Interpreting Radiology Results:

*Focus on MRI of the Lumbar Spine*

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About the Presenter

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Disclaimers

• Dr. Shelley is NOT a radiologist!

• Financial disclosures: None.
Objectives

After completing this educational activity, participants will be able to DESCRIBE:

• How to locate criteria for ordering MRI studies
• Basic lumbar spine anatomy
• Common findings in MRIs of the spine
Clinical History: A 32-year old female presents with back and left leg pain. T2-weighted sagittal and T1-weighted axial images are provided.
The best diagnosis in this case is:

- Disc extrusion
- Disc protrusion
- Disc sequestration
- Herniated nucleus pulposus
PURPOSE

This presentation is about what the common MRI interpretations mean for the pain practitioner.

For which studies to order, and when, please consult the ACR Guidelines (see below).

Here we will focus on MRIs of the lumbar spine, which is a common imaging modality ordered for the spine.

Not addressed: MRIs of the cervical or thoracic spine, plain films of spine or other body parts, CTs, myelograms, and other advanced imaging.
ORDERING, INTERPRETING, AND ACTING ON RADIOLOGIC STUDIES MUST ALWAYS BE DONE IN THE CONTEXT OF SYMPTOMS, SIGNS, AND PLausible MECHANISMS OF INJURY, DISEASE, AND PAIN.

TREAT THE PATIENT, NOT THE MRI.

CLINICAL CORRELATION IS RECOMMENDED!

IT IS IMPORTANT TO TAKE THE TIME TO EXPLAIN FINDINGS, TO THE PATIENT:

CLINICALLY INSIGNIFICANT DISC BULGING ≠ NERVE COMPRESSION
MORE ON CONTEXT

Clinical findings still take precedence over radiologic findings. Radiologic studies are no substitute for careful interview and physical examination.

Radiologic studies have limitations, and results are thus called “interpretations.”
When to Order Plain Films, MRIs, and CTs

• See American College of Radiology (ACR) Appropriateness Criteria for studies:

American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: Low Back Pain

Variant 1: Uncomplicated acute low back pain and/or radiculopathy, nonsurgical presentation. No red flags (red flags defined in text).

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<th>Radiologic Procedure</th>
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Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate

*Relative Radiation Level
Variant 2: Patient with one or more of the following: low-velocity trauma, osteoporosis, focal and/or progressive deficit, prolonged symptom duration, age > 70 years.

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<td>SPECT/CT may be useful for anatomic localization and problem solving.</td>
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*Relative Radiation Level
MRIs

Magnetic resonance imaging utilizes proton resonance technology to obtain soft tissue cross-sectional representations of the spine.

The quality of these images allows the diagnostician to make more detailed and accurate assessments of the intervertebral disc and its relation to the neural structures when compared with more traditional methods, such as lumbar and computed tomography (CT) myelograms.
A systematic review of the available literature involving spinal MRI found MRI to be a highly sensitive and but less specific imaging modality for lumbar spinal conditions.

For example, high sensitivity ranging between 89–100% for disc herniation have been described in previous studies.

The lower specificity, 43–97% for disc herniation has been highlighted in previous literature and relates to the prevalence of asymptomatic disc degeneration and protrusions resulting in a large number of false positives.

In a group of 57 patients with unilateral lower limb radiculopathy, only 30% of these patients had MRI findings of disc herniation and nerve root compression at the same level as the clinical prediction.

Therefore, when reviewing the imaging, one must exert a degree of care when attributing the patient's symptoms to the appearance of their lumbar spine.
**Lumbar spine anatomy**

The lumbar spine consists of five separate vertebrae separated by intervertebral discs and reinforced by multiple ligaments and paravertebral muscles. The thecal sac containing the conus medullaris and nerve roots are located within the central vertebral canal. The nerve roots then exit the spine via the intervertebral foraminal canal obliquely instead of at right angles, which is observed in the cervical spine. Understanding this anatomical relationship allows the clinician to isolate the exact nerve root being irritated by a herniated intervertebral disc.
The exiting nerve roots traverse the neural foramen and this is divided into sections based on its relationship to the pedicle and zygapophyseal joint in the axial and sagittal planes. In the axial plane, the exiting nerve root traverses the subarticular recess from the central zone to the foraminal and extra-foraminal zones. Infra-pedicular, supra-pedicular, pedicular and disc levels are used to separate the areas along the longitudinal axis.

