Spine MRI: The Basics

Wassim Malak, MD
Neuroradiology
Summa Health

Objectives

- Review basic sequences, orientations, and relevant anatomy of the lumbar spine on MRI
- Discuss three common reasons for obtaining MRI
  - Degenerative disc disease
  - Spine trauma
  - Spine masses
- Familiarize ourselves with nomenclature and imaging appearance of each entity

Typical Sequences

T1

T2

STIR

Typical Orientations

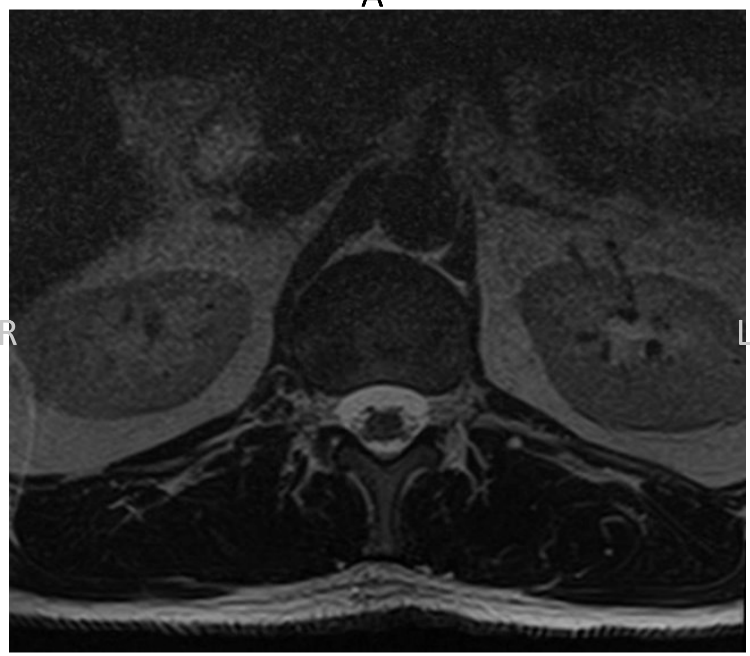
