Degenerative disease of the cervical spine

Feb 8th, 2007

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Neurosurgery Academic Half Day

Overview

- Common Problem
- MRI scans may well reinforce this delusion by demonstrating abnormalities
- Cervical disc degeneration reaches a prevalence of nearly 95% by the age of 65 years
- Surgery is generally used in degenerative disease for decompression of spinal cord or nerve roots

Overview

- The decompression itself may lead to a relative destabilisation of the cervical spin
- This can result in worsened (and potentially disabling) postoperative neck pain
- to avoid this complication decompression procedures may be combined with a simultaneous fusion

Overview

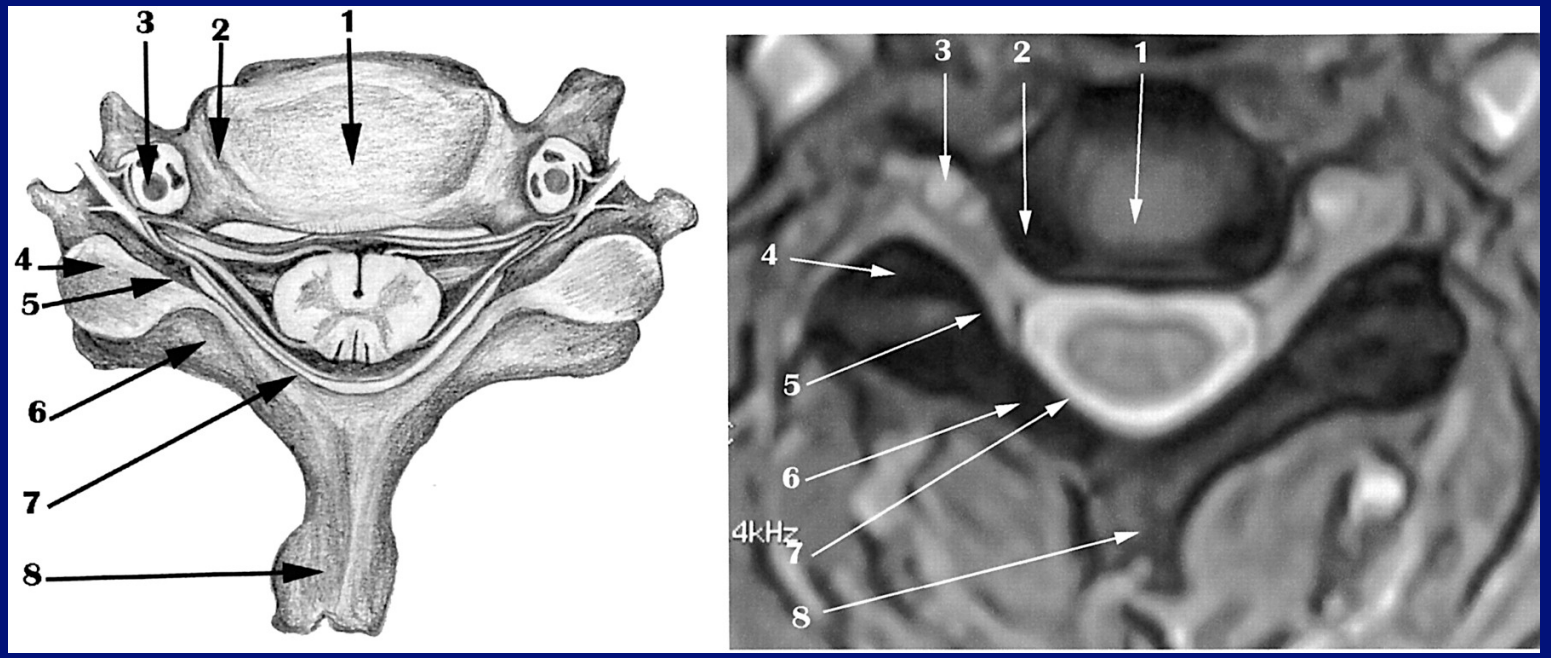
- However, the resultant loss of spinal movement following such a fusion may result in accelerated degeneration at adjacent spinal levels
- So careful consideration of the benefit from surgery must be balanced against risk.
- To do this we need to understand both the natural history of cervical spondylosis and the expected outcomes with surgery

Overview

- Cervical Anatomy
- Cervical Spondylosis
- Cervical Spondylotic Myelopathy (SCM)
- Pathophysiology
- Clinical Presentation
- Diagnosis
- Natural History
- Management

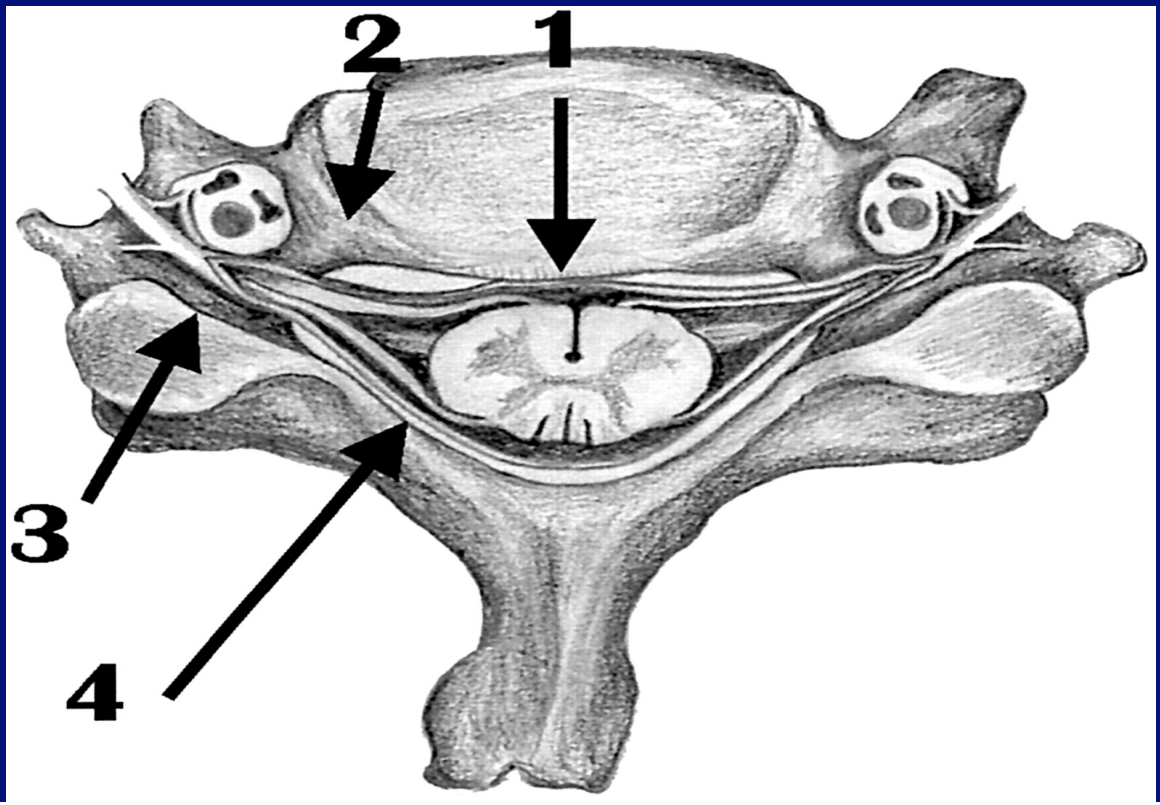
CERVICAL ANATOMY

Figure 1 Axial cervical spine anatomy. The key on the illustration (left) corresponds to the key on the MRI image (right). (1) Anterior vertebral body endplate. (2) Uncus (constituting one side of uncovertebral joint). (3) Vertebral artery within foramen transversarium. (4) Lower facet. (5) Medial aspect of facet joint. (6) Lamina. (7) Site of attachment ligamentum flavum. (8) Spinous process.



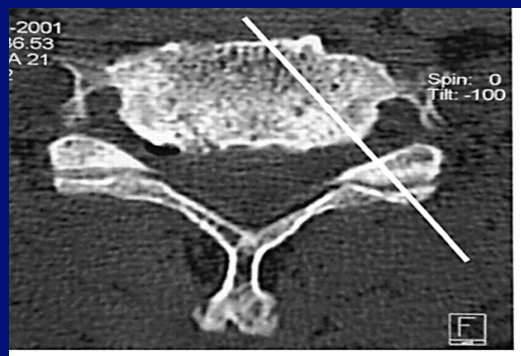
CERVICAL ANATOMY

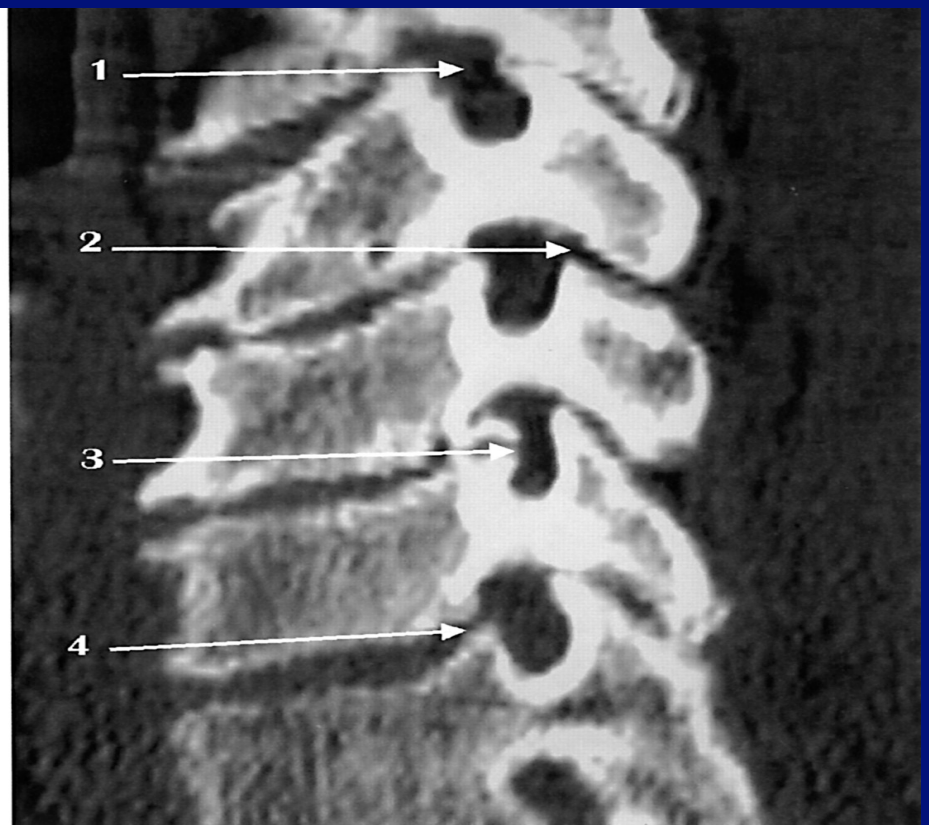
Figure 2 Potential sites of pathology causing compression of the spinal cord or spinal root in cervical spondylosis. (1) Central disc prolapse or osteophyte. (2) Lateral disc prolapse or osteophyte of uncovertebral joint. (3) Medial facet joint osteophyte. (4) Ligamentum flavum hypertrophy.



CERVICAL ANATOMY

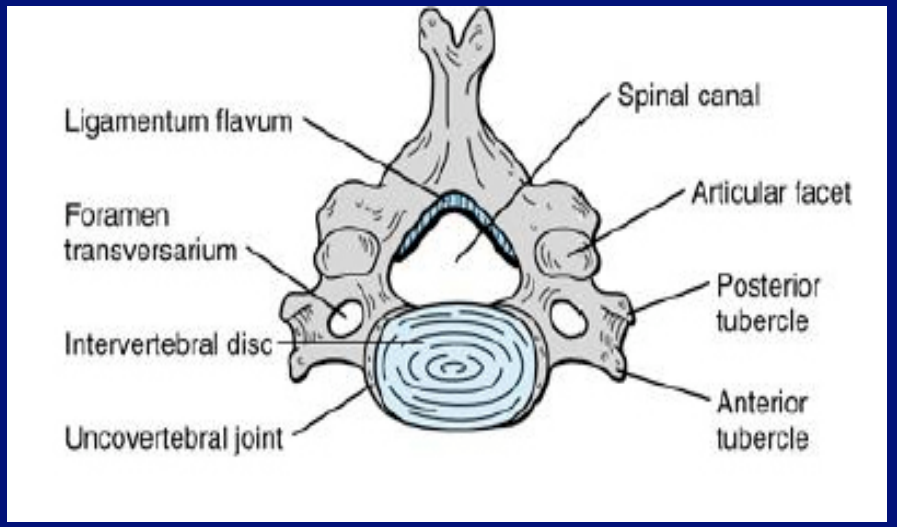
Figure 3 Axial (left) and oblique (right) CT scans of the cervical spine. White line on axial image corresponds to plane of oblique image through root canal. (1) Root canal. (2) Facet joint. (3) Uncovertebral osteophyte causing root canal stenosis. (4) Lateral disc space.