Axial T2-weighted slice: sub-articular zone (SA) to the foraminal zone (FZ) and the extra-foraminal zone (EF); P = pedicle; FJ = facet joint; TP = transverse process; SP = spinous process
**T1 and T2**

The T2 images accentuate high-water-content tissue by making it look white or, in MRI terminology, hyperintense.

T2 images can be used to assess:

- degree of degenerative disc disease (DDD)
- annular tears (via their inflammatory process)
- nerve roots inside of the thecal sac
- dural sleeves (aka, root sleeve) of the traversing nerve roots
Planes

Three planes:
  view from the side (sagittal)
  front (coronal)
  bottom-up (axial)

Typically, the coronal series is not performed.

First, some sagittal images ........
There are two main osseous (made of bone) structures that are clearly visible on the mid-sagittal view of a vertebra: the square-shaped vertebral body of the vertebra (yellow outline) and the spinous process (blue outline) of the posterior arch.

The junction of the spinous process with the laminae (green L) make up the anterior border of the posterior arch which also forms the back of the central canal.
The extremely hyperintense space (almost pure white) between the vertebral bodies and posterior arch is the thecal sac (red T), which of course is filled with CSF. This structure may or may not completely fill the spinal canal, which is the space between the posterior vertebral body (PB) and lamina (L) as represented by the black line. In the mid-sagittal view, the cauda equina is typically not terribly visible (white-blue arrowheads) except near its origin at the conus medullaris (not shown).

Situated between each of the five lumbar vertebral bodies, are the five lumbar discs (red outline & D) that carry the axial-load of the body and act as a pivot-point for trunk motion.
As the name implies, the para-sagittal regions are composed of slices that are lateral to (to the outside of) the mid-sagittal region.

Specifically, the right and left para-sagittal regions lie between the lateral borders of the thecal sac and the medial (to the inside of) borders of the neural foramina. Or, in simple terms, its the space between the thecal sac and neural foramina.

Although much of the anatomy is the same that was visualized on the mid-sagittal cuts, the para-sagittal region does have two unique identifiers. The first is the size of the spinal canal, which is more narrow when compared to the mid-sagittal view.
The second is the appearance of the traversing nerve roots (red arrows) which are seen streaking obliquely downward across the thecal sac, on the way to their respective neural foramina.

The para-sagittal region also contains a very important area of the central canal called the lateral recess (aka nerve root canal, subarticular area) which typically superimposes the entire region. The lateral recess is clinically important because it is the region where disc herniations typically occur. This is because the posterior annulus fibrosus (annulus) of the disc is protected by the posterior longitudinal ligament (PLL) in the mid-sagittal region only; therefore, disc herniations tend to occur just lateral to the PLL, which is in the para-sagittal region.
This is a cut through the para-sagittal zone / lateral recess that demonstrates a moderate-sized disc herniation (red arrows).

Note that the herniation is of enough magnitude to deviate or "tent" (push out of place, red horizontal arrow) the traversing L5 lumbar nerve root (green arrow) from its normal course, which often results in a painful inflammatory response within affected nerve root.

Such a scenario may result in radicular pain down the patient’s lower extremity that mirrors the particular dermatome associated with that nerve root.

Disc herniations that are big enough to actually deviate a lumbar nerve root are not commonly seen in asymptomatic patients and are often problematic.
This is a **foraminal-sagittal** cut that demonstrates the boundaries of the right neural foramen (pink circle).

The roof and floor are created by the pedicles (P) (the strongest part of the vertebra) of the vertebra above and below, respectively. The posterior boundary is created by the superior articular process of the vertebra below, and the anterior boundary is created by the disc and vertebral body (VB).

The neural foramina are hyperintense structures, secondary to their high fat content (fat has a high water content and therefore glows white on T2 MRI). This color scheme provides a good background for the hypointense exiting nerve roots (red arrows).
AXIAL IMAGES

This is a cartoon of a typical lumbar T2-weighted axial image through the L4 disc.