Cranial

A  P

Caudal

Sagittal

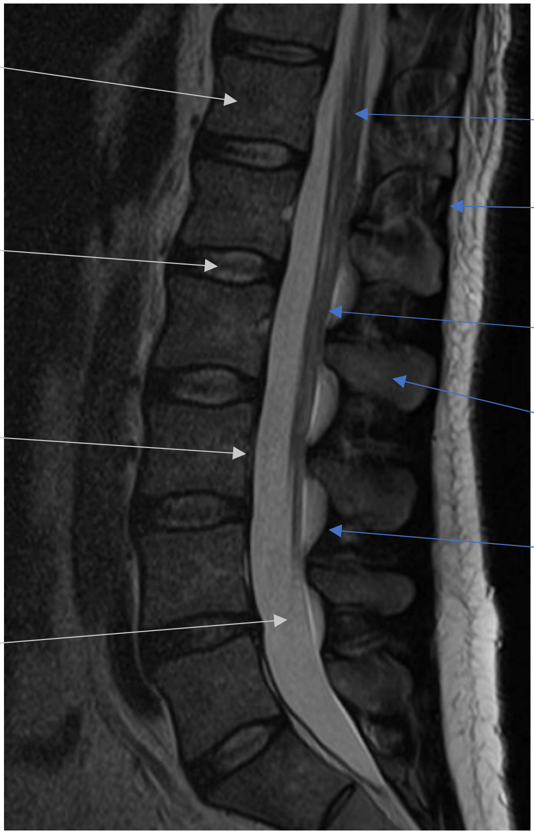
A

R  L

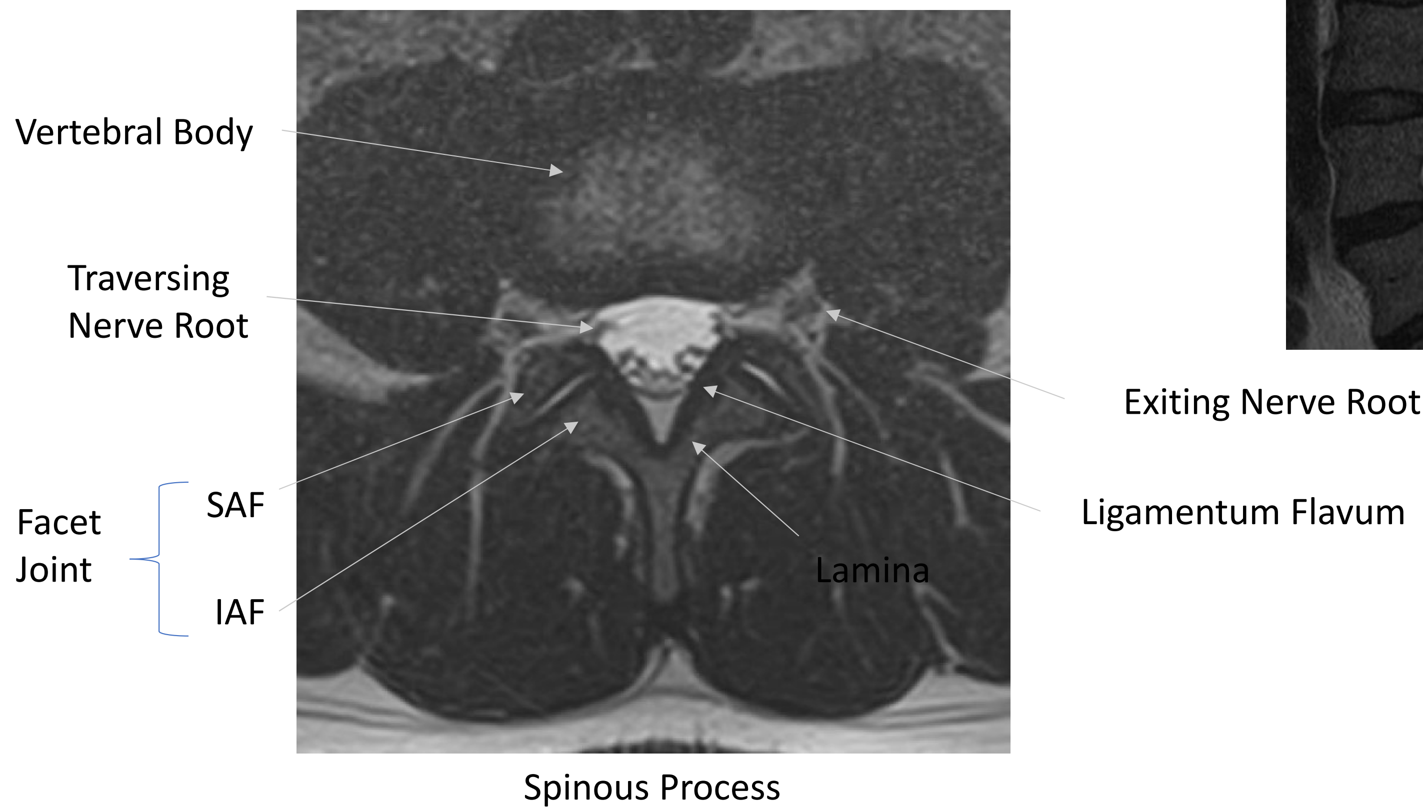
P

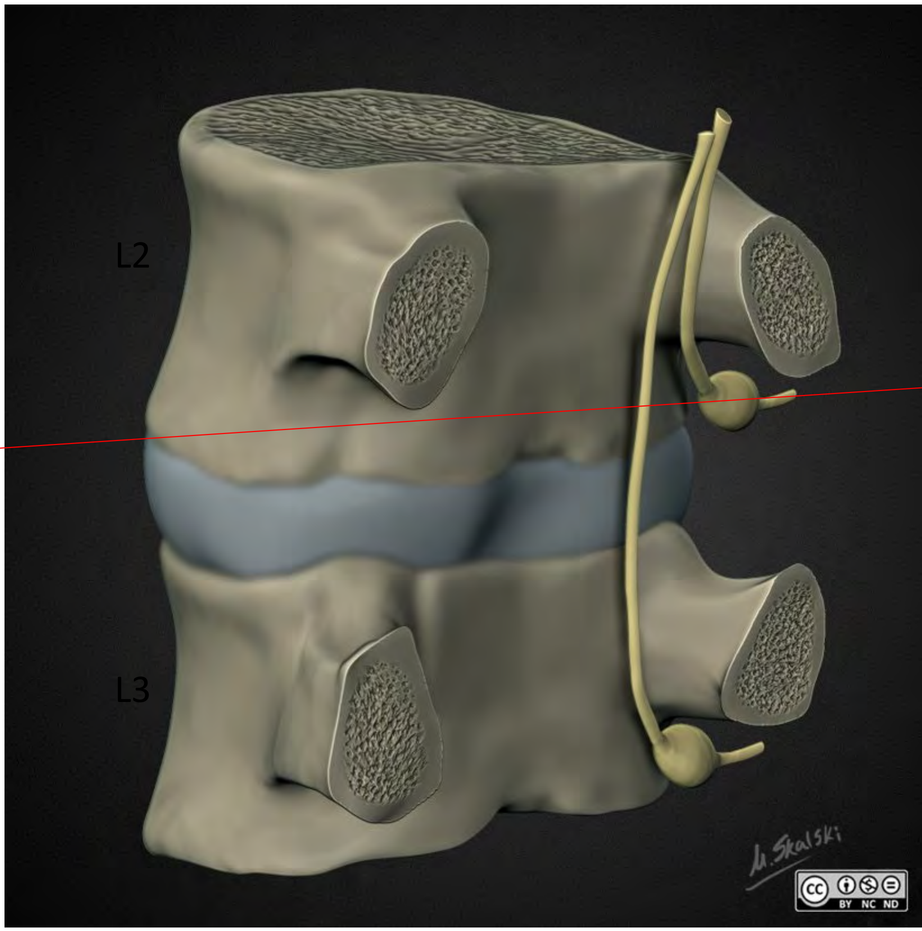
Axial

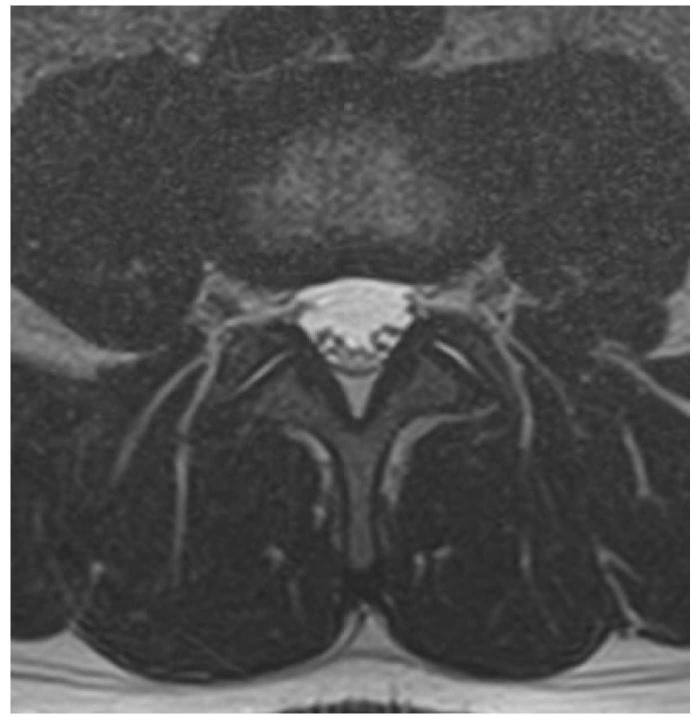
Lumbar Spine – MRI Anatomy



Lumbar Spine – MRI Anatomy







Case courtesy of Dr Matt Skalski, Radiopaedia.org, rID: 60176

Degenerative Disc Disease

- Combination of biomechanical and genetic factors alter metabolic and structural integrity of disc