CERVICAL ANATOMY

- Disc & 4 articulations:
- 2 facet joints
- 2 uncovertebral joins
  (of Luschka)

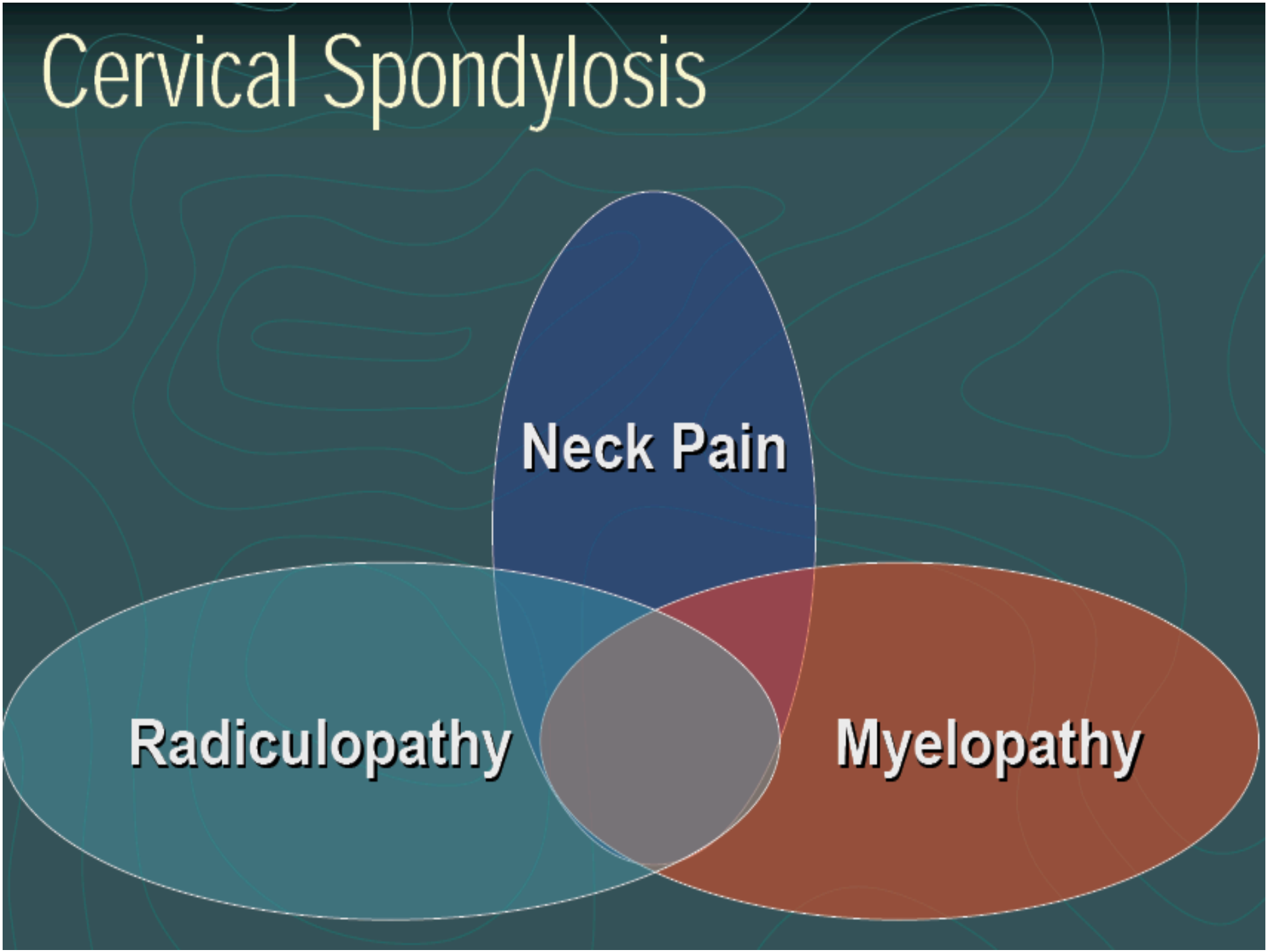


- Cervical canal diameter: average 17mm
- Spinal cord diameter: average 10mm
- If canal reduced to < 13mm spinal ➡ stenosis

Cervical Spondylosis

- Chronic degenerative changes in the spine, including joints, intervertebral discs, ligaments & connective tissue of cervical vertebrae
- Natural consequence of aging
- Clinical syndromes:
    - . Axial Neck Pain (controversial etiology)
    - . Radiculopathy (root compression)
    - . Myelopathy (cord compression)
    - . Combinations

Cervical Spondylosis



Cervical Spondylosis

- Begin symptomatic at age 40-50
- Men > Women
- C5-6 > C6-7
- Risk factors:
  - Frequent lifting
  - Smoking
  - Diving
  - Genetic predisposition

Cervical Spondylotic Myelopathy (SCM)

- The most common cause of spinal cord dysfunction in older persons
- Overall prevalence is unknown
- 23.6% of 585 patients with non-traumatic quadriparesis or paraparesis admitted to a UK neuroscience center (Moore 1997)

SCM

- The most common cause of acquired spastic paraparesis in adults
- Clinical presentation varies depending on severity of stenosis & portion of cord involved
- From subtle findings for years to acute quadriparesis over hours
- Requires high degree of suspicion for diagnosis

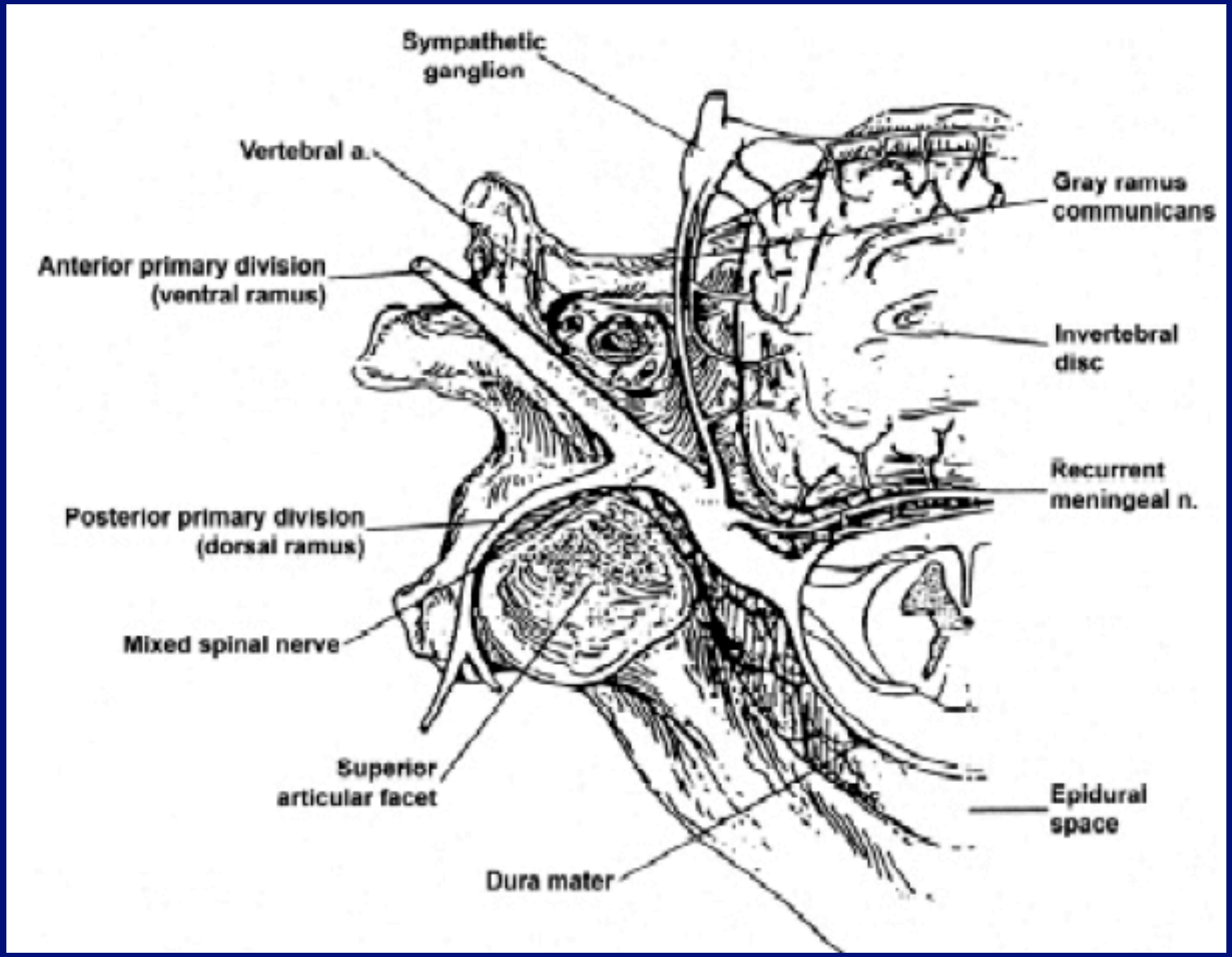
PATHOPHYSIOLOGY

Neck Pain Pathophysiology

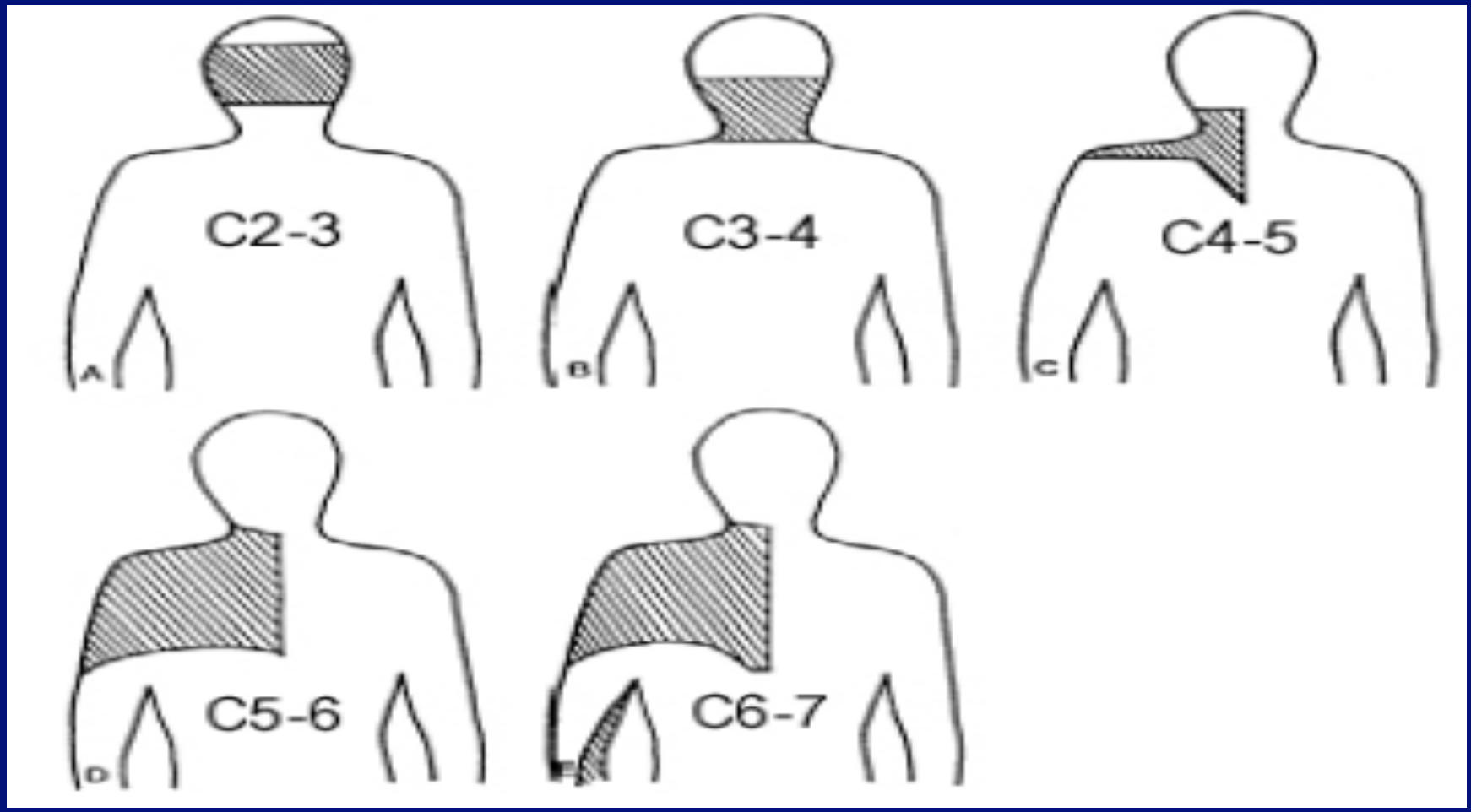
1. Muscular:
   - Muscular: Postural, poor ergonomics, stress ± chronic muscle fatigue
   - May be postural adaptation of primary source of pain in shoulder, craniovertebral junction or TMJ
   - Via unencapsulated free nerve endings

