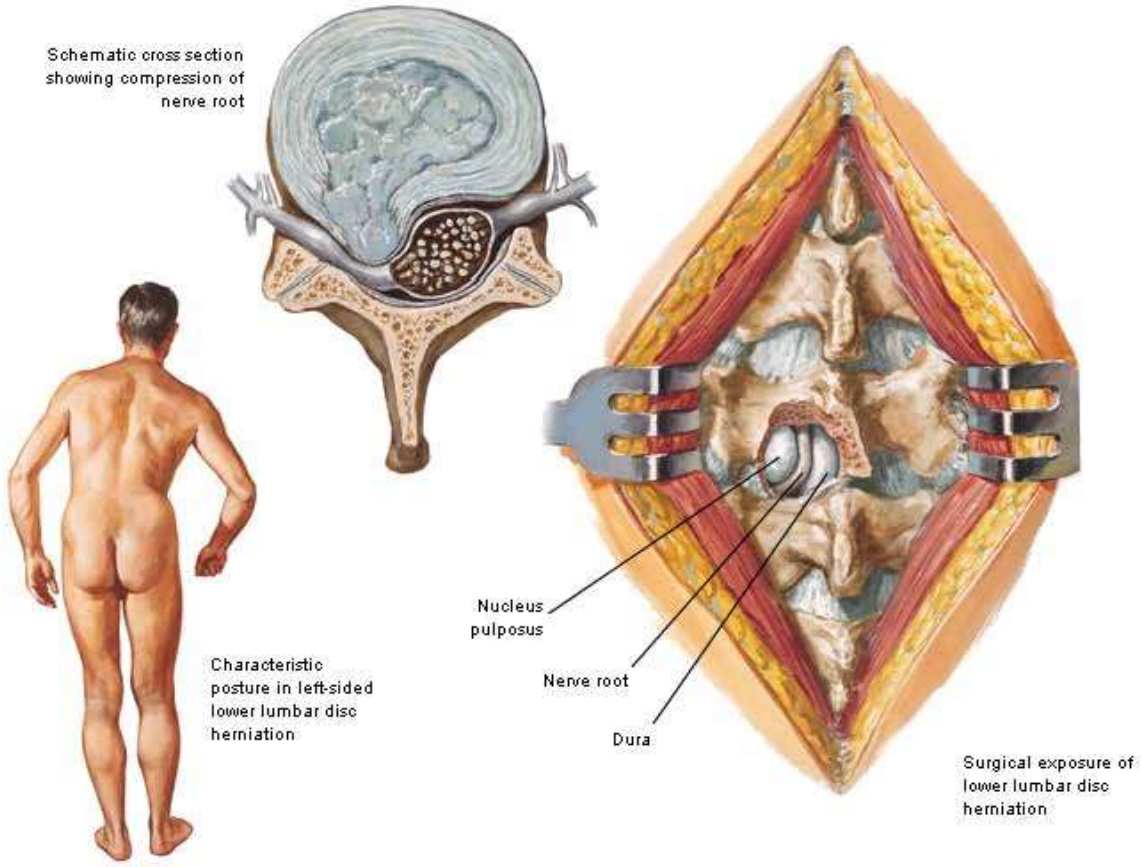


Plate 156A

Lumbar Disc Herniation: Clinical Manifestations



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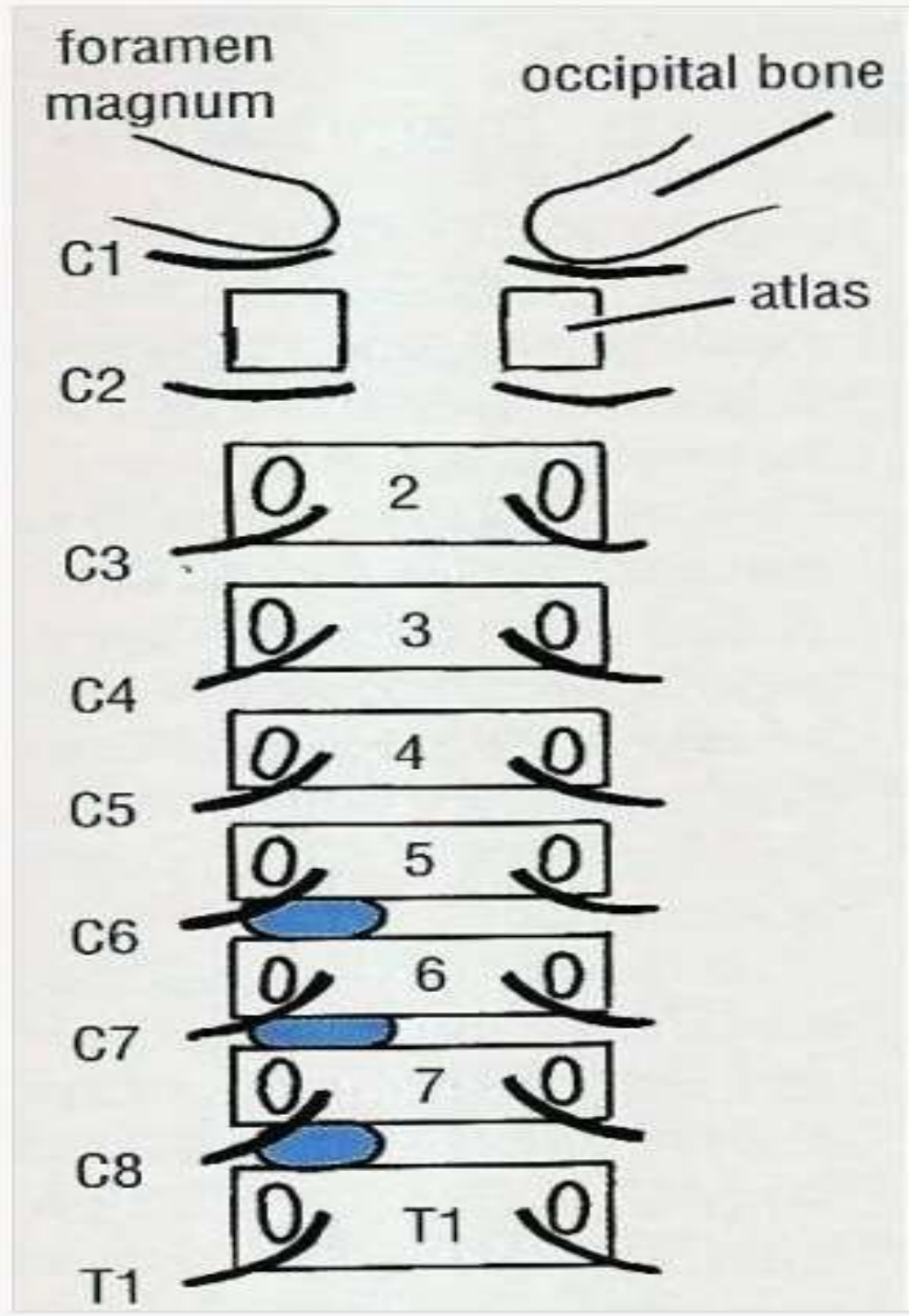
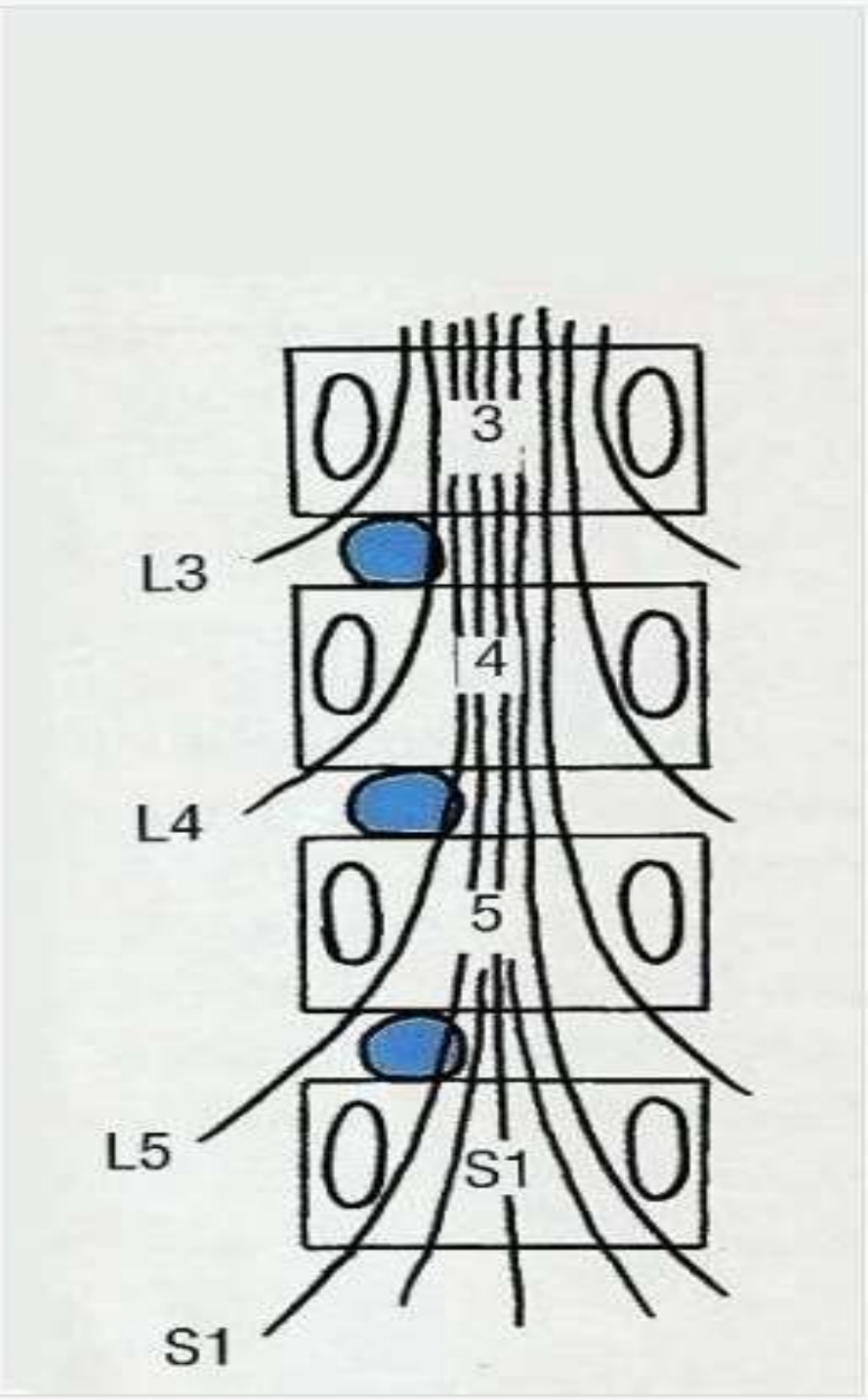