  - Reduced ability of disc to sustain and transmit forces
- Extremely common (85-95% by 50yo)
- LBP, radiculopathy > incontinence, weakness, anesthesia

Modic MT, Ross JS. Lumbar Degenerative Disk Disease. Radiology. Radiological Society of North America; 2007;245(1):43–61.

Natural History

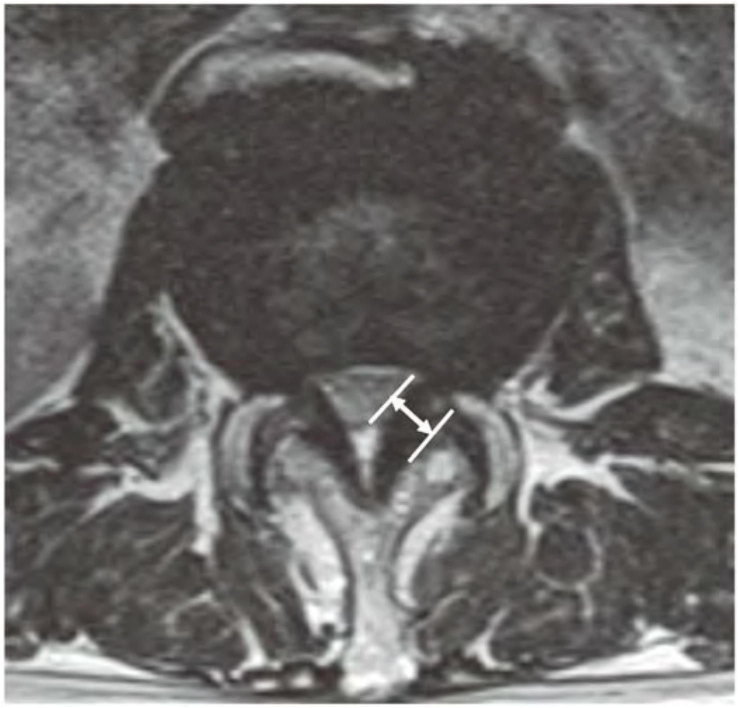
Disc desiccation and loss of elasticity -> disc height loss