Note that the disc is composed of two parts: the tough annulus and the Jell-O-like nucleus, the latter of which is typically more hyperintense on T2-weighted MRI.
Note the parts of the posterior arch and the superior articular processes of the vertebra below (not visualized), which join the inferior articular processes at this level and form the facet joints.

Also note that the traversing L5 nerve roots (the ones destined for the neural foramina below this level) have not yet budded off the thecal sac.

The exiting L4 nerve roots, however, have clearly budded off the thecal sac and are coursing out the same-level neural foramen.
This is a real disc-level T2-weighted axial MRI image, with outlines of the disc, (white) the thecal sac, (green) and the posterior arch (yellow). The left neural foramen is colored red, and the right side of the image is marked (on the left, as if observing from the feet of a supine patient).
Do you see a disc bulge or extrusion here?

(The answer is no.)
Neural foraminal stenosis would be a constriction between purple lines here.

Recall that the neural foramen may be narrowed anteriorly by osteoarthritic thickening of the posterolateral vertebral body, by a posterolateral disc herniation, or by a bulging disc.

The foramen may also be narrowed posteriorly by osteoarthritic thickening of the superior articular process.

Do you see any narrowing of the foramina?

(The answer is no.)
Normally the thecal sac should be symmetrically shaped into a shield-like configuration with the lumbar nerve roots visible and lined-up along its periphery (this is not always the case).

The delicate thecal sac, however, is vulnerable to compressive forces and may be compressed by central and paracentral disc herniations, osteoarthritic-thickening of the posterior vertebral body or laminae, or hypertrophy of ligamentum flavum, resulting in central stenosis.

Do you see significant compression-related deformity of the thecal sac?

(The answer is no.)
Look at the posterior disc margin--there are no focal outpouchings but the entire disc is "bulging" backwards so that it has narrowed the neural foramina as well as the central canal. This is a bulging disc without focal disc herniation.

The posterior arch is abnormal. Specifically, the ligamentum flavum (LF) (which is usually barely seen) has greatly hypertrophied and has compressed the posterolateral corners of the thecal sac, resulting in central stenosis.
Hyperintense thecal sac with scattered nerve roots that shows a symmetrical and open thecal sac; however, the thecal sac is definitely contacted by the disc and there is some thickening of ligamentum flavum bilaterally, resulting in mild central stenosis.

Look at the neural foramina. The right one looks fine but the left one has a very large left foraminal (aka, far lateral) disc herniation that is within the neural foramen. (Note the faint outline of the annular tear.)
In 2001 a Joint Task Force of the NASS, the American Society of Neuroradiology (ASNR) and the American Society of Spine Radiology (ASSR) convened and developed a spine lexicon.

This was strengthened in 2003 with an update including endorsing societies from virtually every professional organization with an interest in managing patients with disc herniations.
Degeneration

This broad term includes a multitude of abnormalities including desiccation, annular tears, bulges, mucinous degeneration, endplate defects or sclerosis, and osteophytes.

These changes can be further subdivided into spondylosis deformans, possibly a consequence of normal aging, and intervertebral osteochondrosis, presumably due to a more pathologic state.

The latter is typically characterized by disc space narrowing, vacuum discs, and endplate reactive changes.

From a practical standpoint, disc degeneration is often used descriptively in MR interpretation to refer to loss of the usual T2-hyperintensity within the discs, and this appearance may be a normal consequence of aging.
A T2-weighted sagittal image reveals diffuse disc degeneration, characterized by low signal intensity on T2-weighted images throughout the discs.

This terminology is preferred to "disc desiccation," as studies have shown that the change in T2 signal characteristics involve more than just differences in water content. At L4-5, additional features of intervertebral osteochondrosis are present, with disc space narrowing and reactive endplate signal changes (arrows) being apparent.
Disc Bulge

A disc is bulging if it extends in a circumferential fashion beyond the edges of the vertebral apophyses.

Though bulges may have a rightward, leftward, or lateral predominance, they must involve greater than 50% of the circumference of the disc.

The mildest disc bulges simply result in the loss of the slightly concave appearance to the posterior disc margin on axial images, and this appearance may be considered a normal variant at L5-S1.