foramen magnum
occipital bone
C1
atlas
C2
2
C3
3
C4
4
C5
5
C6
6
C7
7
C8
T1
T1


3
L3
4
L4
5
L5
S1
S1

CLINICAL PRESENTATION

- History
  - Present with radicular pain NO myelopathy
  - Sciatica: pain, numbness, tingling in the distribution of the sciatic nerve, radiating down the posterior or lateral aspect of the leg, usually to the foot or ankle
    - Disc prolapse is the most common cause of sciatica
    - DD: Spondylosis, LCS, Spondylolisthesis, tumors.

Pain

- **SOCRATES**
  - Site: low back
  - Onset: Sudden
  - Character: Sharp, electrical, lancinating
  - Radiation: into the buttocks, posterolateral thigh, below the knee to the ankle or foot. MORE SEVERE THAN BACK PAIN
  - Associated symptoms: Numbness and tingling, weakness
  - Temporized by: Lying supine, hip flexed, knee flexed, tilted to opposite side
  - Exacerbated By: cough, sneezing, Valsalva, movement
  - Severity: severe

Radiation

- Pattern of radiation gives clue to level of prolapse
  - Posterior thigh, posterior calf, into heel → S1
  - Posterolateral thigh, lateral leg into dorsum of foot and hallux → L5
  - Anterior thigh, anterior lower leg → L4

Examination

- General: in discomfort, lies tilted, with hip and knee flexed
- Straight leg raising (SLR) test is considered positive when the sciatica is reproduced between 10 and 60 degrees of elevation. A positive straight leg test is sensitive, but not specific, for herniated disc. Seated straight leg raising

Examination

- Motor:
  - Look for wasting in muscle groups
  - Weakness:
    - ankle, hallux dorsiflexion → L5
    - Plantar flexion → S1
  - Reflexes:
    - Absent unilateral ankle reflex highly specific for S1
- Sensory Examination

Examination

- At end of examination patient must be examined prone; look for wasting of buttocks (the horizon sign), sensation in posterior thigh and perianal region and anal tone.
- Rectal examination

Testing for lumbar nerve root compromise

Nerve root	L4	L5	S1
Pain			
Numbness			
Motor weakness	Extension of quadriceps	Dorsiflexion of great toe and foot	Plantar flexion of great toe and foot
Screening examination	Squat and rise	Heel walking	Walking on toes
Reflexes	Knee jerk diminished	None reliable	Ankle jerk diminished

INVESTIGATIONS

- Plain x-ray with dynamic views (to exclude spondylolisthesis).
- MRI or CT myelography (urgently if evidence of cauda equina, progressive neurological deficits)
- ESR usually elevated

PLAIN X-RAYS

IMAGING: MRI

TREATMENT

- The conservative treatment includes complete bed rest for two weeks at least, the use of analgesic drugs and NSAID medications and antidepressants. Once the acute episode passes by, then some sort of physiotherapy in the form of back muscles strengthening exercises are recommended. Swimming is encouraged. The resolution of the symptoms can be explained by reduction in prolapsed disc size, or even complete disappearance of the disc, or adaptation of nerve root to external compression and resolution of acute inflammatory process.

TREATMENT

- Sometimes the treating neurosurgeon finds that the pain is the major factor in the patient's complaint, and in the absence of any neurological deficits, he may try alleviating the pain by nerve root block, using local anesthetic and steroid using image guidance. These injections could be diagnostic to differentiate root pain from other pains, or therapeutic. Sometimes it may be required to repeat the injections at intervals.

