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MRI Essentials: Imaging the Spine

Disc herniation terms, Modic changes, cauda equina syndrome and other spinal emergencies, when to refer, and key take-aways for referrers.

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For physiotherapists, chiropractors, podiatrists, osteopaths, sports therapists, GPs and other clinicians

Learning Objectives

- **Anatomy & biomechanics** — recognise core spinal anatomy and load-bearing mechanics
- **Disc pathology** — differentiate normal from abnormal discs, including protrusion vs extrusion
- **Pain generators** — identify degenerative, discogenic, and neuropathic sources of low back pain, including Modic changes
- **MRI protocols** — awareness of correct sequence selection for spinal imaging
- **Spinal emergencies** — recognise red flags for cauda equina syndrome, malignant spinal cord compression, and epidural abscess
- **Case application** — consolidate learning through real MRI cases, with a lumbar-spine focus

Disc Herniation

Disc herniation is defined as a focal displacement of disc material (< 25% of the disc circumference) beyond the limits of the intervertebral disc space.

A herniated disc can be contained (covered by outer annulus fibrosus) or uncontained.

Protrusion – Extrusion

Protrusion indicates that the distance between the edges of the disc herniation is less than the distance between the edges of the base.

Extrusion is present when the distance between the edges of the disc material is greater than the distance at the base. Extrusion is associated with a defect in the annulus fibrosus and is usually non-contained.

Disc Herniation

Migration

Migration indicates displacement of disc material away from the site of extrusion, regardless of whether sequestrated or not.

Sequestration

The term sequestration is used to indicate that the displaced disc material has lost continuity with the parent disc.

Intravertebral herniation

Intravertebral herniation or Schmorl node is herniation of disc material in the vertical direction through a gap in the vertebral end plate.

Disc Herniation / Lateral Recess

Localization of Herniated Discs

Axial plane

Central

Since the posterior longitudinal ligament (PLL) is at its thickest in this region, the disc usually herniates slightly to the left or right of this central zone.

Subarticular / Lateral Recess

Because the PLL is not as thick in this region, this is the number one region for disc herniations.

Foraminal

It is rare for a disc to herniate into the intervertebral foramen. Only 5% to 10% of all disc herniation occur here or farther out. When herniations do occur in this zone, they are often very troublesome for the patient. This is because a super-delicate neural structure called the 'Dorsal Root Ganglion' (DRG) lives in this zone resulting in severe pain, sciatica and nerve cell damage.

Extraforaminal

Disc herniations in this region are uncommon.

Craniocaudal plane

In the craniocaudal plane disc herniations are described as at disc level, suprapedicular level, pedicular level and infrapedicular level.

End Plate Degeneration

Modic Classification

The Modic classification describes degenerative and inflammatory changes involving the vertebral endplates and adjacent vertebral bodies as seen on MRI.

Modic Type 1

Modic Type 1 is seen as low signal intensity on T1WI and high on T2WI, representing fibrovascular tissue, inflammatory changes, and perhaps edema. Type I changes may be chronic or acute.

There is a correlation between low back pain and Modic changes, especially Modic type 1.

Modic Type 2

Modic Type 2 is seen as high signal intensity on T1WI and isointense or high on T2WI, representing bone marrow replacement by fat.

Modic Type 3

Modic Type 3 is seen as low signal intensity on T1WI and low on T2WI, representing reactive sclerosis.

Cauda Equina Syndrome (CES)

- CES is caused by compression of the lumbosacral nerve roots that extend below the spinal cord
- Very rare (1 to 3 in 100,000 population)
- If it is unrecognised or delayed — permanent loss of bladder and bowel function, loss of sexual function, and lower limb paralysis
- Ongoing severe disability despite prompt treatment but, if it is treated before symptoms become severe, this can reduce the risk of permanent disability

Malignant Spinal Cord Compression (MSCC)

MSCC is caused by metastatic or direct tumour spread into the epidural space.

- **Known cancer diagnosis**
- **≥40 years of age**
- **Back pain**
- **Weakness or paralysis**

Osteoporotic Spinal Compression Fractures

Most osteoporotic spinal compression fractures represent an isolated failure of the anterior spinal column due to a combination of flexion and axial compression loading.

The stability of the spine is not compromised with this type of fracture.

Traditionally considered benign injuries that heal without complications.

Cauda Equina Syndrome Symptoms

Cauda Equina Syndrome symptoms with pain radiating down one or both legs and/or severe lower back pain (any combination, seek help immediately):

- Loss of feeling pins and needles between your inner thighs or genitals
- Numbness in or around your back passage or buttocks
- Altered feeling when using toilet paper to wipe yourself
- Increasing difficulty when you try to urinate
- Increasing difficulty when you try to stop or control your flow of urine
- Loss of sensation when you pass urine
- Leaking urine or recent need to use pads
- Not knowing when your bladder is either full or empty
- Inability to stop a bowel movement or leaking
- Loss of sensation when you pass a bowel motion
- Change in ability to achieve an erection or ejaculate
- Loss of sensation in genitals during sexual intercourse

When to Refer to the Spinal Surgical Team

Imaging outcome	Action required
Cauda Equina compression confirmed	Immediate referral to spinal surgical service. Keep patient nil by mouth. If transfer required after response by surgical service, arrange Category 2 ambulance transfer.
No Cauda Equina compression but neural compression to explain radicular pain (sciatica)	Safety net about progression of CES symptoms. Advise patient that pain is very likely to improve. Referral to MSK interface service/triage service.
No cause for symptoms found	Consider alternative diagnoses. Consider referral to other specialties.

Acute vs Chronic Conditions

Acute: Trauma, disc herniation, infection; oedema and inflammation on MRI

Chronic: Degenerative changes, fibrosis, arthritis — less fluid signal

MRI changes: MRI changes differ accordingly

Young Adult Pathologies

- Pars defect (spondylolysis), pars stress fractures
- Role of VIBE sequences: high-res 3D imaging for subtle bony defects
- Common symptoms and clinical relevance
- Scheuermann disease, also known as juvenile kyphosis, juvenile discogenic disease, or vertebral epiphysitis, is a common condition which results in kyphosis of the thoracic or thoracolumbar spine
- Osteoid Osteoma
- Benign haemangiomas, benign lesions and malignancies

Spinal Emergencies

- Cauda Equina Syndrome
- Spinal cord compression (tumor, trauma)
- Epidural abscess (infection)
- Vertebral fractures, unstable injuries

Summary & Key Takeaways

- Recap anatomy, pathologies, and emergencies
- Importance of correct imaging and fast identification
- Referrers' pivotal role – correct clinical info, including malignancy
- Clinical correlation – only you can do it
- Open mind and open dialogue, as imaging with the same finding can present with different symptoms and pathologies
- Diagnose First and Treat Later

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