Although bulges are most commonly a result of disc degeneration, they may also occur as a response to vertebral remodeling due to factors such as osteoporosis or trauma.
A 3D illustration of a bulging disc demonstrates smooth, circumferential extension of disc material beyond the margins of the vertebral apophyses (red line), typical for a disc bulge.

The amount of disc extension circumferentially on the edges of the vertebral endplate (ring apophyses) is assessed initially; the term 'bulging disc' is used to describe extension of the disc around 50–100% of the ring apophyses. Displacement of between 25–50% is described as 'broad-based herniation' and <25% as 'focal herniation'.
Annular Tears/Fissures

An annular tear involves loss of integrity of the annulus with a radial, transverse, or concentric pattern.

Some prefer the term annular fissure since tear may imply trauma.

Common practice by literature review shows preference for tear and as a result this is the accepted terminology.

Annular tears appear as a hyperintense zone on T2-weighted imaging.

Though debatable, some tears are felt to have clinical importance, especially if they involve the outer third of the annulus fibrosus.
T2-weighted sagittal and axial images demonstrates focal hyperintensity within the posterior right L4-5 disc (arrows), compatible with an annular tear.
**Disc Herniation**

A herniated disc is defined as “Localized displacement of nucleus, cartilage, fragmented apophyseal bone or fragmented annular tissue beyond the intervertebral disc space.”

This definition explains why the older term of “herniated nucleus pulposus” is not preferred, as herniations may involve more than simply the nucleus pulposus.

The boundaries of the disc are defined by the vertebral endplates superiorly and inferiorly and peripherally by the apophyses, not including any osteophytes that may be present.

Localized is defined by 50% or less of the circumference of the disc being involved. Disc herniations may be termed “broad-based” if 25-50% of the circumference of the disc is involved. If greater than 50% of the disc circumference is involved, a bulge rather than a herniation is present.
**Protrusion**

A disc protrusion is defined as “A herniated disc in which the greatest distance, in any plane, between the edges of the disc material beyond the disc space is less than the distance between the edges of the base in the same plane.”

Protrusions are the most common form of herniation, and morphologically are the most “mild” appearing.

A test for a disc protrusion is that if you measure the herniated disc from edge to edge in any plane, that measurement cannot be larger than the measurement of the base of the lesion in that same plane.

Because the height of the base of a herniation in the sagittal plane is at most the height of the disc itself, any herniation that extends above or below the level of the disc will measure larger than its base in cephalocaudal dimension, and thus cannot be a protrusion.
A disc protrusion is characterized by a base that is larger than the disc material beyond the disc space, as seen in this 3D illustration. A focal protrusion, such as this, involves less than 25% of the circumference of the disc.
T2-weighted sagittal and axial images demonstrate focal midline posterior extension of disc material (arrows) at L4-5, in a typical protrusion pattern.
Extrusion

“A herniated disc in which, in at least one plane, any one distance between the edges of the disc material beyond the disc space is greater than the distance between the edges of the base in the same plane, or when no continuity exists between the disc material beyond the disc space and that within the disc space.”

Extrusions can be thought of as akin to the appearance of toothpaste squeezed from the tube. Though not a requirement for extrusion, any herniation that extends above or below the level of the disc is an extrusion.
At times, a disc herniation may have features of protrusion in one imaging plane and extrusion in another. In such cases, the herniation is an extrusion.

Disc extrusions that have become displaced from the site of origin can be described as migrated, and if all continuity to the site of origin has been lost, the abnormality can be further characterized as a sequestration, or free fragment.

It should be noted that such free fragments are frequently hyperintense on T2-weighted images, becoming relatively isointense to epidural fat on T2-weighted views, and therefore can be missed if care is not taken to correlate with T1-weighted images.
A disc extrusion, as in the 3D illustration above, refers to a disc herniation in which the displaced disc material is larger (in any plane) than its base of origin.
A T1-weighted axial image through L4-5 has a protrusion-like appearance, as the base of the herniation (blue line) is larger than the displaced component (red line).
The T2-weighted sagittal image, however, reveals extension of disc material above and slightly below the level of the disc. Any such superior or inferior migration results in a herniation (red line) larger than its base (blue line) in the sagittal plane, and thus by definition, this abnormality is a disc extrusion.
A = bulging disc; B = right sided broad based paracentral protrusion; C = sequestration of disc material. Line arrow: separation between the herniated disc (block arrow) and the intervertebral disc space; D = extrusion
Effect on Nerve Roots

When describing any disc herniation, the experienced interpreter of MR should reflexively characterize the abnormality with regard to its effect upon adjacent exiting or traversing nerve roots.