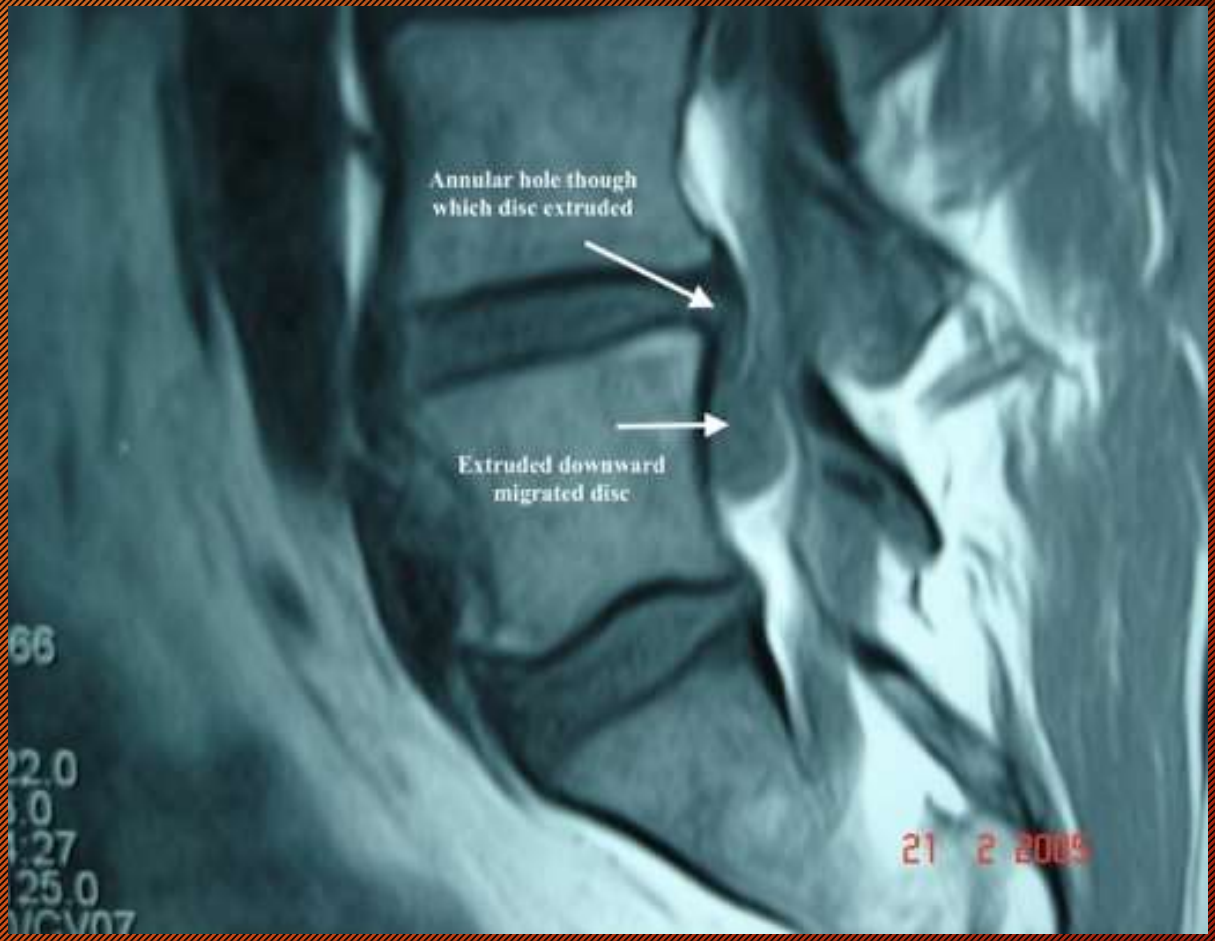
TREATMENT

- If all fail then surgery will be the ultimate choice. This failure and the presence of indications to start with as indicated above could be dealt with using several techniques, of these we mention microsurgical discectomy using an interlaminar approach or via fenestration of a lamina. Newer techniques have been suggested, but they come and go. One of the most recent is endoscopic discectomy. The surgery requires removal of the protruding, or extruded or migrated disc

NEW SURGICAL TECHNIQUES

- Many new techniques incorporate some sorts of fixation or fusion :Trans Lumbar Interbody Fusion (TLIF), Posterior Interbody Fusion (PLIF), Oblique Lateral Interbody Fusion (OLIF) , Direct Lateral Interbody Fusion (DLIF), and Anterior Lumbar Interbody Fusion ALIF) but there is no consensus upon their usage by neurosurgeons.

IMAGING: MRI


Annular hole though which disc extruded
Extruded downward migrated disc

PATHOLOGY SPECIMEN

LUMBAR CANAL STENOSIS

- Narrowing of the spinal canal.
- Narrowing may occur in:
  - central spinal canal.
  - in the area under the facet joints (subarticular stenosis).
  - the neural foramina.

Epidemeology

- incidence and prevalence of symptomatic LCS have not been established
- Most frequent indication for spinal surgery in patients older than 65 years of age
- Symptomatic LCS causing root compression can be due to many causes.
- L4-5 level is most commonly involved, followed by L5-S1 and L3-4

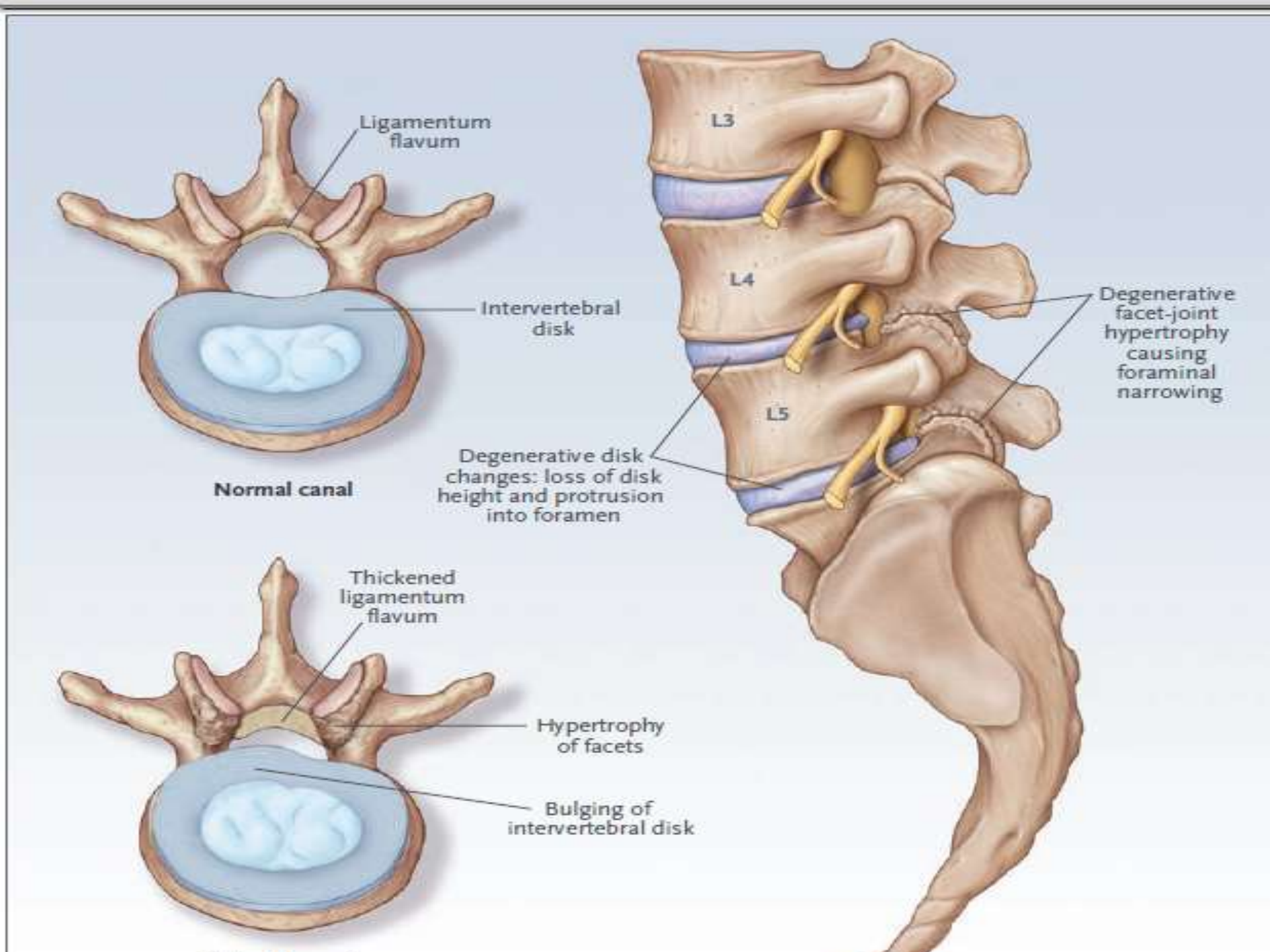
Table 1. Categories of Lumbar Spinal Stenosis.*

Category	Comments
Congenital stenosis (developmental)	Congenitally shortened pedicles; typical age at symptom onset, 20s–40s
Idiopathic	
Achondroplastic	Frequently seen in achondroplastic dwarves
Acquired stenosis	
Degenerative	
Central canal	Disk degeneration, facet osteoarthritis, ligamentum flavum hypertrophy; typical age at symptom onset, 60s–90s
Peripheral canal, lateral recesses	Sciatica-like presentation in patients with lateral recess stenosis
Spondylolisthesis	Back pain may predominate
Combinations of congenital and degenerative stenosis	
Iatrogenic	
Postlaminectomy	Stenosis typically at adjacent level but may recur at operated level
Postfusion	
Spondylolitic	Typical age of symptom onset, teens–20s, associated with spondylolisthesis
Post-traumatic	
Miscellaneous	
Corticosteroid excess (Cushing's syndrome or exogenous source)	Goal of management is to treat underlying condition
Paget's disease, acromegaly	

* The classification is adapted from Arnoldi et al.[2]

Acquired Degenerative Stenosis

- Most frequently observed type LCS.
- Age-associated degeneration of the lumbar discs and facet joints
- loss of disc height with associated bulging of the disc and infolding of the ligamentum flavum.
- Facet osteoarthritis and hypertrophy often lead to osteophyte formation and thickening of the joint capsule
- Cysts originating from these joints can protrude into the spinal canal


Ligamentum flavum
Intervertebral disk
Normal canal
L3
L4
L5
Degenerative facet-joint hypertrophy causing foraminal narrowing
Degenerative disk changes: loss of disk height and protrusion into foramen
Thickened ligamentum flavum
Hypertrophy of facets
Bulging of intervertebral disk