Case courtesy of Dr Laughlin Dawes, Radiopaedia.org, rID: 2969

End plate degenerative changes, disc bulge, and osteophytes

https://radsource.us/wp-content/uploads/2016/04/1b.jpg

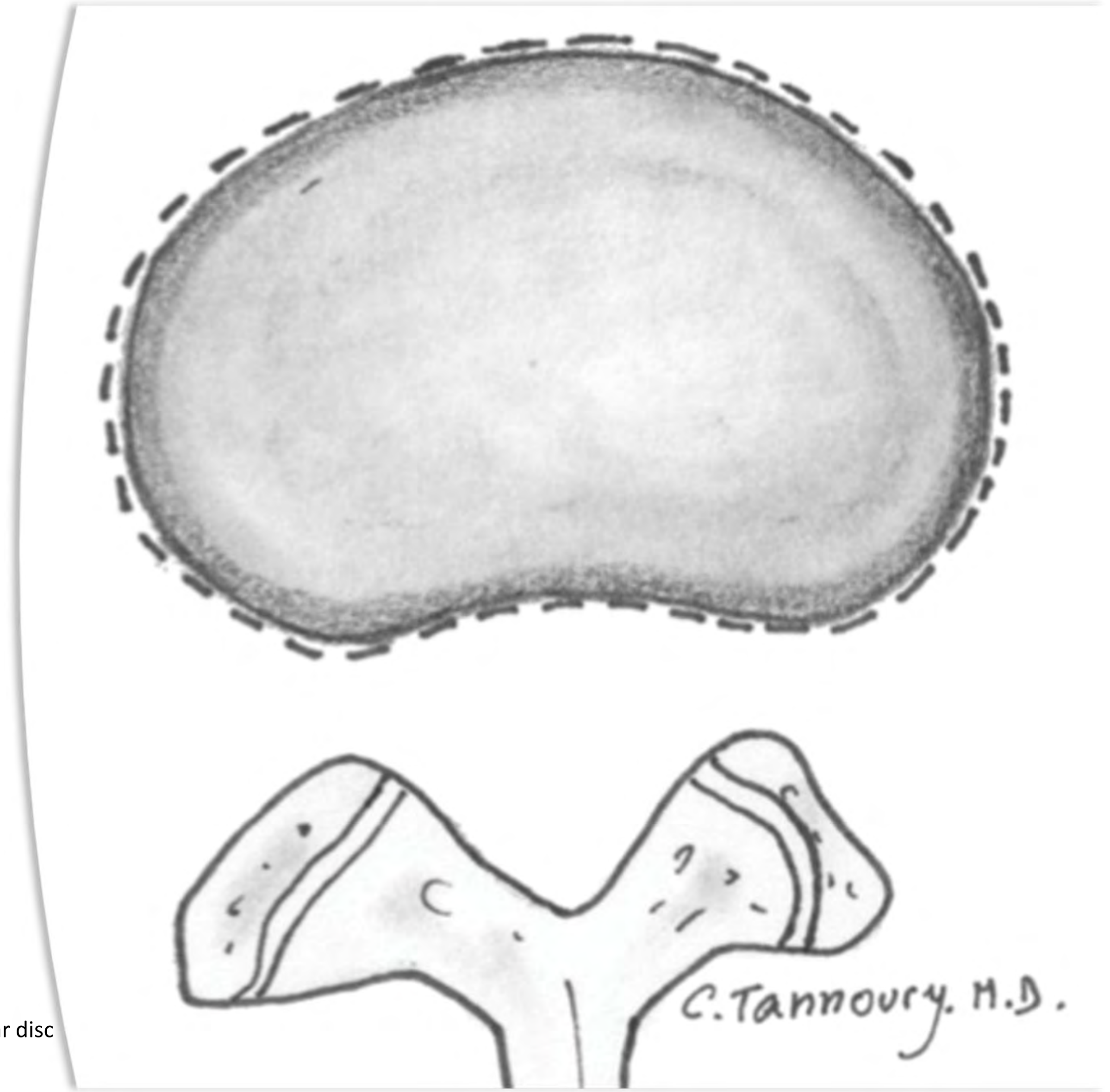
Facet hypertrophy and redundancy of the ligamentum flavum



https://www.asianspinejournal.org/upload//thumbnails/asj-10-1132-g001.jpg

DDD Nomenclature

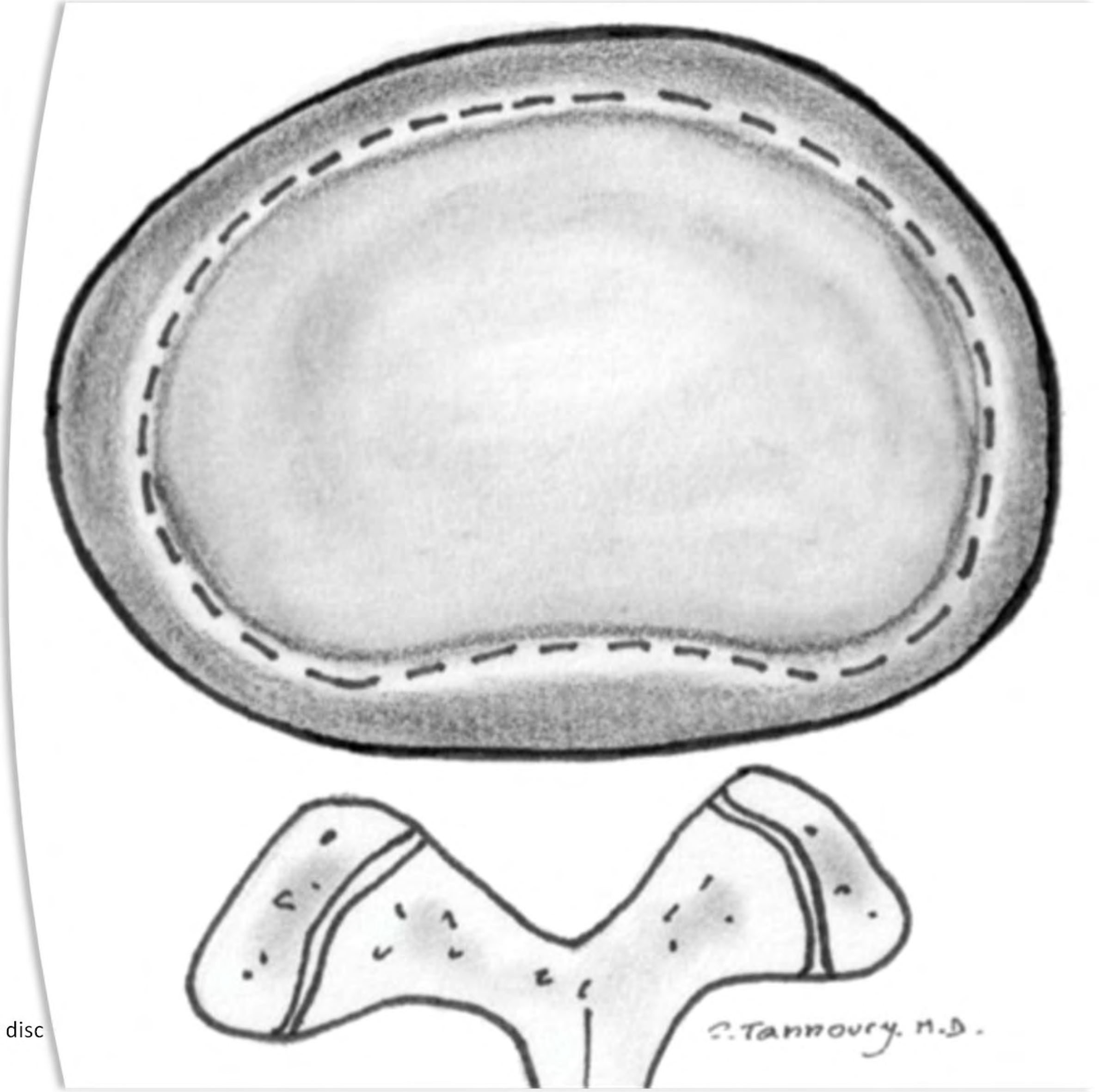
- Normal Disc
  - No disc material outside periphery of disc space



Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. The Spine Journal. 2014;14(11):2525–2545.

DDD Nomenclature

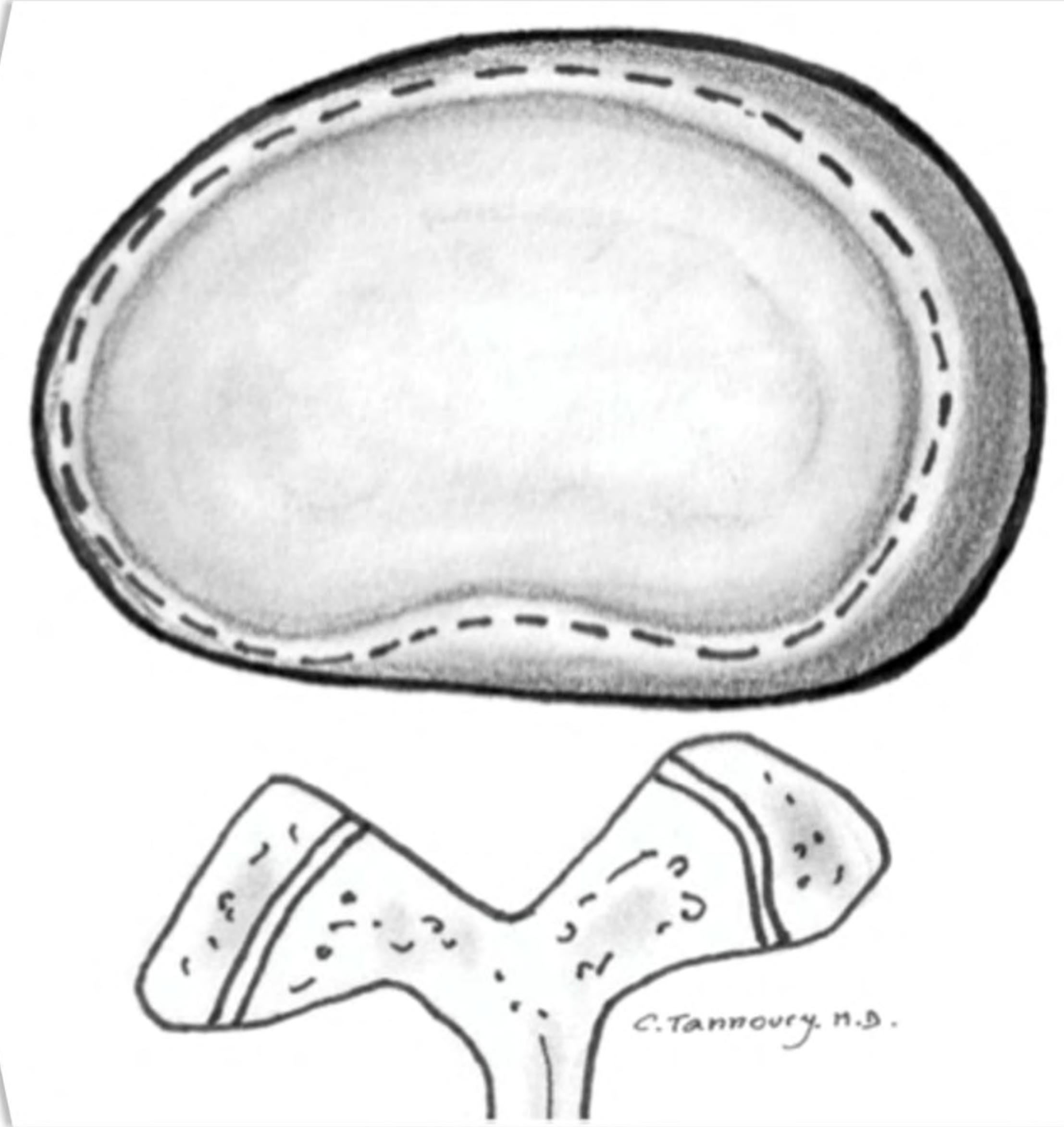
- Disc Bulge - Symmetric
  - Disc material extends symmetrically beyond periphery of disc space



Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. The Spine Journal. 2014;14(11):2525–2545.