If the nerve root is contacted or displaced, that should be reported, allowing the clinician to correlate for radicular signs.

Such correlation is critical when one considers the fact that many herniations seen on MRI have been found to be asymptomatic.
A T2-weighted sagittal image reveals a disc herniation at L5-S1 (arrow).

The corresponding T1-weighted axial image demonstrates protrusion morphology that can also be described as broad-based, as the protrusion (dotted red) involves between 25-50% of the circumference of the disc. The traversing right S1 nerve root (red arrowhead) is posteriorly displaced, and there is contact of the left S1 nerve root (blue arrowhead).
The Wiltse zones for localization of disc herniations are depicted: central (red), subarticular (blue), foraminal (green), extraforaminal (yellow), and anterior (grey).

The central zone is large and a common site of herniations, and thus some prefer to describe those herniations off midline within the zone as either paracentral or right/left central (dotted red).

Posterolateral and far lateral are generally accepted alternatives for subarticular and extraforaminal, respectively.
**Central stenosis**

Central stenosis may result from a disc herniation, though it is of course more commonly seen secondary to diffuse disc bulges and concomitant facet/ligamentous hypertrophy.

The causes of central vertebral canal stenosis can be divided into congenital and acquired conditions, such as neoplastic and degenerative changes. Degenerative changes include facet osteophytes, ligamentum flavum hypertrophy and disc herniations. While some conditions have a specific/dominant cause, most central vertebral canal stenoses are caused by a combination of conditions.

AP dimensions do not adequately account for the overall effects of stenosis factors. What is favored is a visual estimation of the degree of canal compromise relative to a normal level. Central stenosis is described as mild if significant volume loss has occurred but less than 1/3 of the volume of the canal is lost. Stenosis is moderate if between 1/3-2/3 of the original volume has been lost and severe if over 2/3 of original volume is occupied.
T2-weighted axial slices of the lumbar spine of the same patient at different levels. There is severe central vertebral canal stenosis at the L4–5 level (arrow) with no cerebrospinal fluid and crowded cauda equine nerve roots. At L3–4 the nerve roots can be seen as low signal dots surrounded by bright cerebrospinal fluid.
Spondylolisthesis

Spondylolisthesis is defined as a condition where there is malalignment of the lumbar spine in the form of a vertebra slipping out of its normal position relative to the inferior vertebra.

This can result in narrowing of the lateral neural foramen and the central spinal canal.

Furthermore, pars defects and lumbar spondylosis are commonly associated with spondylolisthesis.

The chronic nature of pain experienced by the patient as well as the complex mechanical issues revolving spinal malalignment can often result in failure of conservative treatment and surgical fusion of the affected level maybe required.
Sagittal T2-weighted MRI acquisitions of the lumbar spine. There is anterolisthesis at the L4–5 level, resulting in severe central canal and neural foraminal stenosis with associated nerve impingement.
OTHER MRI FINDINGS

Lordosis

Lordosis is the abnormal increase in normal lordotic (anterior) curvature of the lumbar spine. This can lead to a noticeable “sway-back” appearance.

Lack of lordosis (or hypolordosis) can be caused by spasm or contracture of adjacent muscles, or by degeneration.
OTHER MRI FINDINGS

Syrinx/Syringomyelia

More common in cervical and thoracic spine.

Syringomyelia is the development of a fluid-filled cyst (syrinx) within your spinal cord. Over time, the cyst may enlarge, damaging the spinal cord and causing pain, weakness and stiffness, among other symptoms.