Pathophysiology

- Compression:
  - Direct
  - Indirect
- Ischemia:
  - Compression of venules
  - Increased intrathecal pressure (ITP).
- Effect of standing → reduction of cross sectional area (CSA) and increase in ITP.
  - Relieved by flexion
- Walking→ increase metabolic demand beyond microvascular supply

Diagnosis

- History
  - Neurogenic Claudication (94%): symptoms increase by walking, standing and reduced by sitting or flexing at the waist
  - Pain is the most common symptom, followed by numbness and weakness
  - Symptoms mostly bilateral but asymmetric, unilateral unlikely. Usually involving entire leg
  - Low back pain common (65%). Not necessarily associated with claudication

Examination

- May demonstrate focal weakness and/or sensory loss in the distribution of one or more spinal nerve roots
- Wide-based gait and/or positive Romberg (90% specificity)
- Cauda equina and conus medullaris findings if present

Differential Diagnosis

- Vascular claudication
- Nonspecific back pain from spondylosis without LCS
- Distal polyneuropathy
- Hip OA
- Trochanteric bursitis
- Inflammatory conditions involving the lumbosacral nerve roots or cauda equina

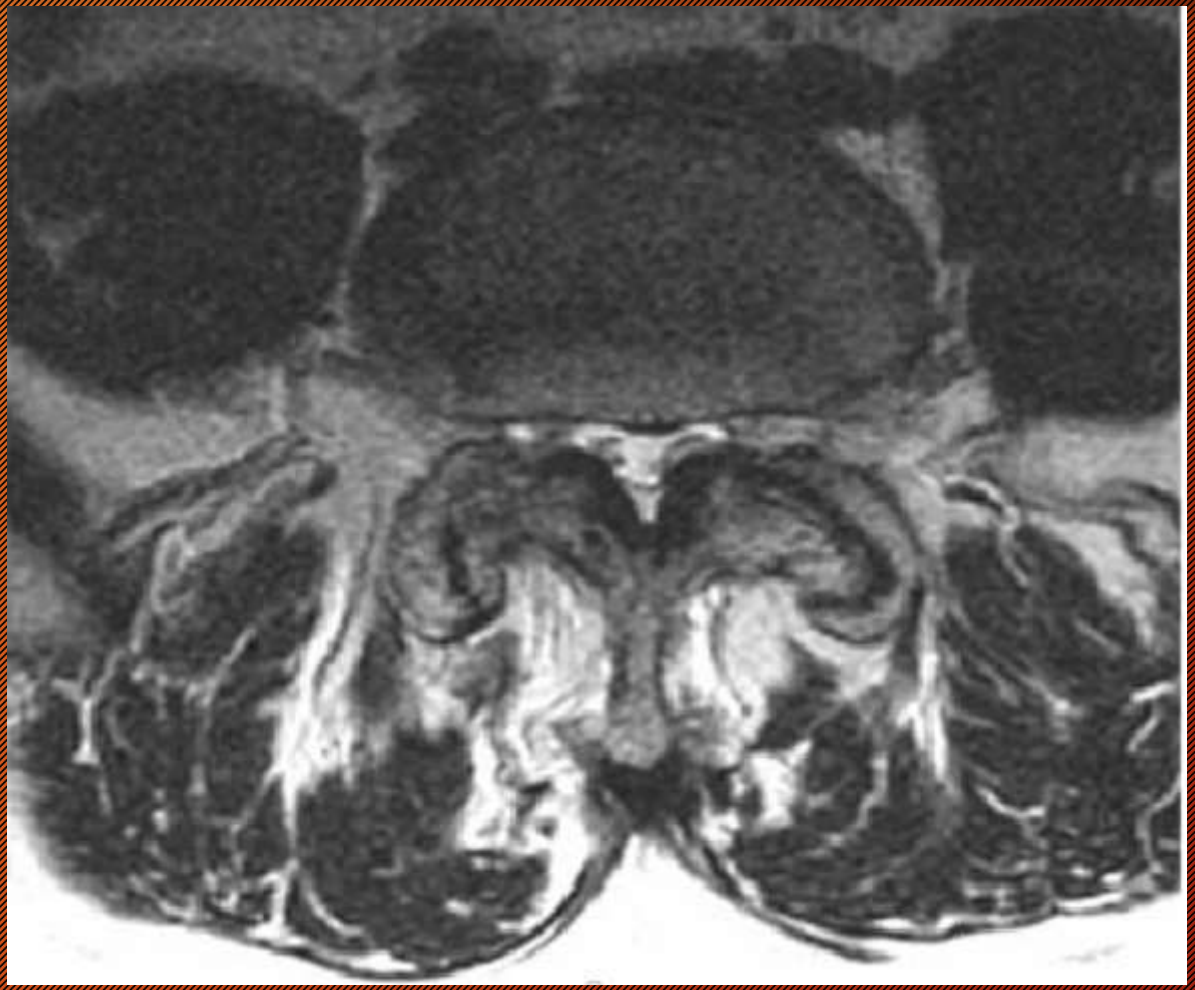
Comparison of symptoms in neurogenic and vascular claudication

Symptoms	Neurogenic	Vascular
Quality	**Pain/numbness/tingling**	**Cramping/tightness**
Increased with walking	Yes	Yes
Relieved walking flexed with a cart	Yes	No
Relieved standing erect	No	Yes
Relieved sitting/lying	Within minutes	Immediate
Increased walking uphill/upstairs	No/less	Yes
Increased walking downhill	Yes/more	Yes
Increased biking/back flexed	No	Yes
Increased biking/back extended	Yes	Yes

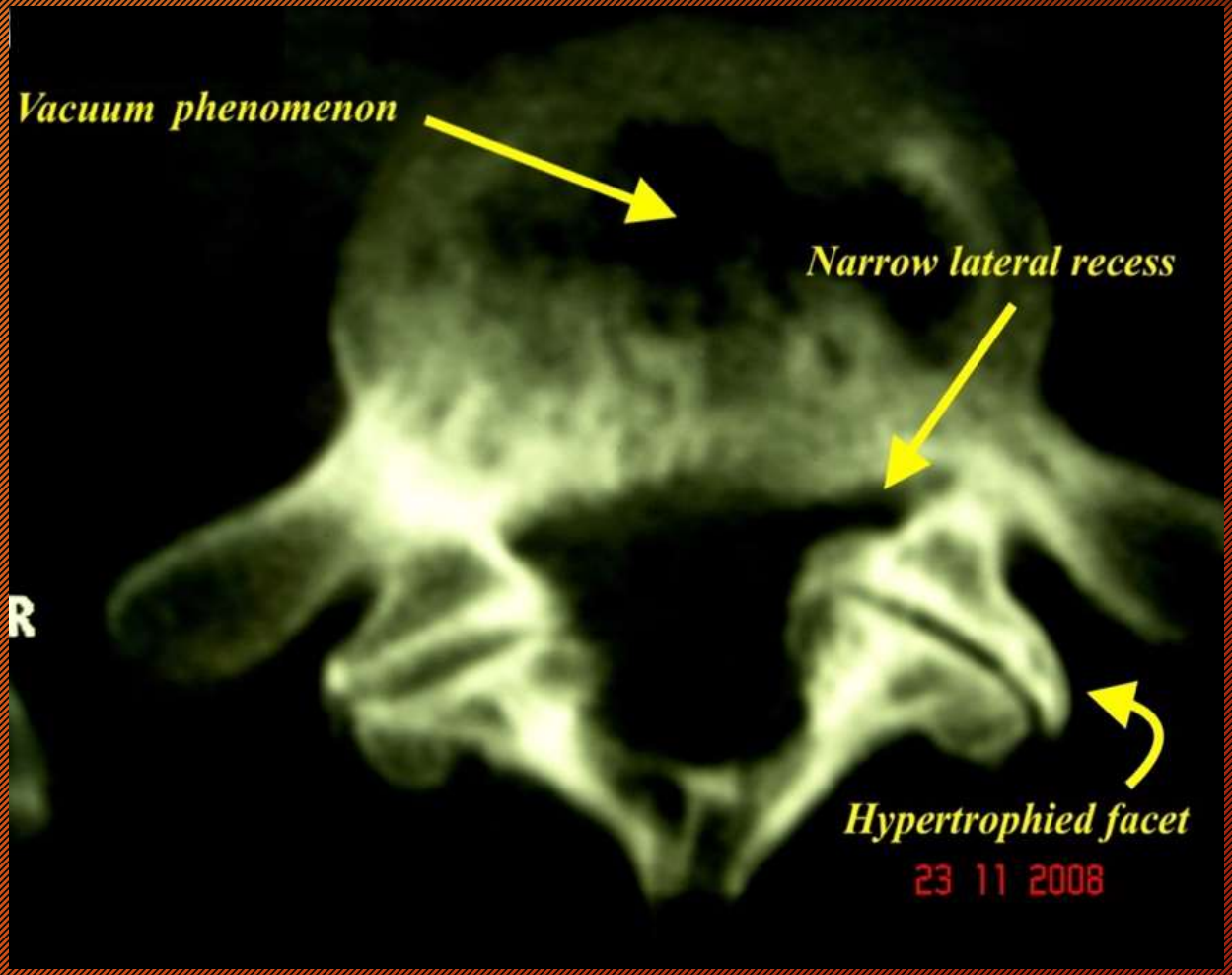
Diagnosis

- History and physical PLUS imaging finding showing canal stenosis
- Neuroimaging
  - MRI is the procedure of choice
  - CT myelography if MRI is contraindicated
- Criteria vary; e.g. intraspinal canal area of less than 76 mm2 and 100 mm2 to identify severe and moderate stenosis
- Interpret results with caution; findings present in asymptomatic patient (> 20% in pts > 60)