DDD Nomenclature

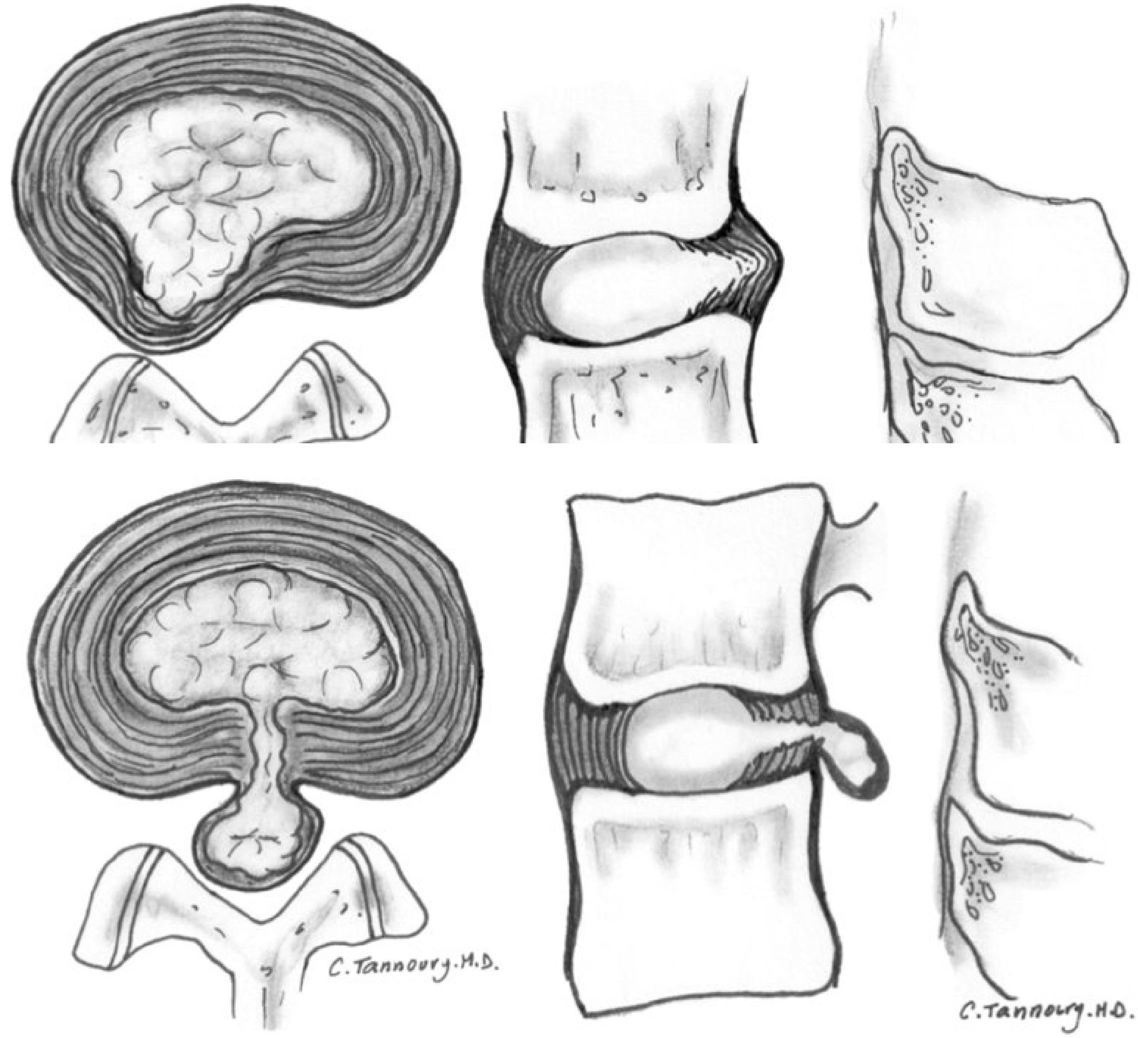
- Disc Bulge - Asymmetric
  - Disc material extends asymmetrically beyond periphery of disc space (25-50% of circumference)



Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. The Spine Journal. 2014;14(11):2525–2545.

DDD Nomenclature

- Disc Herniation
  - <25% (<90o) of disc circumference is displaced
- Two types
  - Protrusion
    - Neck > dome
  - Extrusion
    - Dome > neck



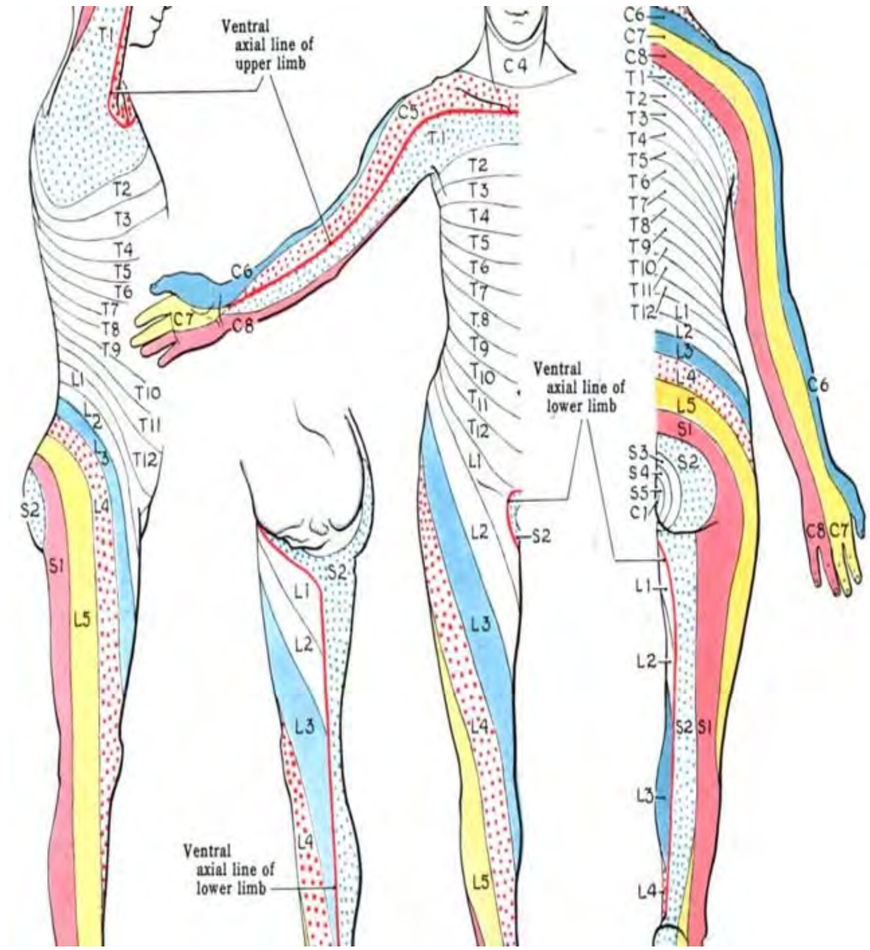
Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. The Spine Journal. 2014;14(11):2525–2545.