Neck Pain Pathophysiology

2. Discogenic:
   - Sinuvertebral nerve (recurrent meningeal) Bogduk1988
     . Formed by branches from ventral nerve root & sympathetic plexus
     . Supplies posterior annulus, PLL, periosteum of vertebral body & pedicle
   - Reliable pattern of neck pain with 12 yr experience of discography (Grubb 2000)


Sympathetic ganglion
Vertebral a.
Anterior primary division (ventral ramus)
Posterior primary division (dorsal ramus)
Mixed spinal nerve
Superior articular facet
Dura mater
Gray ramus communicans
Invertebral disc
Recurrent meningeal n.
Epidural space

Grubb 2000

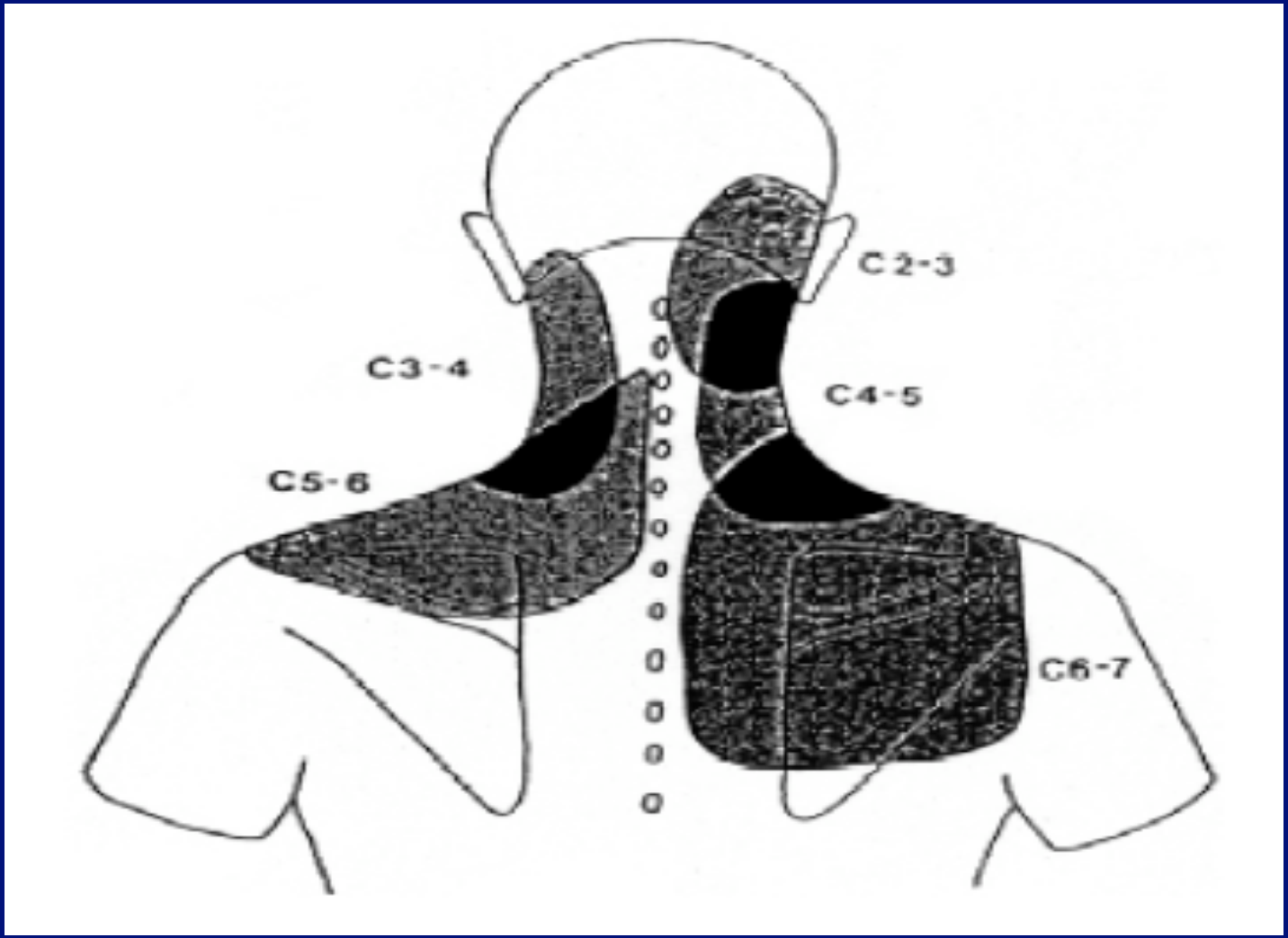


Neck Pain Pathophysiology

3. Facet-joint-induced:
   - Dwyer 1990: provocative injections of facet joints at multiple levels different pain patterns
   - Aprill1990: facet joint blocks relieved the pain

- Bogduk1993:
  - 56 patients with post-traumatic neck pain underwent both discography and facet joint blocks
  - 41% both pathology responsible, 23% only facet joints, 20% only disc, 17% neither

Dwyer 1999



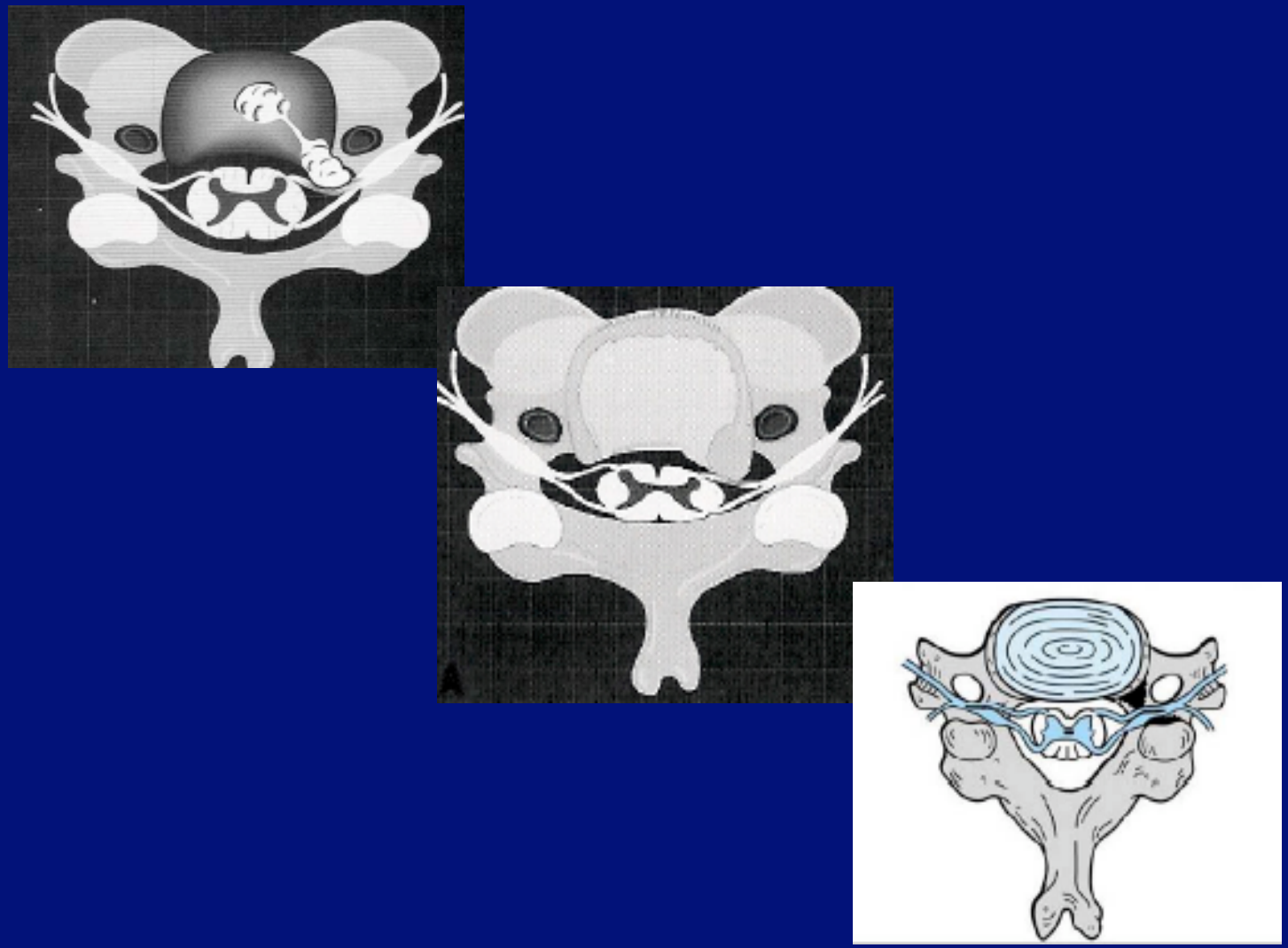
Cascade of spondylotic changes

- Age-related changes in chemical composition of NP & AF ⇒ progressive loss of viscoelasticity
- Loss of disc height & bulge posteriorly into the canal
- Vertebral bodies drift toward one another
- Infolding of ligamentum flavum & facet joint capsule ⇒ decrease canal & foraminal dimension
- Osteophytes form around disc & at uncovertebral & facet joints