IMAGING: MRI



IMAGING: CT


Vacuum phenomenon
Narrow lateral recess
R
Hypertrophied facet
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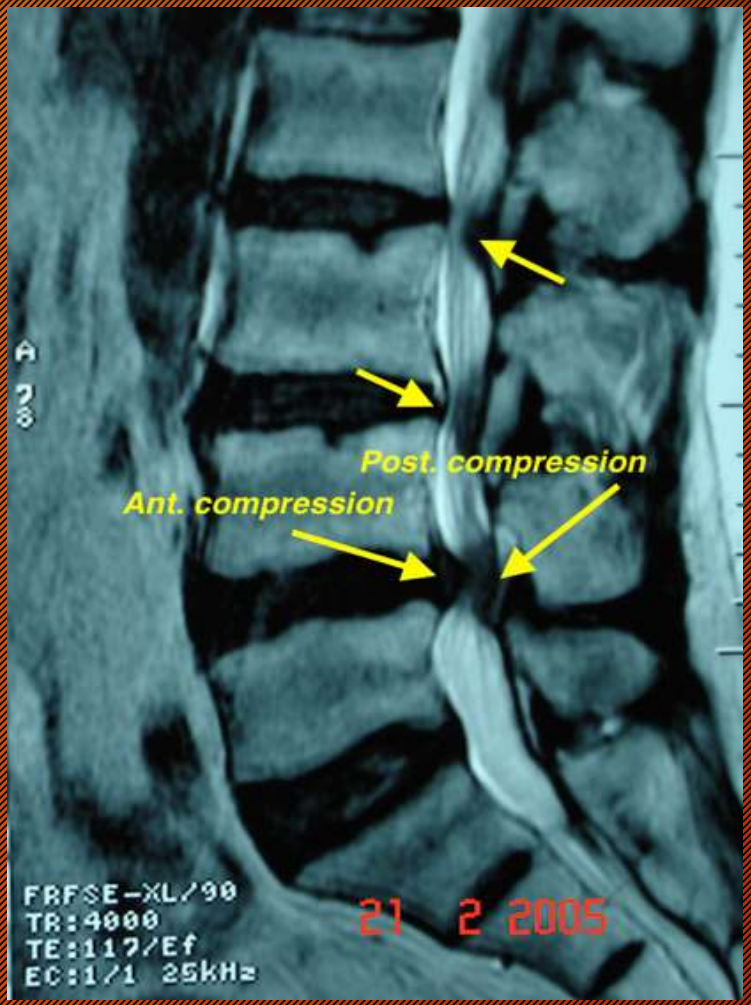
IMAGING: MRI


Post. compression
Ant. compression
FRFSE-XL/90
TR:4000
TE:117/Ef
EC:1/1 25kHz
21 2 2005

MANAGEMENT

- The definitive treatment for lumbar canal stenosis is the relief of the compression by a decompressive laminectomy or multiple laminotomies or fenestrations. The aim is to decompress the canal and/or root or roots, remove any spurs of bone abutting the foramina, and excise the thickened ligamentum flavum.

MANAGEMENT

- However, while this is true for those patients who cannot go along with their daily mobility, or those who had incurred neurological deficits especially if they are bilateral or are suffering from urinary compromise.

MANAGEMENT

- conservative treatment in the absence of any of the above-mentioned situations could be advised, especially if the patient is old or has some concomitant diseases which make surgery hazardous. This treatment usually consists of some medications for the pain and asking the patient to limit his activities to within his claudication distance.

OPERATIVE TECHNIQUES

- Laminectomy and partial facetectomy
- Additional Lumbar arthrodesis (fusion procedure) in patients with stenosis accompanied by spondylolisthesis
- Interspinous distraction (instrumentation is used to distract adjacent spinous processes, thus imposing lumbar flexion)

SPONDYLOLITHESIS

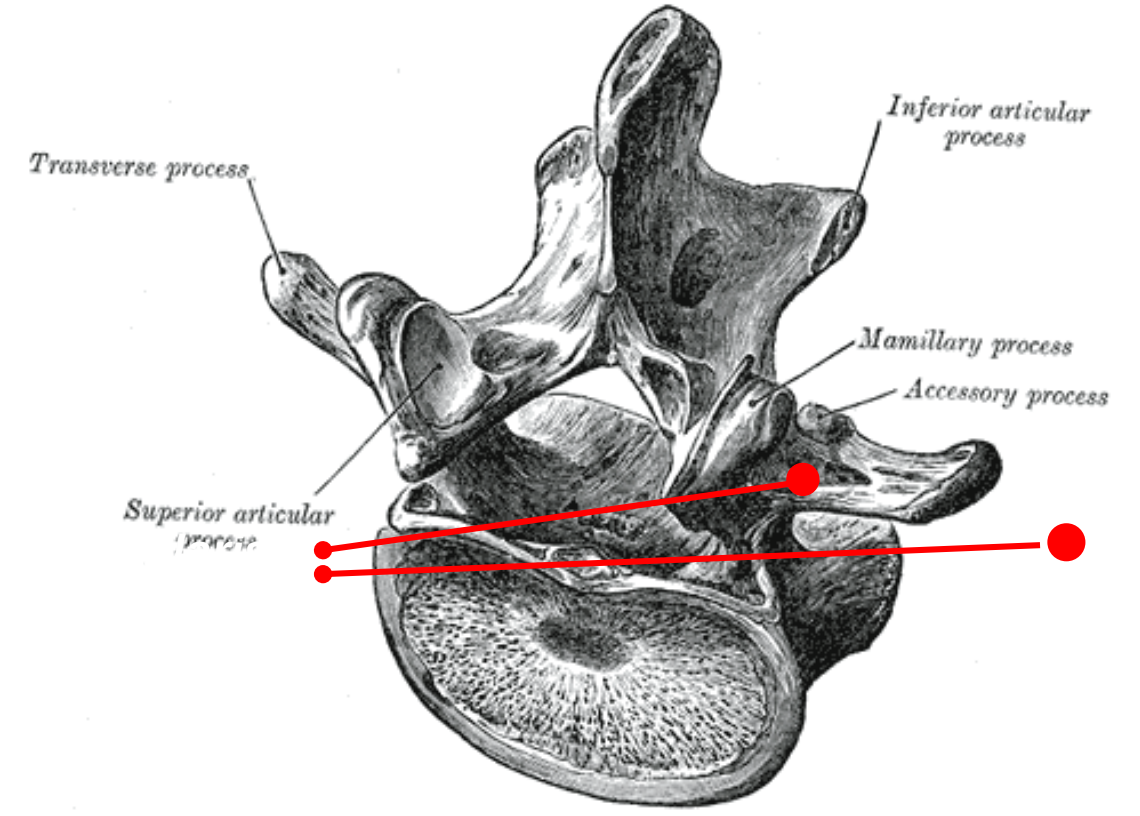
- Subluxation of one vertebra on another
- Types:

Table 13.4 Classification of spondylolisthesis.