Syringomyelia has several possible causes, though the majority of cases are associated with a condition in which brain tissue protrudes into the spinal canal (Chiari malformation). Other causes of syringomyelia include spinal cord tumors, spinal cord injuries and damage caused by inflammation around the spinal cord.
OTHER MRI FINDINGS

**Schmorl’s Nodes**

- Nonacute Schmorl's nodes (SNs) are common spinal abnormalities regarded as incidental observations on MR images or plain X-rays of the thoracolumbar spine.
- They may occur in 38% to 75% of the population.
- The term SN represents a remote herniation or extrusion of intervertebral disk nuclear material through the vertebral body endplate, thought to be asymptomatic and of no clinical consequence.
- If it is assumed that SNs represent invagination of disk material into the vertebral body through a vertebral body endplate fracture, at one time, some of them may have been traumatically produced, symptomatic, and painful.
- Axial-loading trauma is known to result in vertebral endplate fractures with clinical features of localized, nonradiating low back pain, and local tenderness of sudden onset. The eventual observation of a classical chronic and asymptomatic SN may be assumed in select cases to have originated as an acute and painful event.
Image of a 40-year-old man who experienced axial loading injury when thrown from a car and who presented with nonradiating lumbar pain and tenderness directly over the L3 and L5 vertebral bodies.

Sagittal gradient-echo (450/12/1) MR image, obtained 2 months later when the patient experienced some but not complete resolution of pain and tenderness, shows that a chronic SN formed at the superior endplate of L5 (curved arrow). Note resolution of marrow edema at L5 with persistent but improved edema of L3 (straight arrow). Further follow-up did not show SN formation at L3. This case illustrates that some endplate fractures may evolve into SNs and some may not.
OTHER MRI FINDINGS

**Tarlov Cyst**

- Tarlov cysts are abnormal sacs of spinal fluid that usually form at the sacrum. Tarlov cysts contain spinal nerve fibers within the cyst wall.
- The cause of a Tarlov cyst is unknown but may be related to:
  - Trauma to the spine
  - Increase in cerebrospinal fluid pressure
  - Blockage of cerebrospinal fluid
- Although gender may not be a risk factor, Tarlov cysts have more often been found in women than men.
- Tarlov cysts may be linked to connective tissue disorders such as systemic lupus erythematosus and Marfan syndrome.
- Often asymptomatic but trauma may cause them to become painful.
OTHER MRI FINDINGS

Modic changes

- **Modic type endplate changes** represent a classification for vertebral body endplate MRI signal, first described in 1988. It is widely recognized by radiologists and clinicians and is a useful shorthand for reporting MRIs of the spine.

- Recently **Modic type 1** has received renewed attention due to the possibility of it representing low grade indolent infection.

- Albert and Manniche (2007) demonstrated, in a randomized controlled trial with 181 patients, that Modic changes type 1 is more strongly associated with non-specific low back pain than Modic changes type 2. They also suggested in this study, that disc herniation is a strong risk factor for developing Modic changes in the same level, during the following year.
OTHER MRI FINDINGS

- **Modic type I**
  - **T1**: low signal
  - **T2**: high signal
  - represents bone marrow edema and inflammation

- **Modic type II**
  - **T1**: high signal
  - **T2**: iso to high signal
  - represents normal red hemopoietic bone marrow conversion into yellow fatty marrow as a result of marrow ischemia

- **Modic type III**
  - **T1**: low signal
  - **T2**: low signal
  - represents subchondral bony sclerosis
The overload in the endplates, caused by disc degeneration, induces changes in the MRI. 
A) Modic type 1, the endplates are black in T1 incidence and white in T2 incidence (edema).
B) Modic type 2, The endplates are white in both T1 and T2 incidences (fat).
C) Modic type 3, The endplates are black in both incidences (sclerotic).
OTHER MRI FINDINGS

Myelopathy

- Myelopathy describes any neurologic deficit related to the spinal cord.
- Myelopathy is usually due to compression of the spinal cord by osteophyte or extruded disk material in the cervical spine.
- Osteophytic spurring and disk herniation may also produce myelopathy localized to the thoracic spine, though less commonly.
- Other common sources of myelopathy are cord compression due to extradural mass caused by carcinoma metastatic to bone, and blunt or penetrating trauma.
- Many primary neoplastic, infectious, inflammatory, neurodegenerative, vascular, nutritional, and idiopathic disorders result in myelopathy, though these are very much less common than discogenic disease, metastases, and trauma.
- A variety of cysts and benign neoplasms may also compress the cord; these tend to arise intradurally. The most common of these are meningiomas, nerve sheath tumors, epidermoid cysts, and arachnoid cysts.
Since the spinal cord ends in the middle back at L1 or at the L1-L2 vertebrae (varies), only herniations of L1-L2 discs can cause spinal cord compression or myelopathy.