Pathophysiology of Radiculopathy

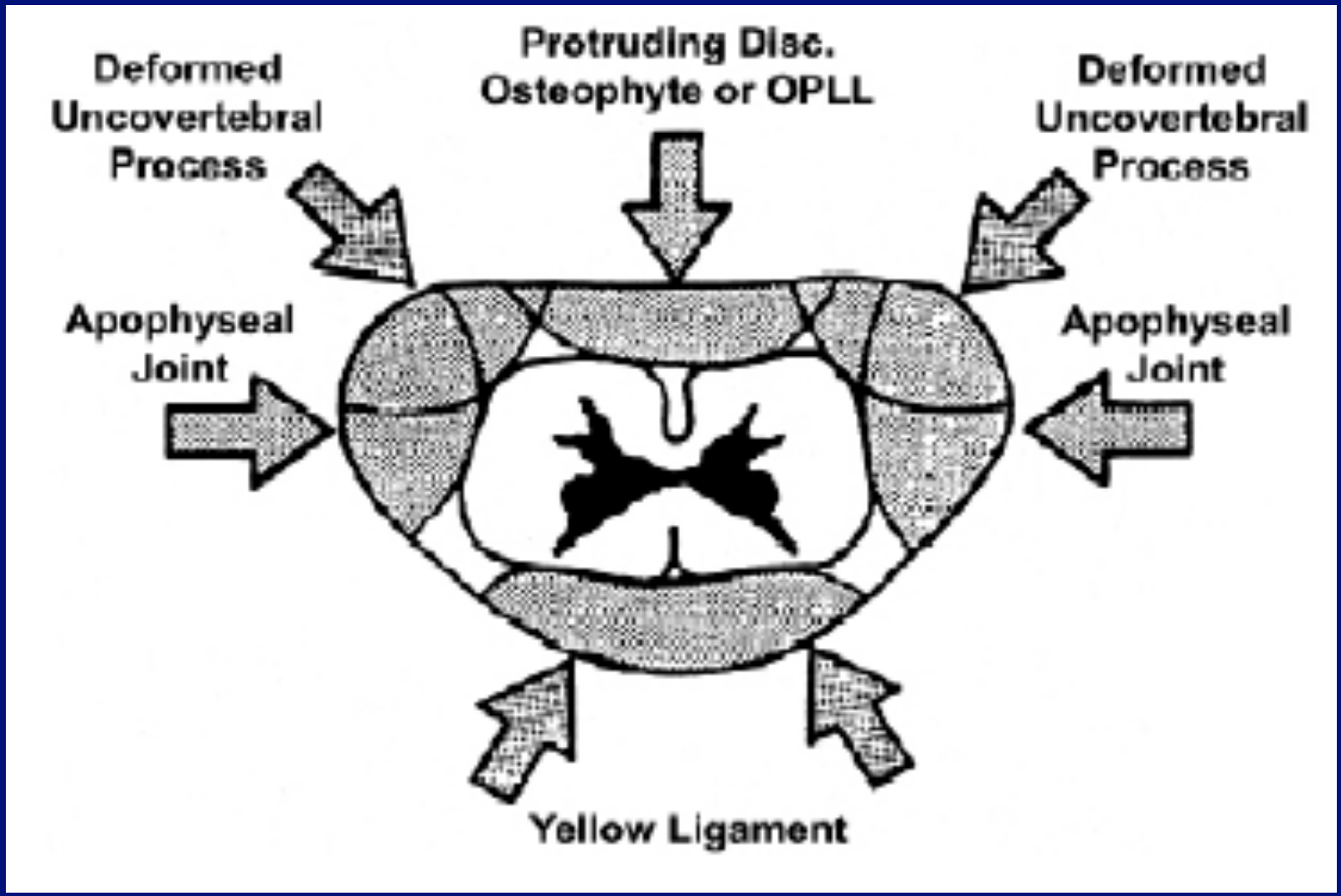
- **Mechanical compression:**
  - Herniated disc, osteophytes, thickened soft tissue, foraminal stenosis
- **Chronic edema: Cooper 1993**
  - Compression ⟹ increase permeability of intrinsic blood vessels of nerve root
  - Chronic edema & fibrosis ⟹ alter the response to threshold & increase sensitivity
- **Dorsal root ganglion:**
  - Chemical mediators & florid local response

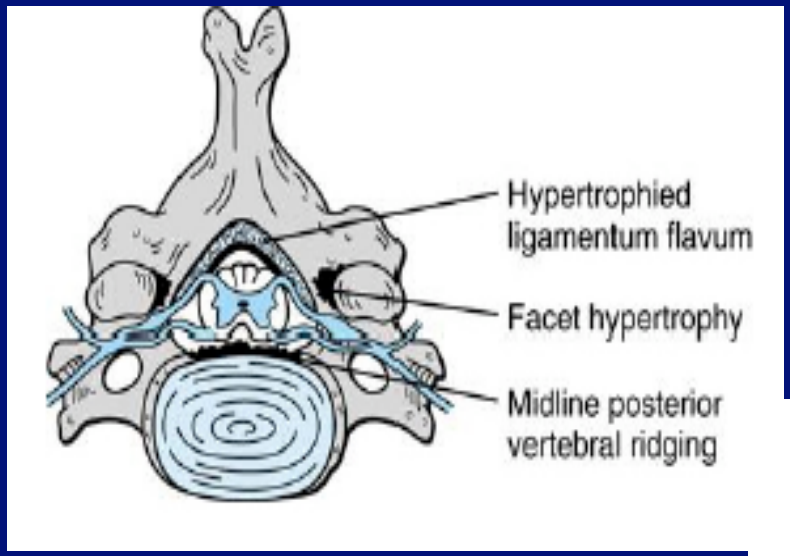
Radiculopathy

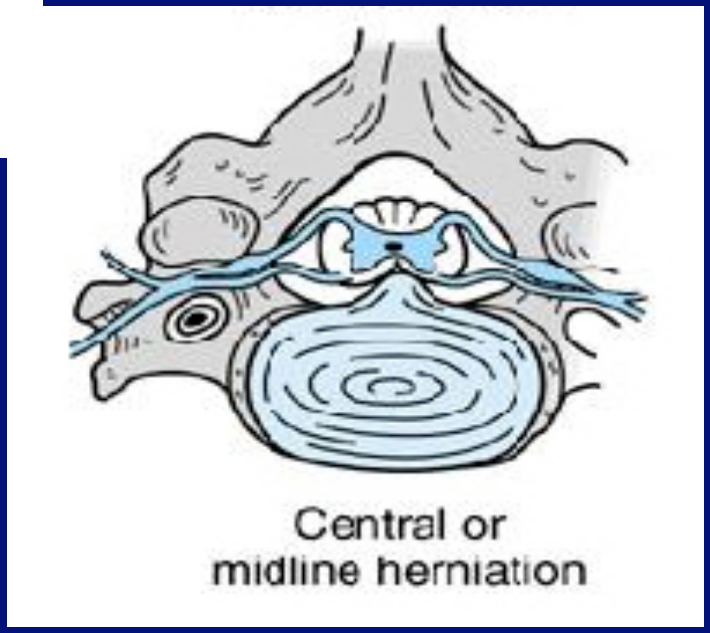


Pathophysiology of Myelopathy

- **Mechanical:**
  - Compression: disc, osteophytes, OPLL
  - Congenital Stenosis: AP diameter of canal < 13mm
- **Dynamic:**
  - Dynamic cord compression: hyperextension narrows the spinal canal by shingling the laminae& buckling the ligamentum flavum
  - Dynamic changes of cord morphology (Breig1966): cord stretches with flexion. shortens & thickens with extension
- **Vascular**


Protruding Disc,
Osteophyte or OPLL
Deformed
Uncovertebral
Process
Deformed
Uncovertebral
Process
Apophyseal
Joint
Apophyseal
Joint
Yellow Ligament


Hypertrophied
ligamentum flavum
Facet hypertrophy
Midline posterior
vertebral ridging


Central or
midline herniation

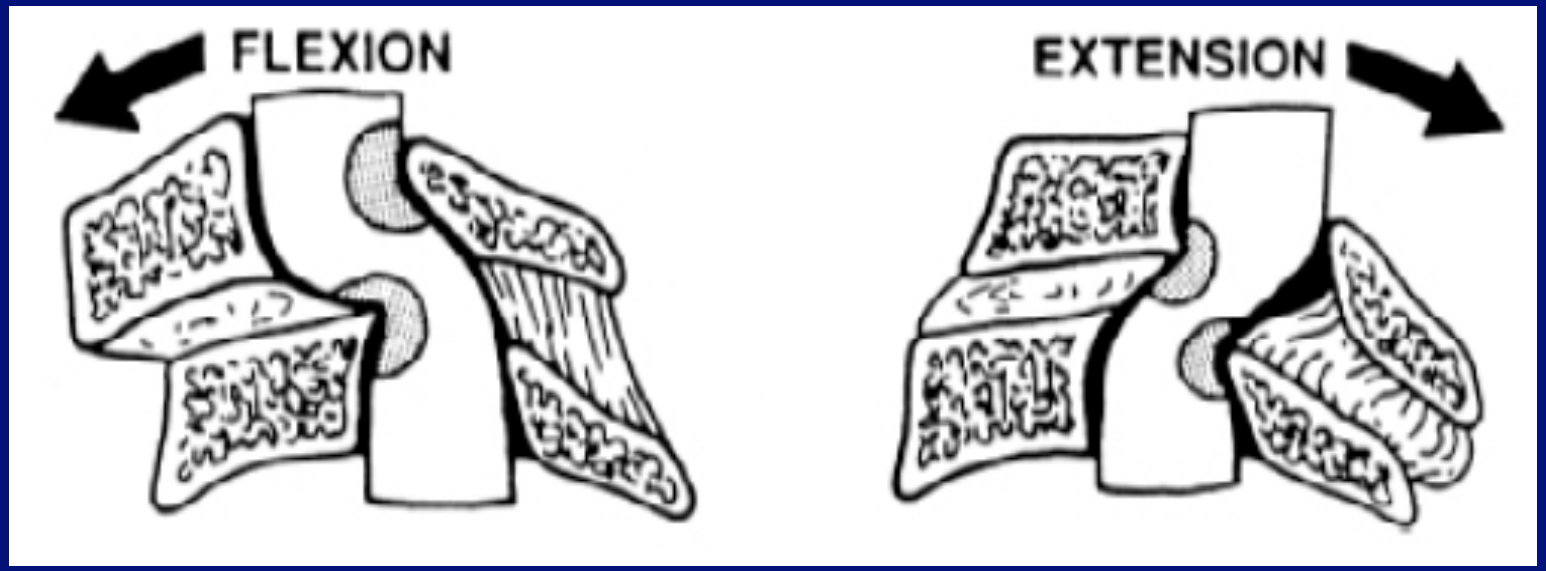
Causes of
Spinal cord compression in CSM

Stenosis

compensatory
subluxation

Cervical Kyphosis

OPLL


FLEXION
EXTENSION

5 Categories of CSM
Crandall & Batzdorf1966

1. Transverse Lesion Syndrome:
   - Corticospinal, spinothalamic& posterior cord tracts involved with equal severity
   - Longest duration of symptoms, ? end stage
2. Motor System Syndrome:
   - Corticospinal tracts & anterior horn cells affected
   - Spasticity

5 Categories of CSM
Crandall & Batzdorf1966

3. Central Cord Syndrome:

- Motor & sensory deficits affecting upper extremity > lower

4. Brown-Séquard Syndrome:

- Ipsilateral motor deficits with contralateral sensory deficits
- The least advanced form of the disease

5. Brachialgia Cord Syndrome:

- Radicular pain in the upper extremity with motor ± sensory long tact signs

CSM Syndromes
Ferguson & Caplan1985

1. Medial Syndrome: long tract symptoms
2. Lateral Syndrome: radicular symptoms
3. Combined: medical & lateral, most common
4. Vascular Syndrome: rapidly progressive, vascular insufficiency of the cord

Clinical Presentation

Signs & Symptoms of CS

Neck Pain:

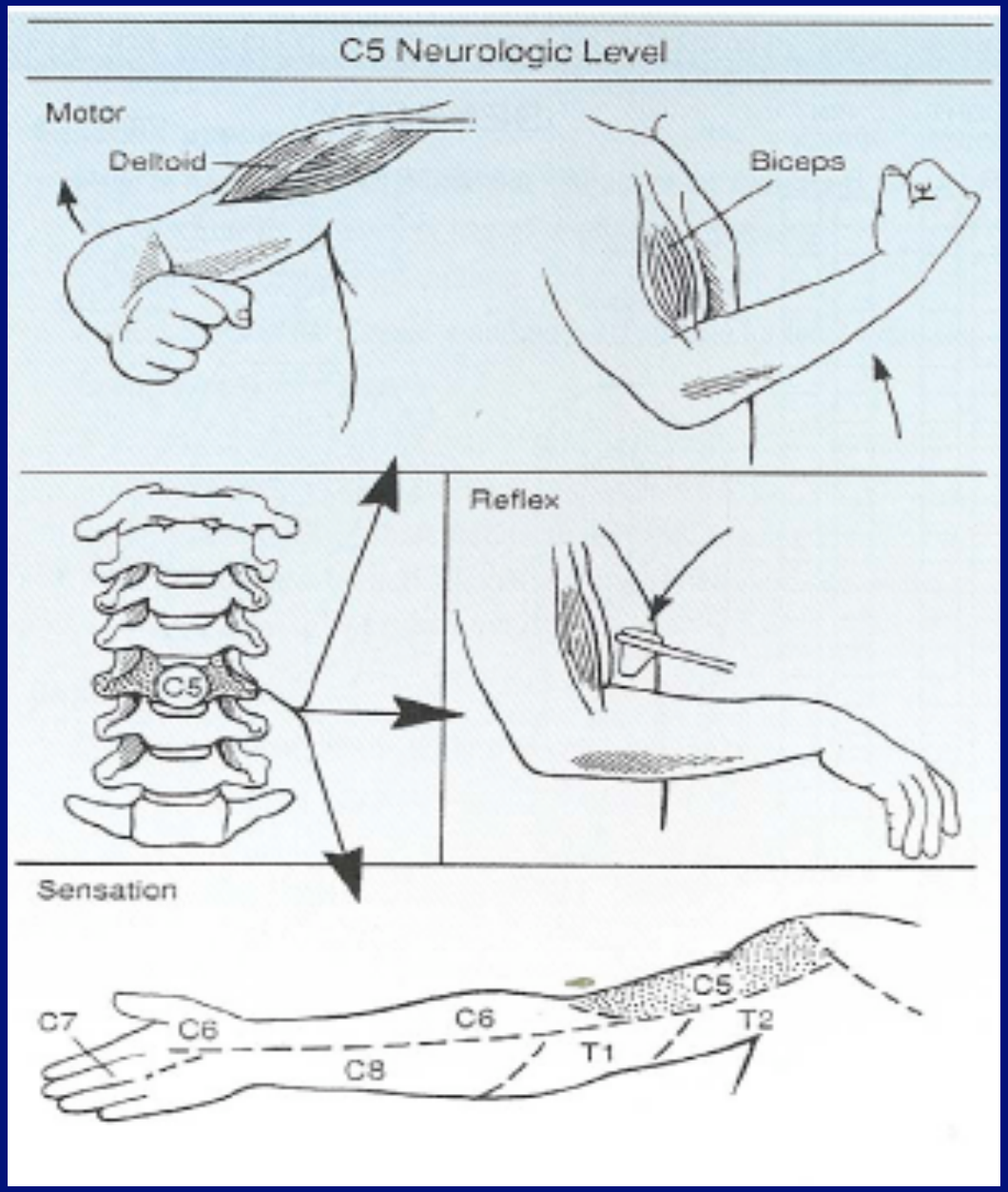
- Insidious neck pain, exacerbated by excess motion
- Occipital headache
- No neurologic signs or symptoms

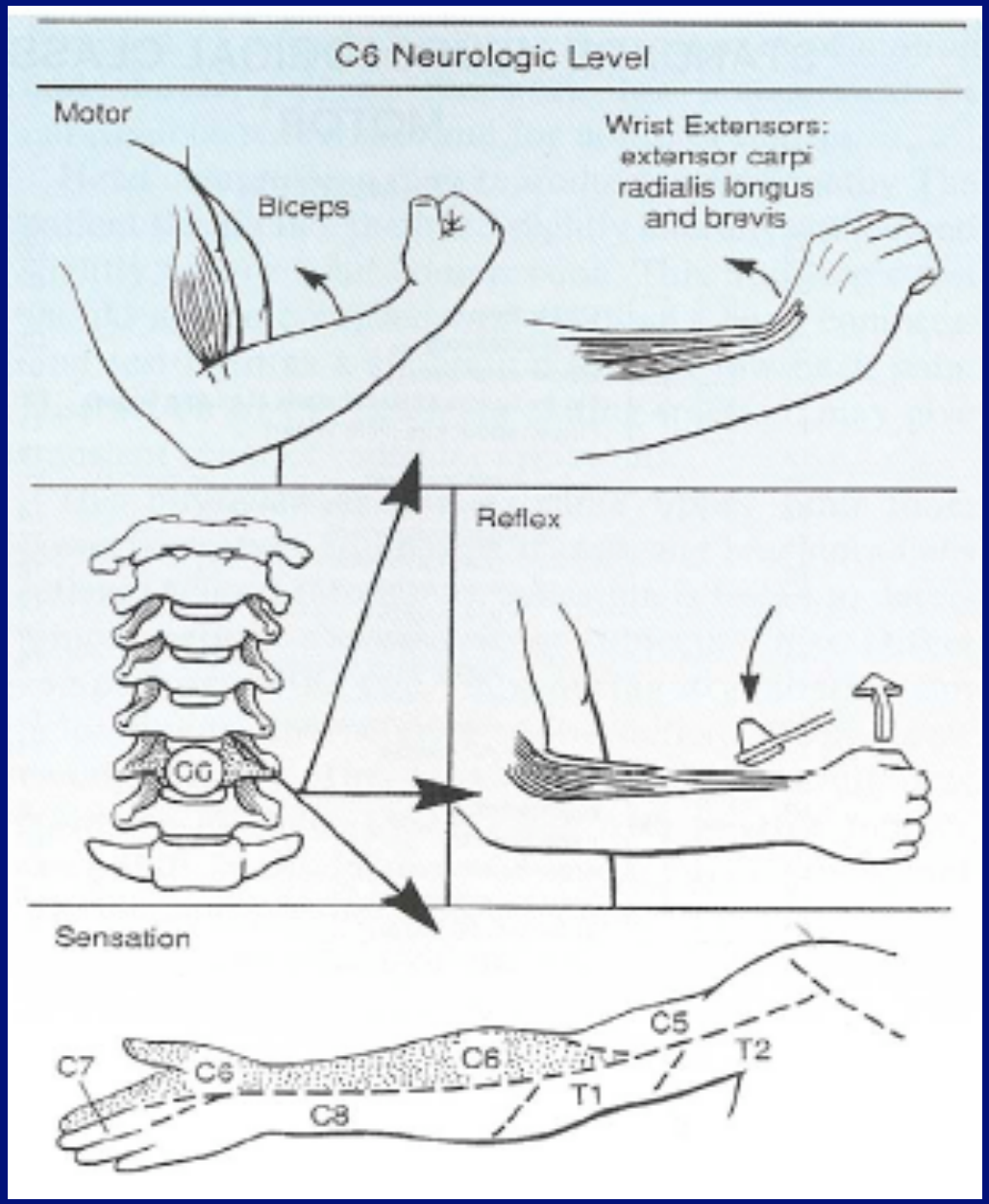
Radiculopathy:

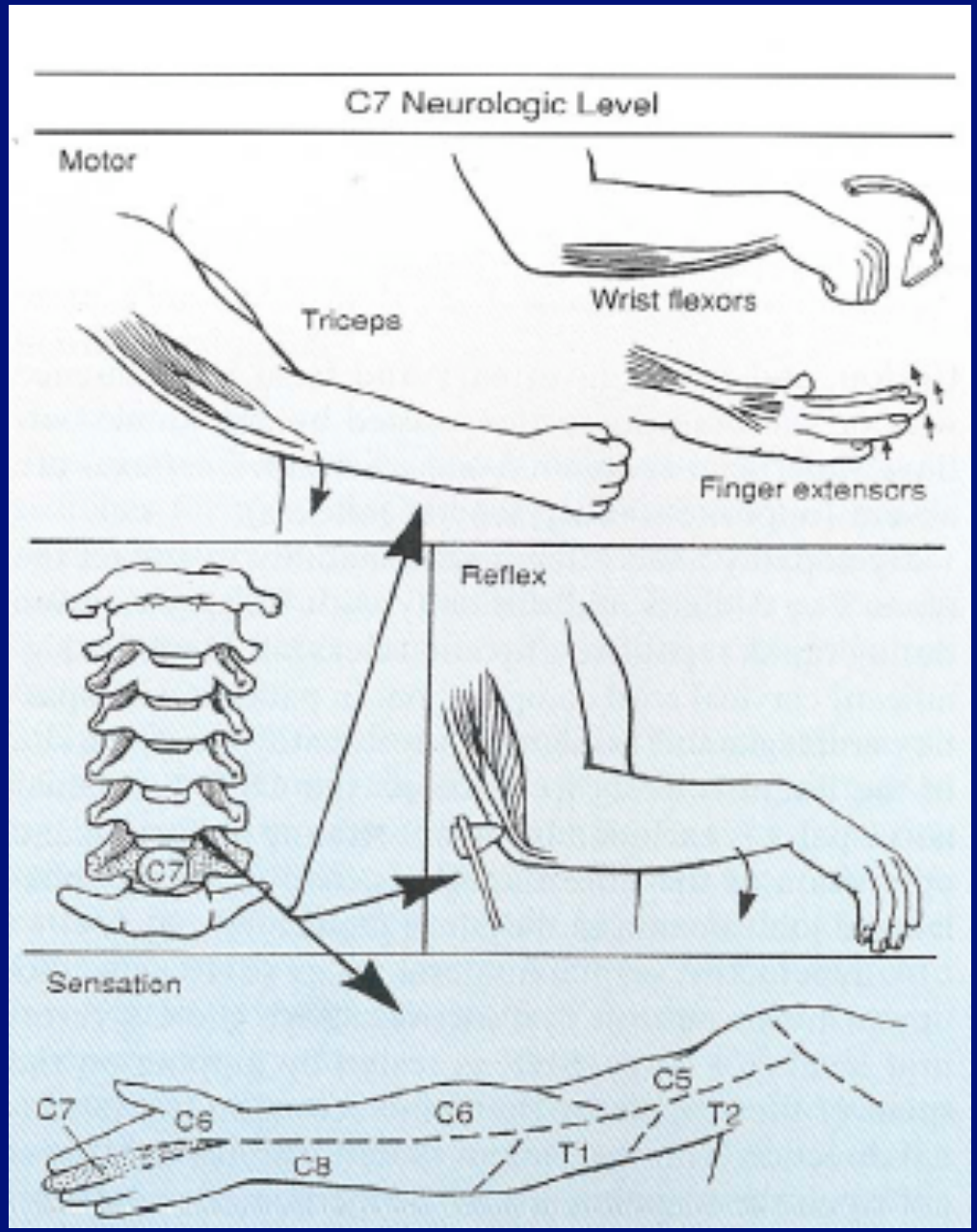
- One or multiple roots
- Neck, shoulder ± arm pain, paresthesias & numbness
- Physical Examination: Motor, Sensory & Reflexes (LMNLs)
- Overlap of findings b/c intraneural intersegmental connections of sensory nerve roots