Congenital	
Dysplastic	Congenital deficiency of superior facet of sacrum or inferior facet of 5th lumbar vertebra
Isthmic	Lesion in pars interarticularis
	Lytic fatigue fracture
	Elongated but intact pars
	Acute fracture
Degenerative	In adults, usually at L4/5; a cause of lumbar canal stenosis
Traumatic	
Pathological	Paget's disease, neoplastic, osteogenesis imperfecta and achondroplasia

PATHOLOGY

Pars Int



CLASSIFICATION

Meyerding Classification of Spondylolisthesis

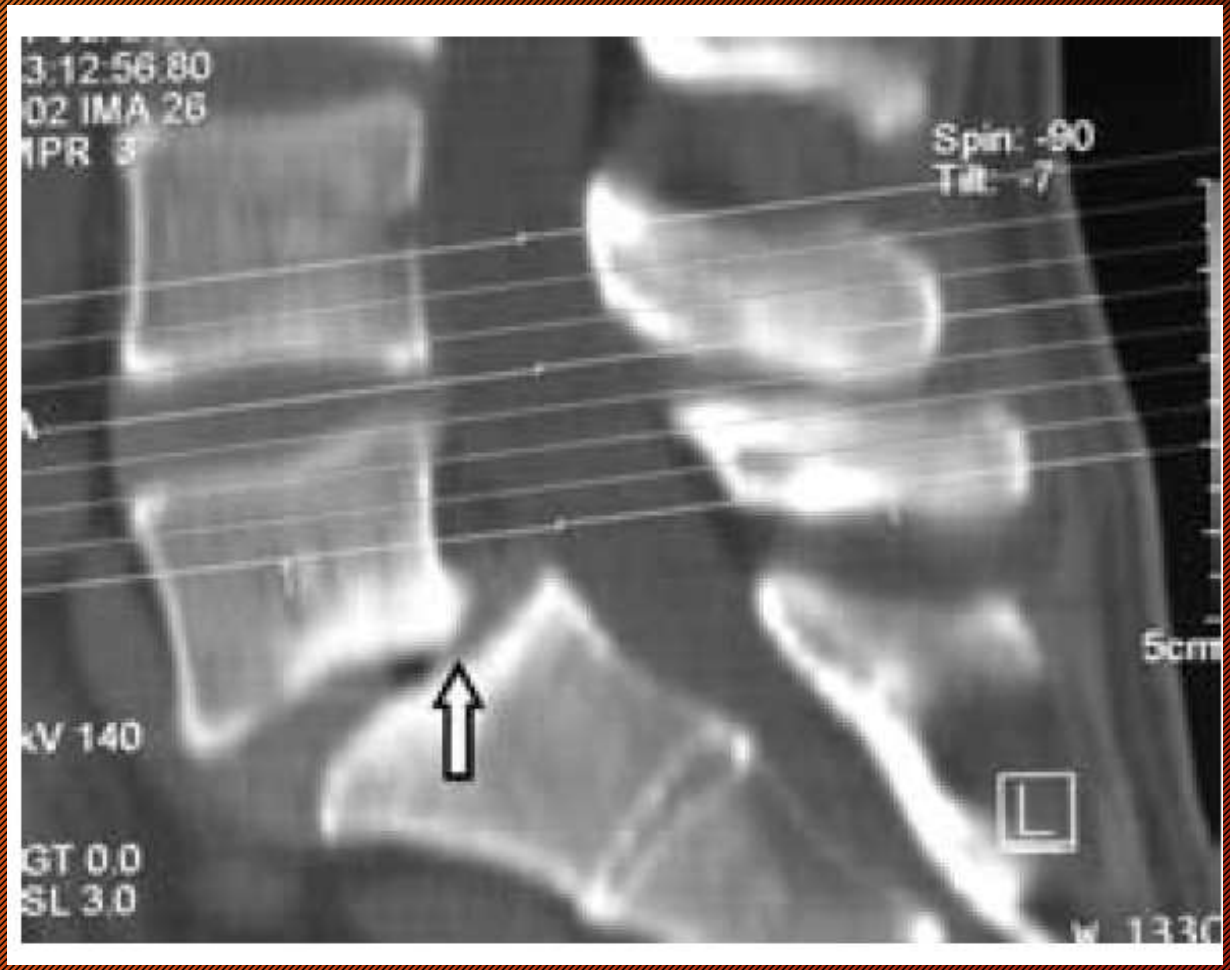
Grade I: 0-25%
Grade 11: 26-50%
Grade III: 51- 75%
Grade IV: 76- 100%
Grade V: >100% (spondyloptosis)

PRESENTATION

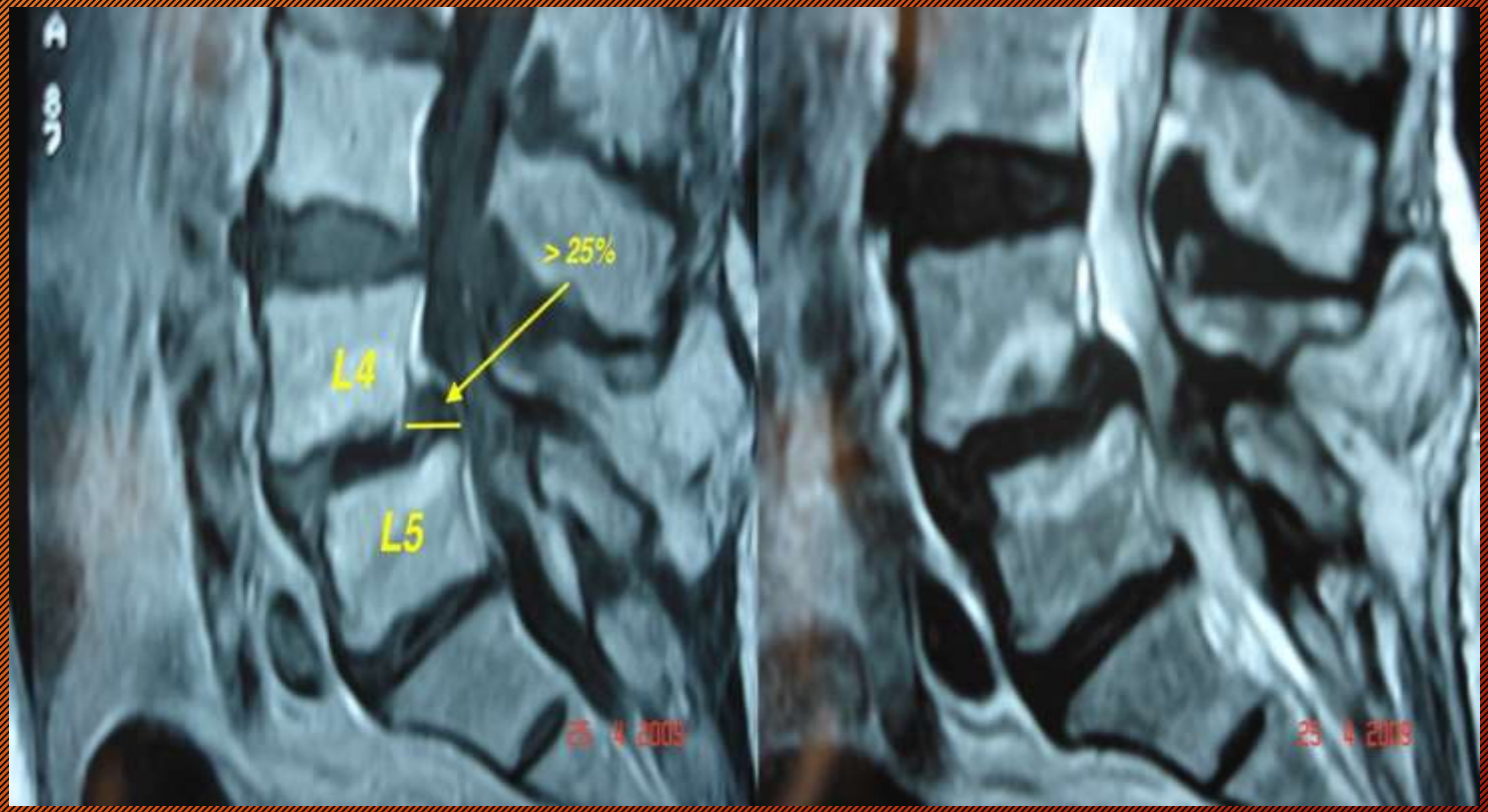
- Back Pain (more) and Leg pain
- Sciatica
- LCS