45yoF low back pain extending into RLL, specifically R lateral and posterior thigh, lateral calf.

Case 1

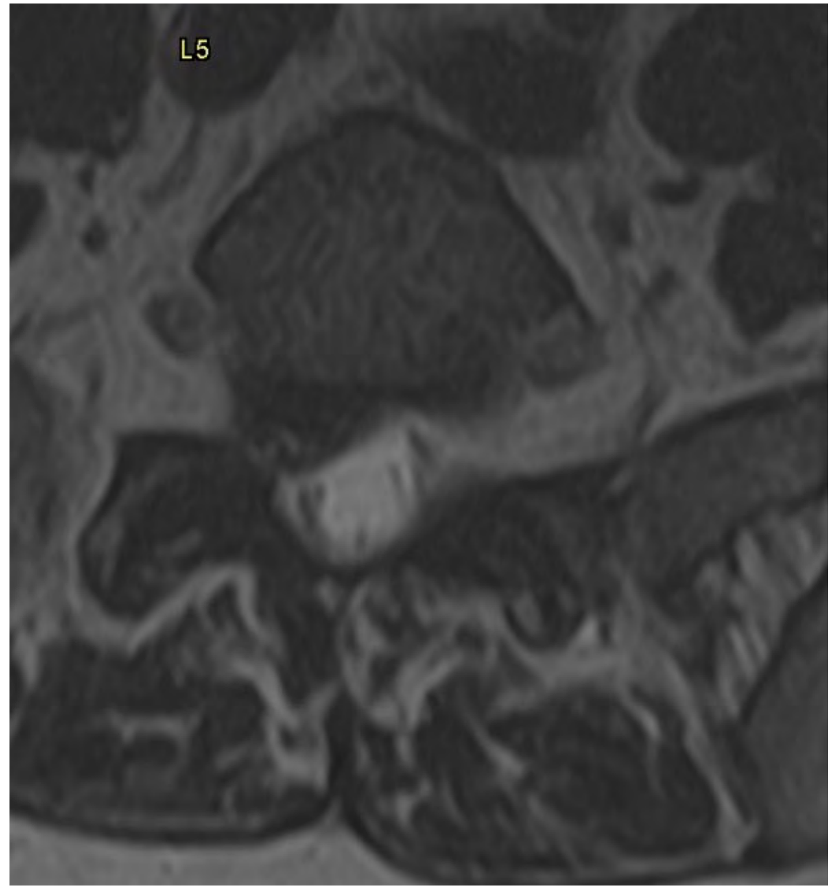
Case 1

45yoF low back pain extending into RLL, specifically R lateral and posterior thigh, lateral calf.



https://teachmeanatomy.info/the-basics/embryology/dermatomes/


L3
L4
L5
S1 (Sacrum)


L5

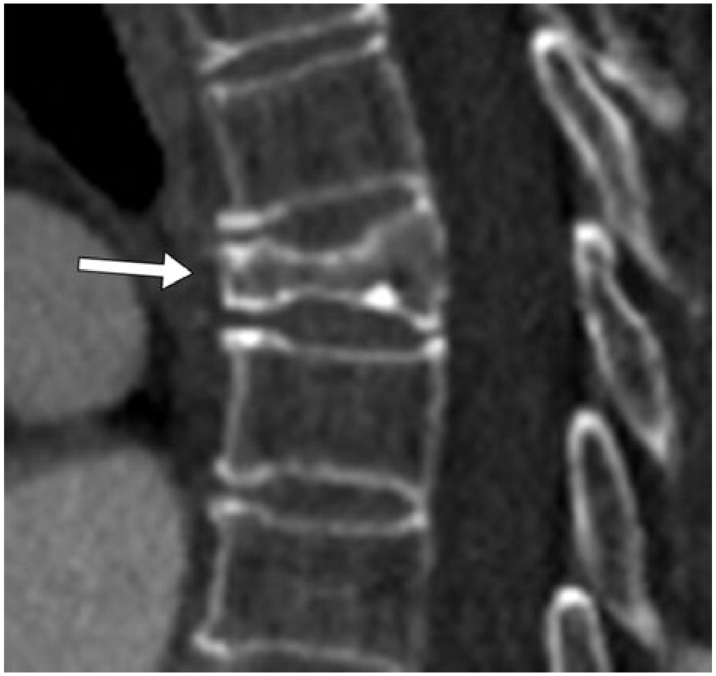
Spine Fractures

- Traumatic injury to the spinal column
- Mechanism, fracture pattern, (in)stability, neurologic status, etc.
- Radiograph or CT – first line of imaging
- MRI – indications in acute spinal trauma
  - Ligamentous injury
  - Epidural hematoma or disc herniation
  - Spinal cord assessment
  - CT/Xray negative but high clinical suspicion