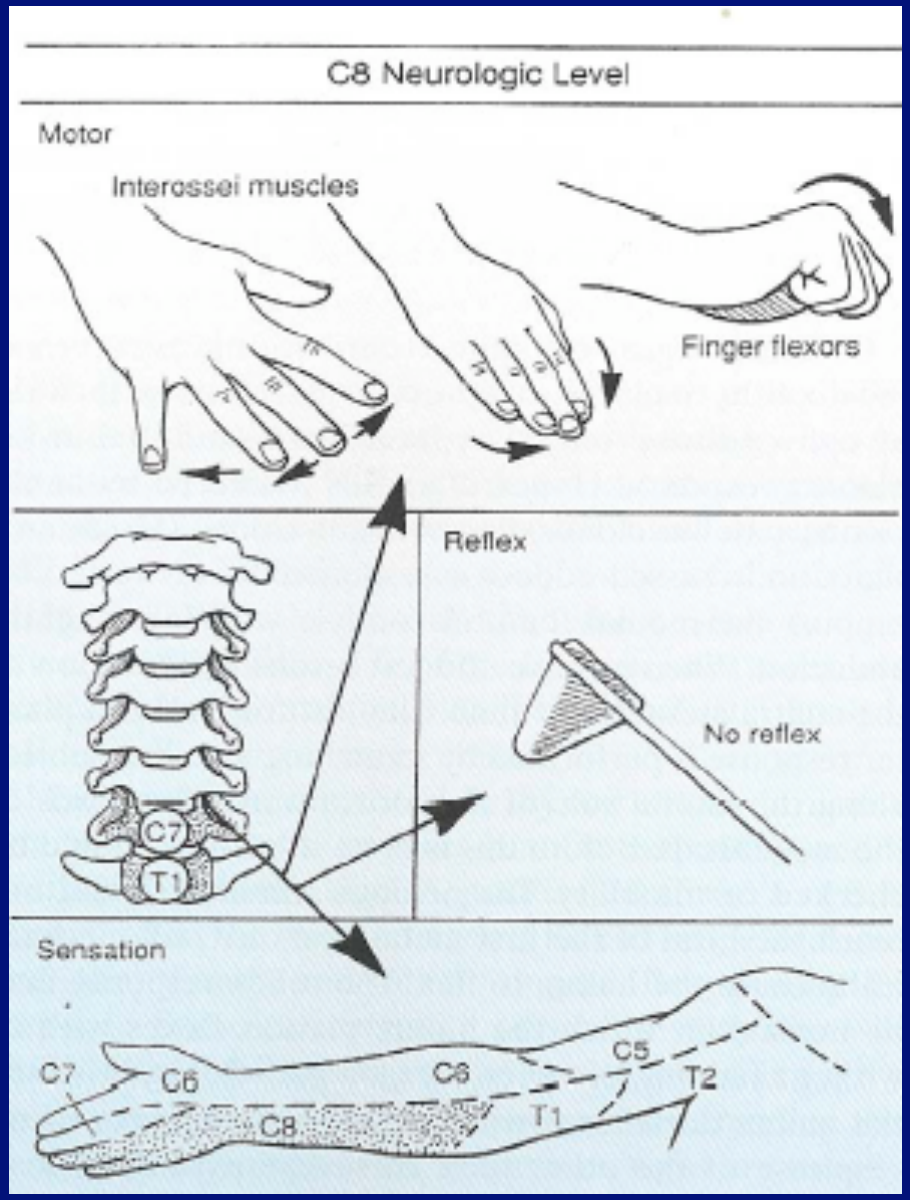
Findings in Nerve Root Compression

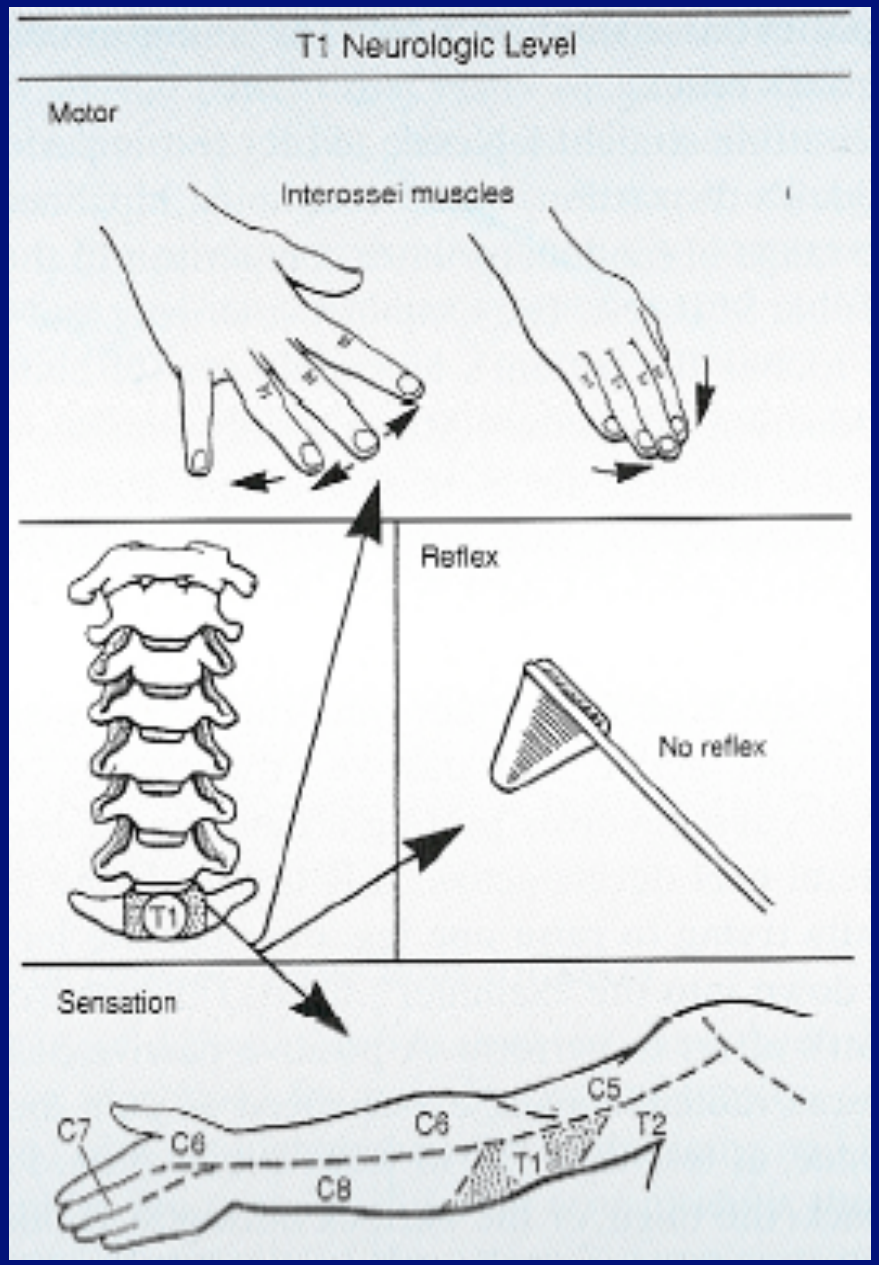
Level	Root	Muscles Affected	Sensory Loss	Reflex
C3-4	C4	Scapular	Lateral neck, Shoulder	None
C4-5	C5	Deltoid, Biceps (variable)	Lateral arm	Biceps (variable)
C5-6	C6	Biceps, ECRL & ECRB Triceps (supination)	Lateral forearm, thumb & index	Biceps Brachioradialis
C6-7	C7	Triceps Wrist flexors (FCR)	Middle finger	Triceps
C7-8	C8	Interossei Finger flexors (variable)	Ulnar hand	None
C8-T1	T1	Interossei	Ulnar forearm	None


C5 Neurologic Level
Motor
Deltoid
Biceps
Reflex
C5
Sensation
C7
C6
C6
C5
T2
T1
C8


C6 Neurologic Level
Motor
Biceps
Wrist Extensors:
extensor carpi
radialis longus
and brevis
Reflex
C6
Sensation
C7
C6
C6
C5
T2
T1
C8


C7 Neurologic Level
Motor
Triceps
Wrist flexors
Finger extensors
Reflex
C7
Sensation
C7
C6
C8
C6
C5
T1
T2


C8 Neurologic Level
Motor
Interossei muscles
Finger flexors
Reflex
No reflex
C7
T1
Sensation
C7
C6
C8
C6
T1
C5
T2


T1 Neurologic Level
Motor
Interossei muscles
Reflex
No reflex
T1
Sensation
C7
C6
C8
C6
C5
T1
T2

Differential Diagnosis of Radiculopathy

- Peripheral Entrapment Syndrome (may coexist)
- Rotator cuff/shoulder pathology
- Brachial plexitis
- Herpes Zoster
- Thoracic outlet syndrome
- Tumor
- Cardiac ischemia

Clinical Presentation of Myelopathy

- **Symptoms:**

  variable α level & extent of involvement

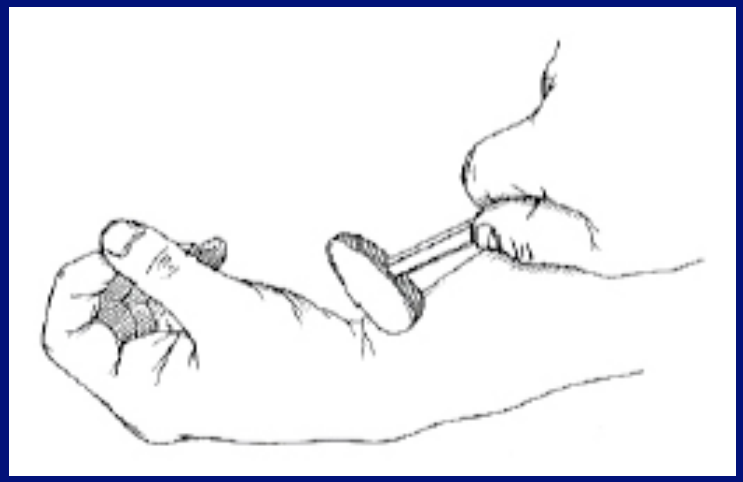
  - Weakness (upper > lower extremity)
  - ↓manual dexterity
  - Ataxic broad-based gait, difficulty walking
  - Sensory changes
  - Spasticity
  - Urinary retention

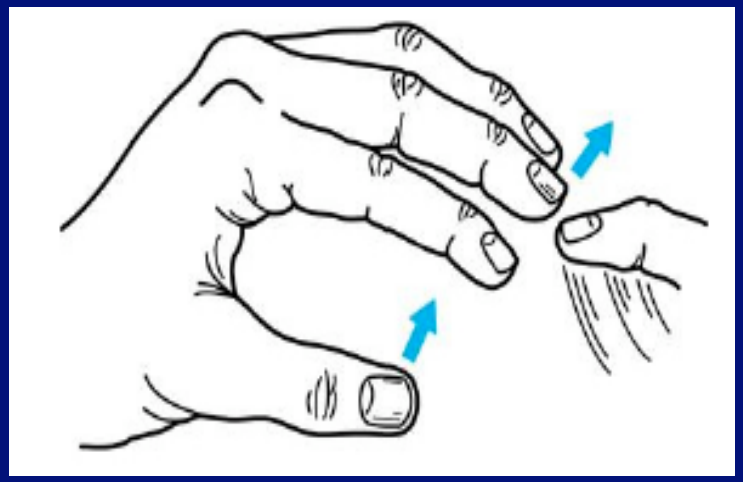
Nurick Classification of Disability from CSM 1972

- **Grade I:** No difficulty in walking
- **Grade II:** Mild gait involvement not interfering with employment
- **Grade III:** Gait abnormality preventing ` employment
- **Grade IV:** Able to walk only with assistance
- **Grade V:** Chair bound or bedridden

Clinical Presentation of Myelopathy

- **Signs:**
  - Extent of cord ± root involvement
  - **Upper motor neuron lesion signs** below level of cord pathology: Hyperreflexia, Hoffmann's sign, inverted radial reflex, clonus, Babinski's sign, spasticity
  - **Lower Motor Neuron Lesion** Signs (coexisting radiculopathy) at level of root pathology
  - Lhermitte's phenomenon (radiating lightning-like sensation down the back with neck flexion)



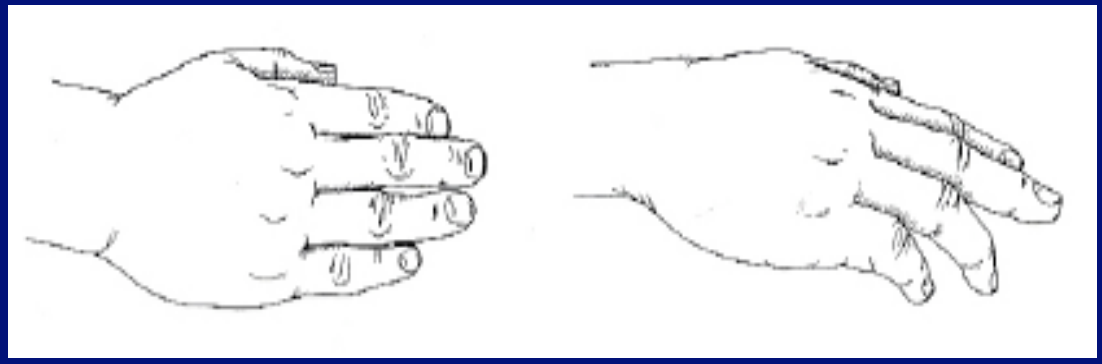


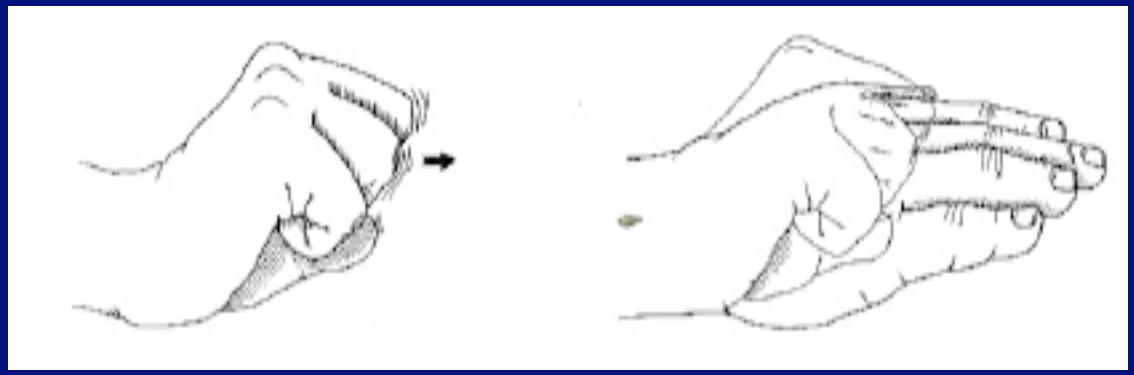
Myelopathy Hand”