IMAGING

CT BONE WINDOW



MRI T1 AND T2



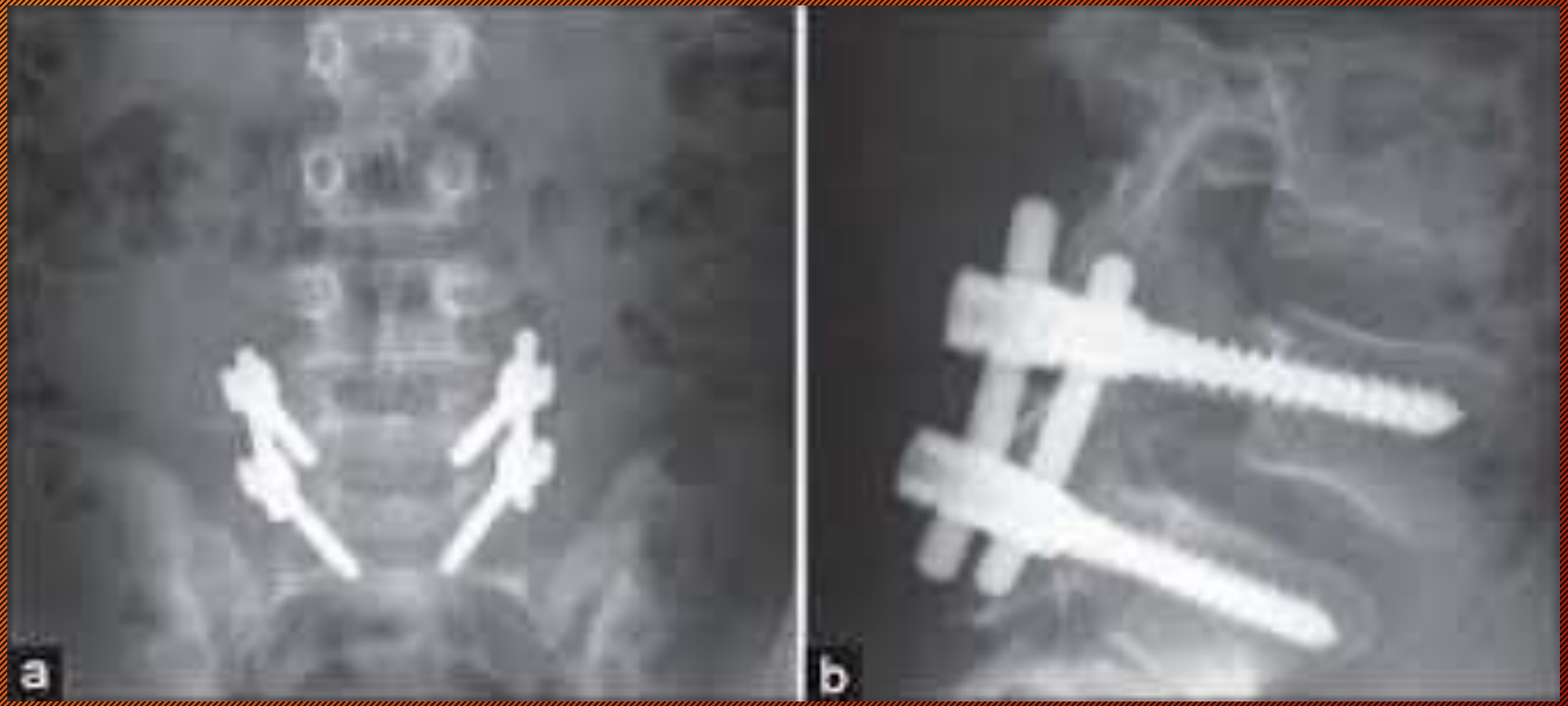
TREATMENT

- For patients complaining of lower back pain, a course of NSAID should be tried, and once the acute attack of pain subsides, a course of physiotherapy in the form of strengthening exercises to the abdominal and back muscle should be prescribed. However, the patient must be advice to change his life style, avoid prolonged sitting or carrying heavy objects. He should refrain from playing sports apart from walking and swimming.

TREATMENT

- If conservative treatment as outlined above fails, or if the patient has manifestations of cauda equina compression, then a decompressive laminectomy should be performed to the affected level associated with fixation of the spine using pedicle screws.

PEDICLE SCREWS FIXATION



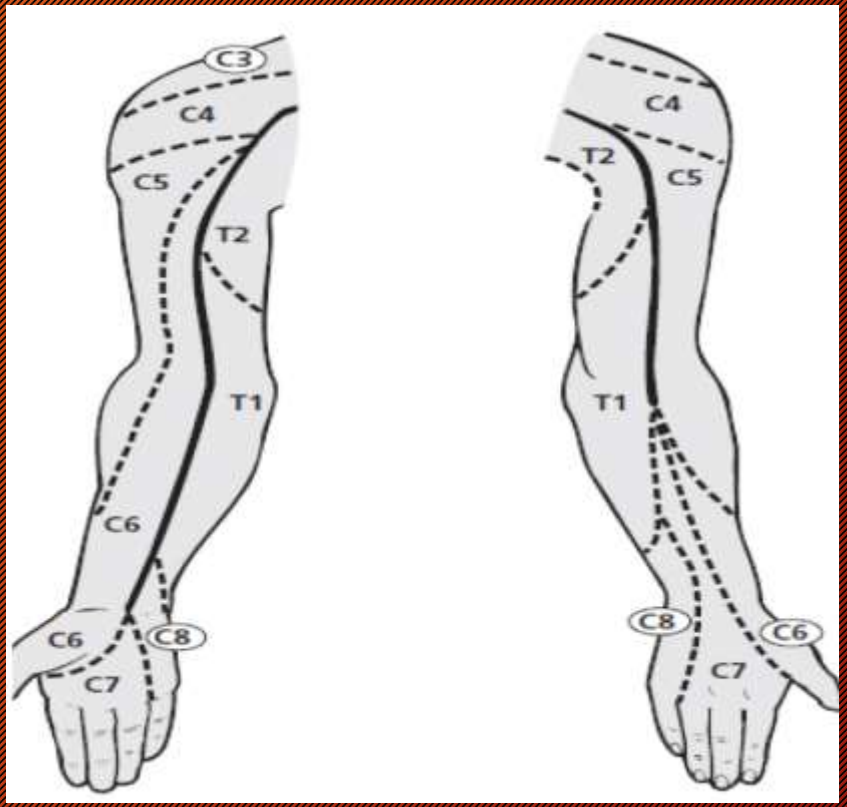
CERVICAL DISC PROLAPSE

- Prolapse is less common than in the lumbar region
- Most common in C6/C7 and C5/C6
- Mostly posterolateral herniation

ANATOMY (DERMATOMES)

Table 14.2 Segmental innervation of upper limb joint movements.

Shoulder	Abductors and lateral rotators	C5
	Adductors and medial rotators	C6, 7, 8
Elbow	Flexors	C5, 6
	Extensors	C7, 8
Forearm	Supinators	C6
	Pronators	C7, 8
Wrist	Flexors and extensors	C6, 7
Digits	Long flexors and extensors	C7, 8
Hand	Intrinsic muscles	C8, T1



PRESENTATION

- Pain:
  - begins in the cervical region, radiates into periscapular region and shoulder and down the arm.
  - Conforms to course of nerve.
- Sensory disturbance
  - Numbness, tingling in **dermatomal** distribution
  - Index C6, Middle finger C7, ring and small finger C8
- Weakness in myotomes

EXAMINATION

General: Head is tilted towards lesion, moderately flexed

Neurological Exam:

Motor: Wasting

Weakness

Hypo/areflexia

Sensory

N.B: Assess the lower limbs for U.M.N signs (indicating a cervical myelopathy)

DIFFERENTIAL DIAGNOSIS

- Spondylosis
- Compression by tumor
- Thoracic outlet syndrome
- Pancoast’s tumor
- Peripheral nerve entrapment

IMAGING (PLAIN X-RAYS)

MRI

TREATMENT

- Conservative treatment which may take the form of the use of medications like NSAID and painkillers, wearing a neck collar and in certain situations; physiotherapy. It has to be understood that this conservative treatment has no place in management if there is muscle weakness and other cord signs.

TREATMENT

- If a good trial of conservative treatment (6-12 week), fails to control acute or recurrent attacks of pain. Or there was indication for surgery like the presence of neurological deficits in the cord or a root., then a decision to perform surgery has to be taken and here one has to decide which is the most appropriate approach: Anterior or Posterior??