Disc disorders with myelopathy occurring between lumbar vertebrae L3 to L5 are rare.

Herniations of L2-L3 through L5-S1 can cause radiculopathy (compression of one spinal nerve root) or cauda equina syndrome (many spinal nerve roots compressed).
OTHER MRI FINDINGS

Cauda Equina Syndrome

- The collection of nerves at the end of the spinal cord is known as the cauda equina, due to its resemblance to a horse's tail. The spinal cord ends at the upper portion of the lumbar spine. The individual nerve roots at the end of the spinal cord that provide motor and sensory function to the legs and the bladder continue along in the spinal canal. The cauda equina is the continuation of these nerve roots in the lumbar region. These nerves send and receive messages to and from the lower limbs and pelvic organs.

- Cauda equina syndrome (CES) occurs when the nerve roots of the cauda equina are compressed and disrupt motor and sensory function to the lower extremities and bladder. Patients with this syndrome are often admitted to the hospital as a medical emergency. CES can lead to incontinence and even permanent paralysis.
Glossary of Other Terms

- **Conus medullaris**
  - The most distal bulbous part of the spinal cord
  - its tapering end continues as the filum terminale
- **Vacuum disks**
  - Vacuum phenomena involving the intervertebral discs are a result of accumulation of gas (principally nitrogen) within the crevices of the intervertebral discs or adjacent vertebrae.
- **End-plate sclerosis**
  - thickening; see Modic
- **Osteochondrosis**
  - A group of disorders that affect the progress of bone growth by bone necrosis.
  - Only seen in children and adolescents who are still growing.
Glossary of Other Terms (cont.)

**Ring apophysis**: bony corner of v. body

**Pseudoarthrosis**
- from the Greek terms meaning "false joint," is a term used with the surgery does not result in a solid fusion.

**Sacralization**
- Where the bottom lumbar segment (L5) is fused to the sacrum below, or to the ilium at the side (the large ear-shaped bones of the pelvis). Sacralisation with the sacrum can be termed central sacralisation, whereas to the sides it can be either uni- or bi-lateral transverse sacralisation. Being fused or semi-fused the L5 segment has more in common with its sacral neighbours than its lumbar ones, so it is said to be sacralised.

**Lumbarization**
- the uppermost segment of the sacrum is not fused. Rather it is free to move and participates, along with the neighbouring lumbar vertebrae in spinal activity. The first sacral segment is said to be lumbarised.
Quiz

**Clinical History:** A 32-year old female presents with back and left leg pain. T2-weighted sagittal and T1-weighted axial images are provided.
Both the T2-weighted sagittal image and the T1-weighted axial image reveal abnormal extension of disc material (arrows) beyond the margins of the disc at L4-5. The diameter of the disc material displaced from its site of origin is significantly larger than the base.
The best diagnosis in this case is:

- Disc extrusion
- Disc protrusion
- Disc sequestration
- Herniated nucleus pulposus
**Answer**

This is indeed a disc herniation (preferred term to herniated nucleus pulposus), but the best answer is (1), a disc extrusion. Utilizing the recommendations of the combined task force of the North American Spine Society, the American Society of Spine Radiology, and the American Society of Neuroradiology, a disc extrusion refers to a herniated disc that has an apex that is larger than its base in any plane.
Objectives

After completing this educational activity, participants will be able to DESCRIBE:

- Where to find ordering criteria for MRI studies
- Basic lumbar spine anatomy
- Common findings in MRIs of the spine
SOURCES

http://radsourc.us/spine-nomenclature/ re:


http://www.chirogeek.com/MRI%20READING/MRI-reading.html

http://www.mayoclinic.org/diseases-conditions/syringomyelia/basics/definition/con-20034245


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The mission of Project ECHO (Extension for Community Healthcare Outcomes) has been to develop the capacity to safely and effectively treat chronic, common, and complex diseases in rural and underserved areas, and to monitor outcomes of this treatment.

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