Ono 1987

- **Finger-escape Sign:**
  - When asked to fully extend the digits with the palm facing down, the ulnar digits drift into abduction & flexion

- **Grip-and -release Sign:**
  - Weakness & spasticity of the hand result in a decreased ability to rapidly open & close the fist





Tandem Spinal Stenosis

- **Spondylotic degeneration** can give rise to concurrent stenosis of the lumbar and cervical portions of the spinal canal in tandem

- **Triad:**
  - intermittent neurogenic claudication
  - progressive gait disturbance
  - findings of mixed myelopathy and polyradiculopathy in both the upper and lower extremities

Differential Diagnosis of CSM

- Peripheral Neuropathy
- Motor Neuron Disease
- Amyotrophic Lateral Sclerosis
- Multiple Sclerosis
- CVA
- Syringomyelia
- Tumors: intrinsic spinal cord or extrinsic metastatic

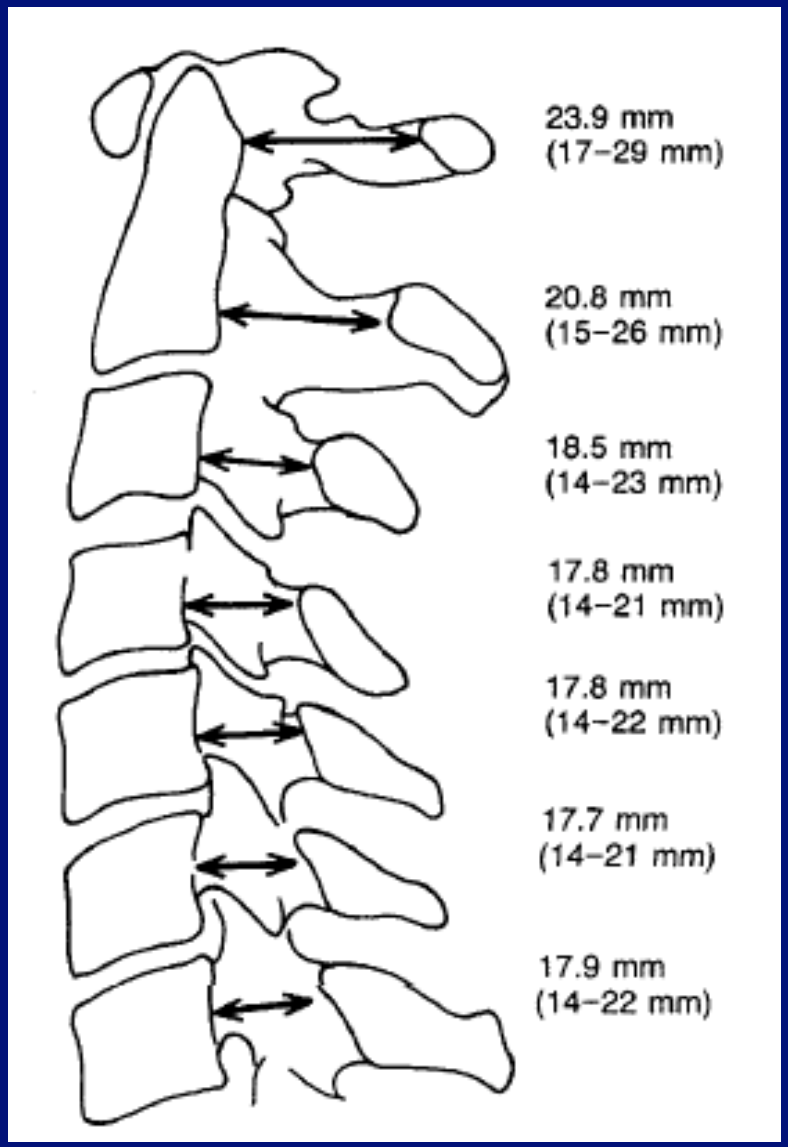
Diagnosis

Diagnosis of CS

- **Signs & Symptoms**
- **Radiography:**
  - Plain X-ray:
  - CT
  - MRI
  - CT Myelogram
  - Discography
- **Electro diagnostic Studies:** EMG, NCV, SSEPs

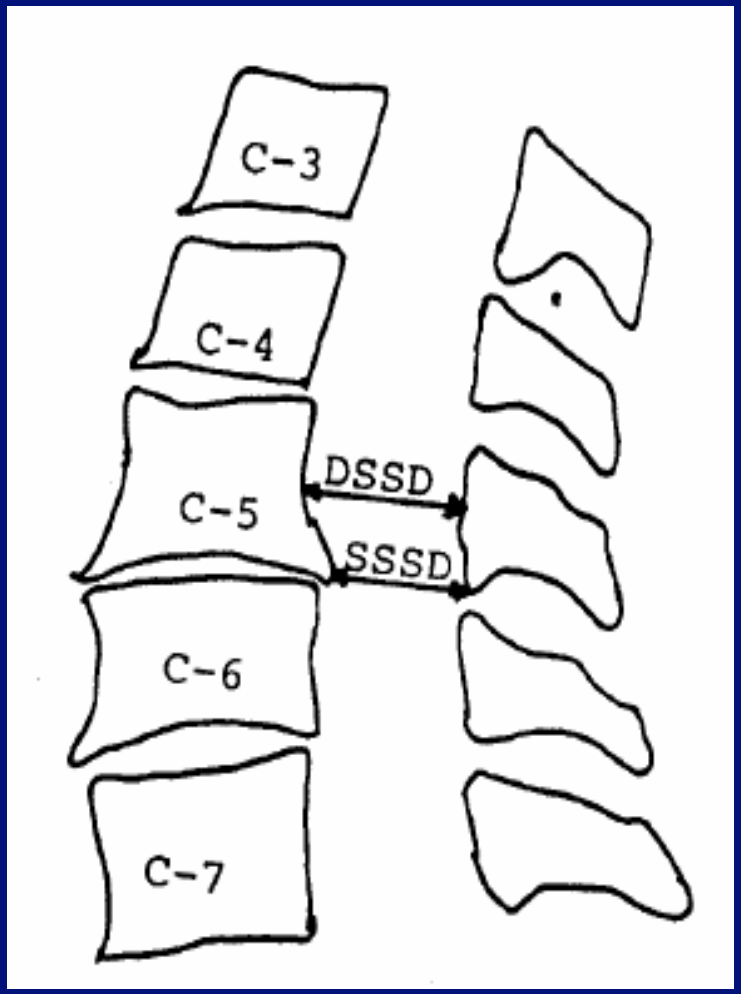
Plain X-ray

- AP, Lateral, Oblique (Flex-Ex if suspect instability)
- Abnormalities of alignment (spondylolisthesis), spontaneous fusion, osteophyte formation, overall bone quality
- Do not visualize the neural elements directly or indirectly
- Direct measures of canal size from plain radiography not reliable
- Pavlov's Ratio= AP diameter of spinal canal / AP diameter of vertebral body
  - Normal >1
  - < 0.8 ⟹ absolute stenosis



If diameter < 13mm ➡
Cervical spinal stenosis

X-ray measurement represents 20-30% magnification



Spondylosis Index =
DSSD -SSSD

DSSD: Developmental Segmental Sagittal Diameter

SSSD: Spondylotic Segmental Sagittal Diameter

MRI

- **Advantages:**
  - No radiation
  - non-invasiveness
  - ability to directly visualize in multiple planes, including sagittal
  - excellent resolution of disk and neural elements
  - ability to visualize intrinsic changes in the cord and disk
  - ability to detect prevertebrale dema suggestive of acute trauma

MRI

Disadvantages:

- Expense
- limited visualization of neural foramen
- inability to distinguish between soft and hard disk pathology or OPLL
- high incidence of major abnormalities in a symptomatic patients

MRI

- AP compression ratio (Ono 1977)
  - AP diameter of cord / transverse diameter x 100
  - If < 0.4 ⟶ worse neurologic function

MRI signal change as a prognositc indicator

- 67 pts. Prospective case series study
- TI & T2 MRI performed within 3 ms of Sx
- Results (Conclusion):

1. Focal high-intensity changes on T2 not indicate poor functional recovery.
2. low-intensity changes on T1 & multi level high-intensity changes on T2 , indicate poor functional recovery.

J Neurosurg Spine. 2007 Jan;6(1):17-22.

Fernandez de Rota JJ ,et al
Malaga, Spain.

Myelography

- Demonstrates neural compressive pathology indirectly through duralsac contour
- Invasive and not very specific:
  - central compression may represent an osteophyte or a soft disk herniation
  - sleeve cut-off may represent foraminal narrowing or a lateral disc
- 70-90% accurate.

CT-Myelography

- Combination CT and myelography yields more information than either alone
- Direct visualization of neural compression
- Better visualization of lateral pathology
- Differentiation of soft from hard disk and OPLL

Natural History

Natural History

- **DePalma1972:**

  - Patients with axial symptoms from cervical spondylosis after 3 mo of non-operative care:
    . 21% complete relief, 49% partial relief, 22% no relief

- **Rothman & Rashbaum1978:** similar group
  - 23% of patients remained partially or totally disabled by end of 5 yr
  - No difference between operative & non-operative treatment for axial neck pain

Natural History of CSM

- Current literature does not allow prediction of course

- **Clark & Robinson 1956:**
  - once myelopathy is recognized, complete remission never occurs
  - Spontaneous regression of neurologic deficits is unusual
  - 75% had progressive myelopathy: 2/3 ongoing deterioration, 1/3 stabilized

Natural History of CSM

- **Symon& Lavender 1967:** >60% steady progressive deterioration, 18% improved

- **Kumar 1999:** 18% of patients with CSM will improve spontaneously, 40% will stabilize & 40% will deteriorate if no treatment is given

Management

Neck Pain Management

- **Non-operative:**
  - NSAIDs
  - Soft collar
  - Physiotherapy: traction, heat & ultrasound
  - Activity modification: avoid extension & heavy lifting
  - Epidural steroid injection: controversial

- **Operative:** not recommended
  - Whitecloud& Seago1987: 70% good-to-excellent results from anterior interbody fusion for patients with concordant neck pain on discography
  - Conor& Darden 1993: 84% of patients positive discography; 13% complications including quadriplegia; 46% good-to-excellent

Decision Making

1. Which neurologic structure is compromised?
2. What is the source of compression?
3. What is the direction of compression?
4. How many levels are involved?
5. What is the cervical alignment?
6. Are there coexisting segmental instability?
7. Prior cervical spine or head & neck surgery or radiation?
8. Any medical comorbidities?