TREATMENT

- The first of the surgical procedures and the most practiced is the anterior cervical discectomy and fusion (ACDF) usually done using the microscope, it is preferred by neurosurgeons because it can deal with centrally located herniations, it allows for the removal of the compressing disc, and of the osteophytes in the affected foramen and it will reduce the possibility of subluxation. The disc is replaced with a bone graft or a cage, which could be fixed in position by plate and screws.

ACDF

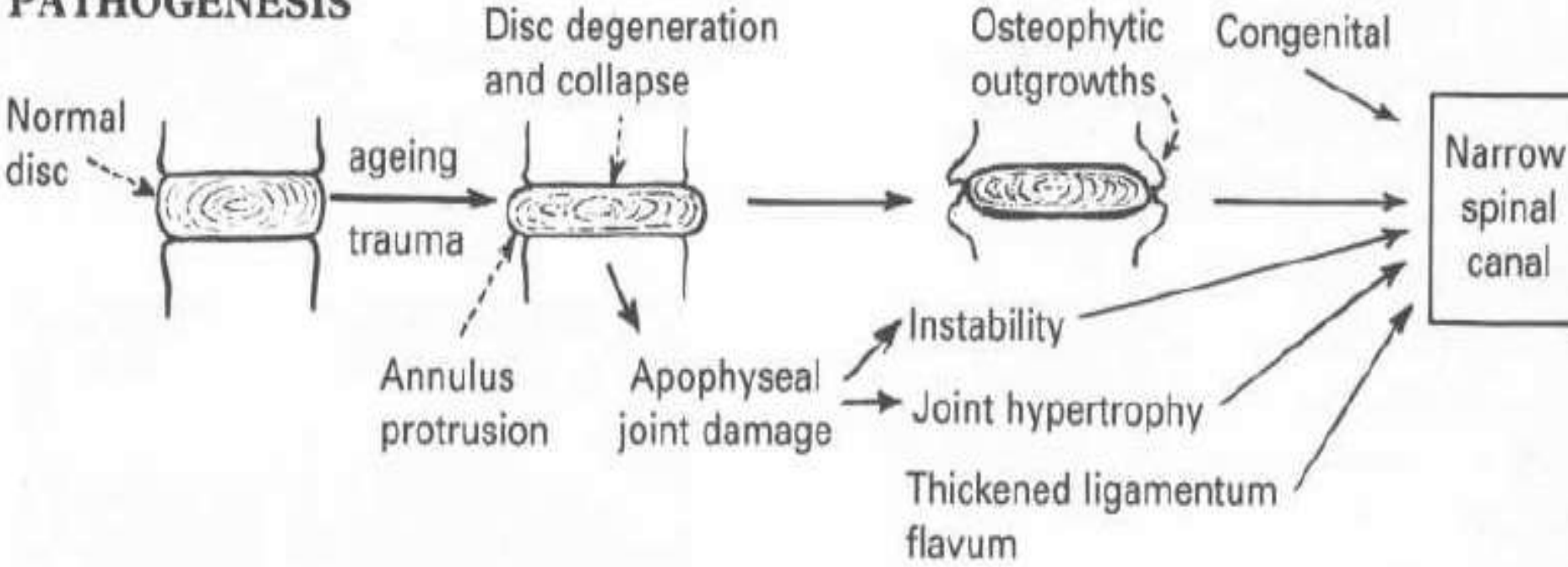
CERVICAL SPONDYLOSIS

- It is a degenerative arthritic process involving the cervical spine and IVDs
- Radiological findings are present in > 75% if people over 50 who are asymptomatic

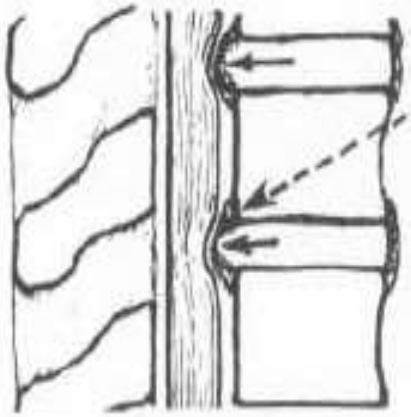
Pathophysiology

- Reduced water content and fragmentation of the nuclear portion of the cervical discs
- Stress on the articular cartilages of the vertebral end-plates
- osteophytic spurs develop around the margins of the disintegrating end-plates
- Project **posteriorly** into the spinal canal and **anteriorly** into the prevertebral space

PATHOGENESIS



Disc/osteophytic protrusion may:



Compress the spinal cord . . .

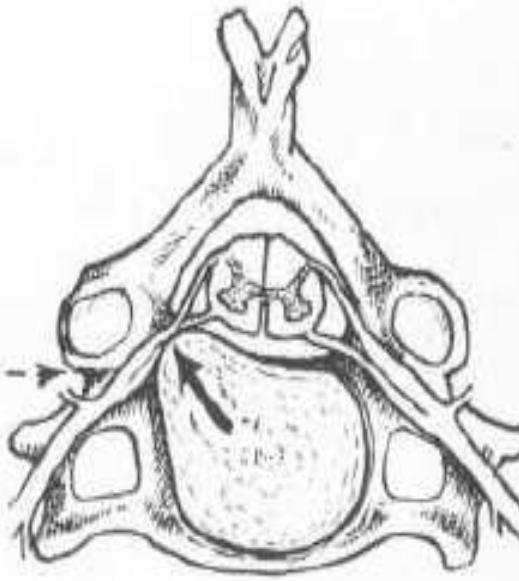
↓

MYELOPATHY

. . . and/or the adjacent nerve roots ----

↓

RADICULOPATHY



PRESENTATION

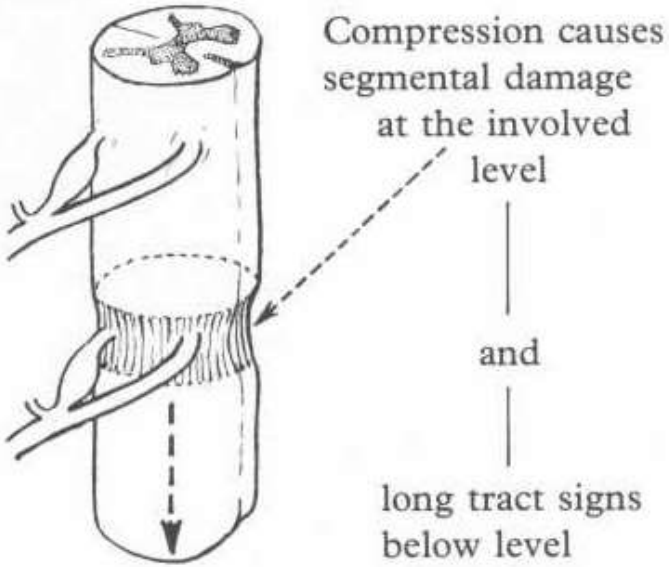
1. Neck Pain
   - Most common symptom
   - Remitting relapsing picture
2. Radicular arm pain
   - Sharp, stabbing pain, worse on coughing, may be superimposed on dull aching background pain, radiates to shoulder, periscapular region.
   - Paresthesia
   - Sensory loss in dermatomal distribution
   - Weakness and wasting (l.m.n.) and hyporeflexia

PRESENTATION

3) Cervical myelopathy

CLINICAL FEATURES (*contd*)

Myelopathy



Arms: l.m.n. signs and symptoms, as above, at the level of the lesion

and/or

u.m.n. signs and symptoms below the level of the lesion

e.g. C5 lesion { biceps weakness, wasting: diminished biceps jerk: increased finger jerks.

Legs: u.m.n. signs and symptoms, i.e. difficulty in walking due to stiffness; 'pyramidal' weakness, increased tone, clonus and extensor plantar responses; sensory symptoms and signs are variable and less prominent.

Sphincter disturbance is seldom a prominent early feature.

IMAGING

- Plain cervical x-rays
  - Narrowing of the disk space
  - Osteophytosis
  - Subluxation; flexion/extension views may be required
- MRI: procedure of choice

PLAIN X-RAYS


Degenerative Changes:
Cervical Spine
Narrow
disc space
Bone
spurs

MRI

TREATMENT

- Conservative
  - Bed rest
  - Soft collar
  - Analgesics

TREATMENT

- Surgery

There are different approaches; anterior and posterior depending on the site of the pathology. So that an anterior pathology like bars and osteophytes are treated from anteriorly and pathologies like enfolding of the ligamentum flavum, hypertrophied facets or stenosed foramina could be dealt with via a decompressive laminectomy or keyhole foramintomy.