Cervical Radiculopathy Management

- **Non-operative:**

  Same as for axial neck pain

- Indications for surgery:
  - Failure of a 3-month trial of non-operative treatment to relieve persistent or recurrent radicular arm pain with or without neurologic deficit
  - Progressive neurologic deficit

Surgical Options for Radiculopathy

- **Anterior Decompression:**
  - Anterior cervical discectomy (ACD) ± interbody fusion (ACDF)
  - Anterior corpectomy with fusion (ACF)
  - Microsurgical anterior cervical foraminotomy (uncoforamenotomy) Tascioglu2001, Saringer2002

- **Posterior Decompression:**
  - Posterior laminoforaminotomy
  - Laminectomy ± fusion
  - Laminoplasty

- **Combined**

Surgical Options for Radiculopathy

- **ACDF:**
  - Radiculopathy with significant degenerative neck pain
  - Bilateral radiculopathy
  - Presence of localized kyphosis
  - Anterior plating recommended for 3 levels, or 2 levels with highrisk of nonunion

- **ACF:**
  - Alternative to 2 levels ACDF
  - Posterolateral soft disc herniation at 2 levels
  - Spondylotic radiculopathy at 2 levels
  - Migrated (sequestered) disc fragment behind vertebral body

Surgical Options for Radiculopathy

- **Posterior laminotomy/foraminotomy:**
  - Unilateral radiculopathy w/o significant neck pain
  - Absence of localized kyphosis
  - C7-T1 level in short neck patients

- **Laminectomy:**
  - Multiple-level radiculopathy
  - Bilateral radiculopathy at multiple levels
  - Maintenance of cervical lordosis
  - Absence of significant neck pain
  - Ankylosed or stiff neck

Surgical Options for Radiculopathy

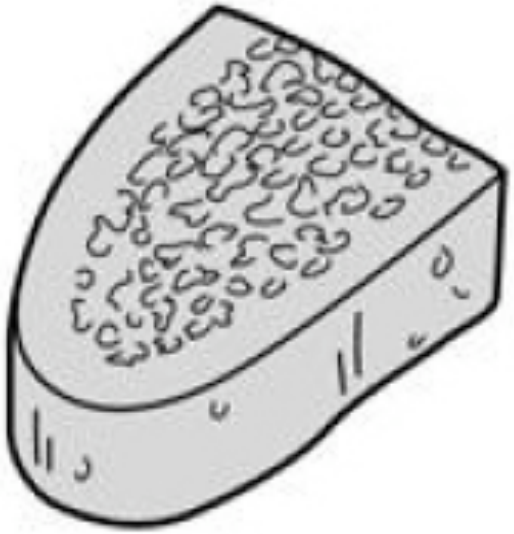
- Laminoplasty:
  - Unilateral, multilevel radiculopathy
  - Congenital cervical stenosis
  - Maintenance of cervical lordosis
  - Absence of significant neck pain

ACDF

- **Robinson:**
  - Tricortical iliac crest wedge graft
    - . Donor site morbidity
  - Freeze-dried tricortical iliac crest allograft
    - . Zdeblick& Ducker 1991: allograft has more non-union & more collapse, but similar clinical result

- **Simmons:**
  - Rectangular iliac crest contoured to match the beveled surface of vertebral bodies

- **Others:**
  - Clowardand Bailey & Badgley: no direct nerve root decompression, seldom used



Robinson horseshoe graft

Cloward dowel graft

Keystone graft

ACD

- **Chestnut 1992:** The presence of fusion following discectomy has not been uniformly correlated with a favorable clinical outcome,nor has nonunion consistently resulted in a clinical failure

- **Pseudoarthrosis** may be associated with a good clinical result led to concept of ACD.

- **Advantage:**
  Lack of donor site morbidity

- **Disadvantages:**
  - Postoperative neck pain > ACDF
  - Post - discectomy collapse & angular kyphosis ⇨ recurrent nerve root compression (so bilateral foraminotomy is a must)

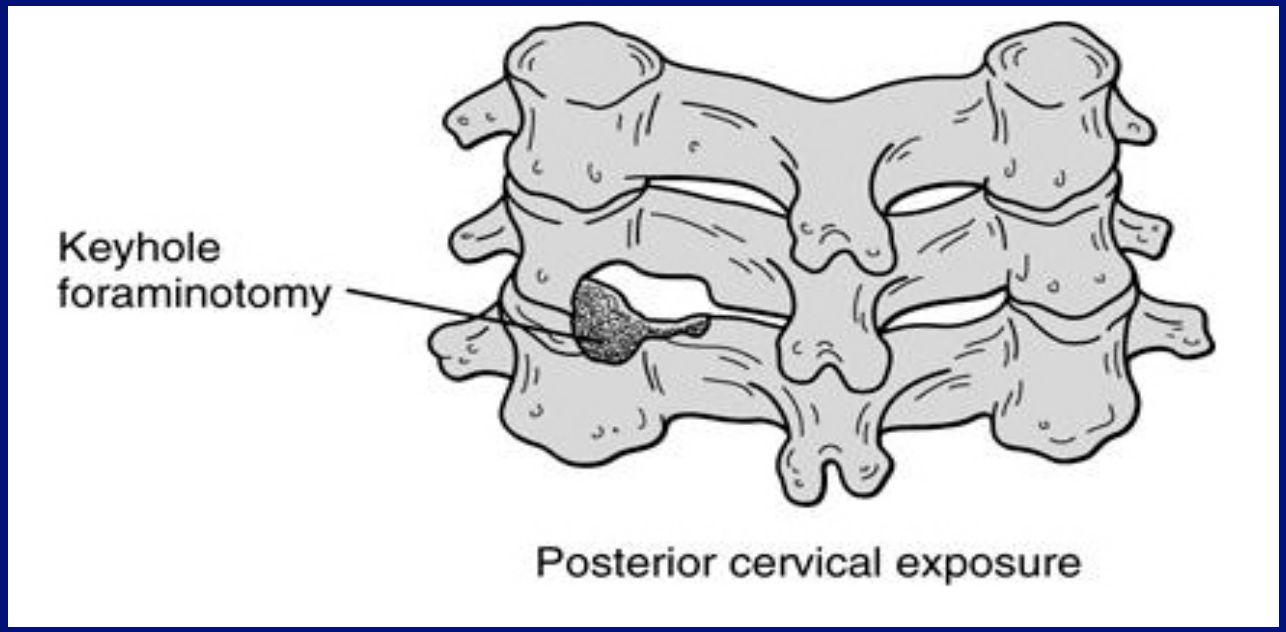
- Avoid in patients with evidence of spondylosis who requires distraction

ACF

- Necessary if a sequestered fragment has migrated behind the vertebral body
- Preferred over two-level ACDF, because less surfaces that must fuse
- Consider anterior cervical plate ± rigid external orthosis to maintain stability postoperatively

Laminoforaminotomy

Remove no more than 50% of the facet to prevent iatrogenic instability

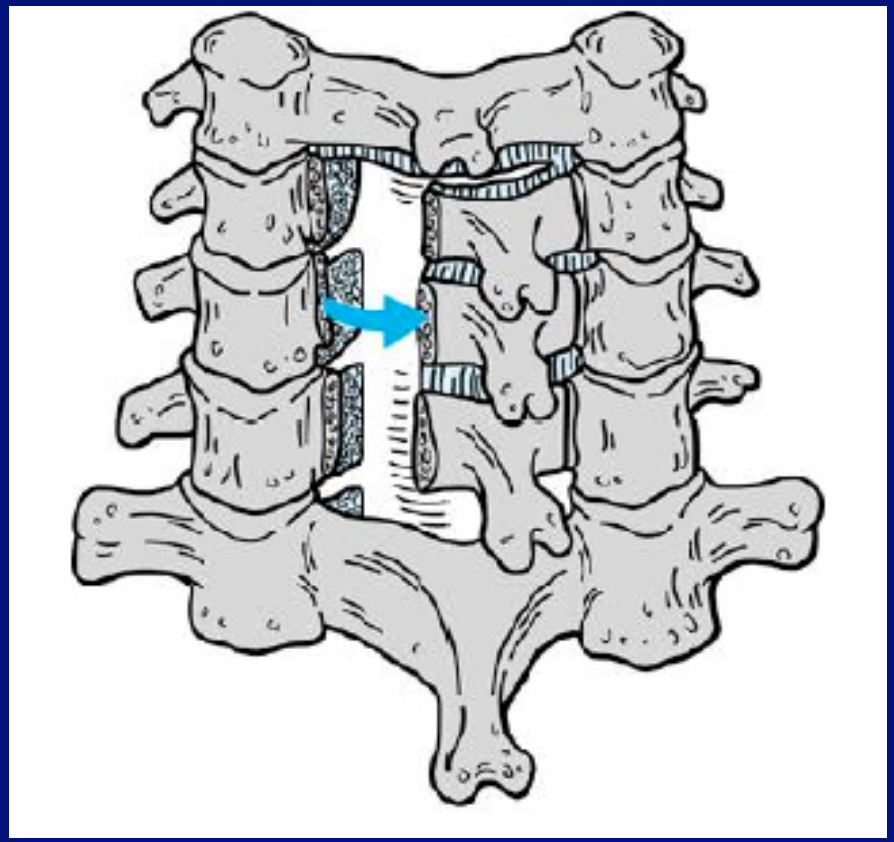


Laminectomy

- An option for multilevel spondylotic radiculopathy with anterior bony ankylosis when cervical lordosis has been preserved.

- Risk of subsequent subluxation & kyphotic deformity ➡ consider primary fusion

Laminoplasty



Combined Anterior & Posterior

- Patients with advanced osteopenia (three or more level & slow fusion)
- Impaired healing potential (RA, renal failure, transplant)
- Excessive use of tobacco or nicotine products
- Anticipated inability to comply with postoperative restrictions (e.g., psychopathology, movement disorder)

Management of Cervical Myelopathy

- **++ controversy**, natural history is not well known
- **Close Observation & Follow Up:**
  - . e.g., a patient with mild, non-progressive, long-standing myelopathy that does not cause significant disability
- **Indications for surgery:**
  - . Progressive myelopathy
  - . Moderate or severe myelopathy that is stable & short duration (< 1 yr)
  - . Mild myelopathy that affects routine activities of daily living
- Goal of surgery: to prevent neurological worsening independent of age or severity

Anterior vs. Posterior

- Factors:
  - Site of compression
  - Presence or absence of spinal stability
  - Sagittal alignment of the cervical spine
  - Extent of the disease process

Scenarios

- Anterior compression of spinal cord limited to intervertebral disc space w/o intervening stenosis of canal at the vertebral body level → ACDF
- If multiple levels involved → ACF
- Compressive pathology at disc level & posterior to vertebral body → ACF
- If kyphosis presents → ACF
- If kyphosis accompanied by significant subluxation → combined anterior & posterior
- Spondylotic spurring & spinal stenosis over several segments → posterior approach
- If compression ratio < 0.5 (sagittal diameter/transverse diameter of spinal cord) → posterior

Surgical Options for cervical Myelopathy

- **ACDF:**
  - Myelopathy with one-(or more) level disease due to disc herniation
  - Anterior plating recommended for multilevel cases

- **ACF:**
  - Myelopathy due to disc or osteophyte posterior to the vertebral body at multiple levels
  - Loss of cervical lordosis
  - Presence of significant neck pain

Surgical Options for cervical Myelopathy

- **Laminectomy:**
  - **Cord compression at 3 or more levels**
  - **Maintenance of cervical lordosis**
  - **Ankylosed, stiff spine**
  - **Absence of significant neck pain**
  - **Concomitant fusion recommended if there is vertebral subluxation or instability, or significant neck pain**

Surgical Options for cervical Myelopathy

- **Laminoplasty:**
  - **Continuous OPLL at multiple levels**
  - **Congenital cervical stenosis**
  - **Maintenance of cervical lordosis**
  - **Absence of significant neck pain**

Spinal Instrumentation

- The role in radiculopathy & myelopathy is less clear than in traumatic conditions
- In spondylosis, nonunion rate & graft dislodgement increase with the number of levels operated on
- Goals of instrumentation:
  - Provide immediate stability
  - Increase fusion rate (not documented in spondylosis)
  - Prevent loss of fixation of the bone graft
  - Improve postoperative rehabilitation
  - Avoid requirements for an external orthosis

Advantages

Anterior

- Direct decompression
- Stabilization with fusion
- Correction of deformity
- Axial lengthening of spinal column
- Good axial pain relief

Posterior

- less loss of motion
- not as technically demanding
- less bracing needed
- Avoids graft complications

Disadvantages

Anterior

. Technically demanding

. Graft complications

. Need postop bracing

. Loss of motion

. Adjacent segment disease

Posterior

. Indirect decompression

. Preoperative Kyphosis limitations

.Inconsistent axial pain results

. Late instability

Complications

- Approach-related:
  - Anterior: recurrent laryngeal nerve stretching, dysphagia, upper airway compromise
  - Posterior: axial neck pain, late instability
- Decompression-related:
  - Injury of spinal cord or nerve root, vertebral artery
- Graft-related:
  - Graft donor site morbidity: pain, hematoma, fracture, nerve injury
  - Graft: dislodgement, fracture, sever settling
- Long-term
  - Anterior: pseudoarthrosis, adjacent-segment disease
  - Posterior: post laminectomy kyphosis, swan-neck deformity, instability

Complications of Anterior Approach

- **Vocal Cord Paralysis:**
  - Right vs. Left: Beutler2001 –no difference
  - Apfelbaum2000: retractor displaces the larynx against the shaft of the ET, allowing impingement on the vulnerable intralaryngeal segment of the RLN
    - Recommend: monitoring ET cuff pressure and release of pressure after retractor replacement or repositioning was used, which allowed the ET to recenter within the larynx

- **Injury to internal branch of Superior Laryngeal Nerve:**
  - Retraction or accidental ligation

Bottom Line

CS is disease of controversy