Kumar Y, Hayashi D. Role of magnetic resonance imaging in acute spinal trauma: a pictorial review. BMC Musculoskelet Disord. 2016;17:310.

Compression Fracture

- Most common
- Axial loading injury
- Loss of vertebral body height
  - Anterior wedge shaping
- Traumatic
  - Osteoporosis
- Pathologic
  - Tumor
  - Infection



Benign Compression Fractures

- Osteoporosis
- Retropulsion
- Multiplicity; chronic healed fxrs
- “Fluid” sign
- “Vacuum cleft" sign

Fluid Sign

Case courtesy of Dr. Abhinav
Ranwaka, Radiopaedia.org, rID: 24669

Vacuum Cleft Sign

https://radiologykey.com/wp-content/uploads/2016/10/A307169_1_En_8_Fig5_HTML.jpg

Mauch JT, Carr CM, Cloft H, Diehn FE. Review of the Imaging Features of Benign Osteoporotic and Malignant Vertebral Compression Fractures. AJNR Am J Neuroradiol. 2018;39(9):1584–1592.

Malignant Compression Fractures

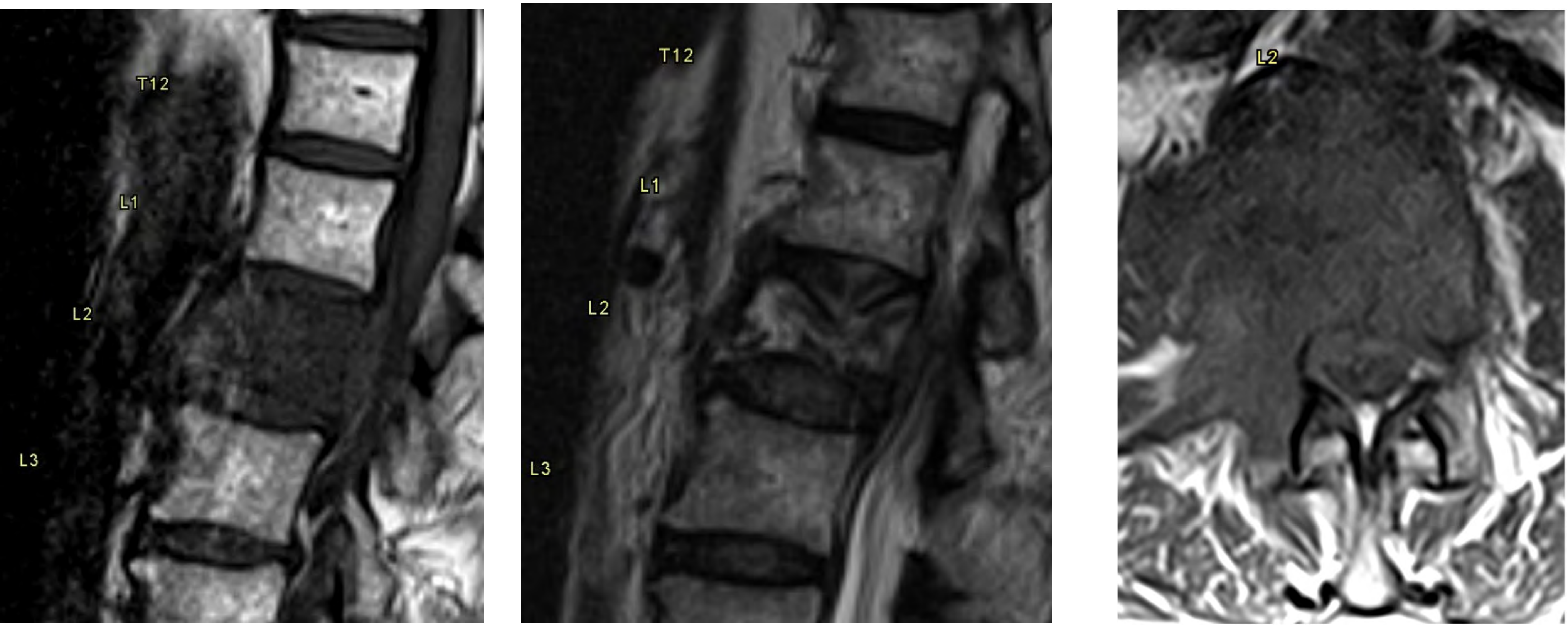
- Metastatic > primary
- Soft tissue component
- Convex posterior contour
- Posterior elements
- Total marrow replacement
- Enhancement

Uetani M, Hashmi R, Hayashi K. Malignant and benign compression fractures: differentiation and diagnostic pitfalls on MRI. Clinical Radiology. Elsevier; 2004;59(2):124–131.

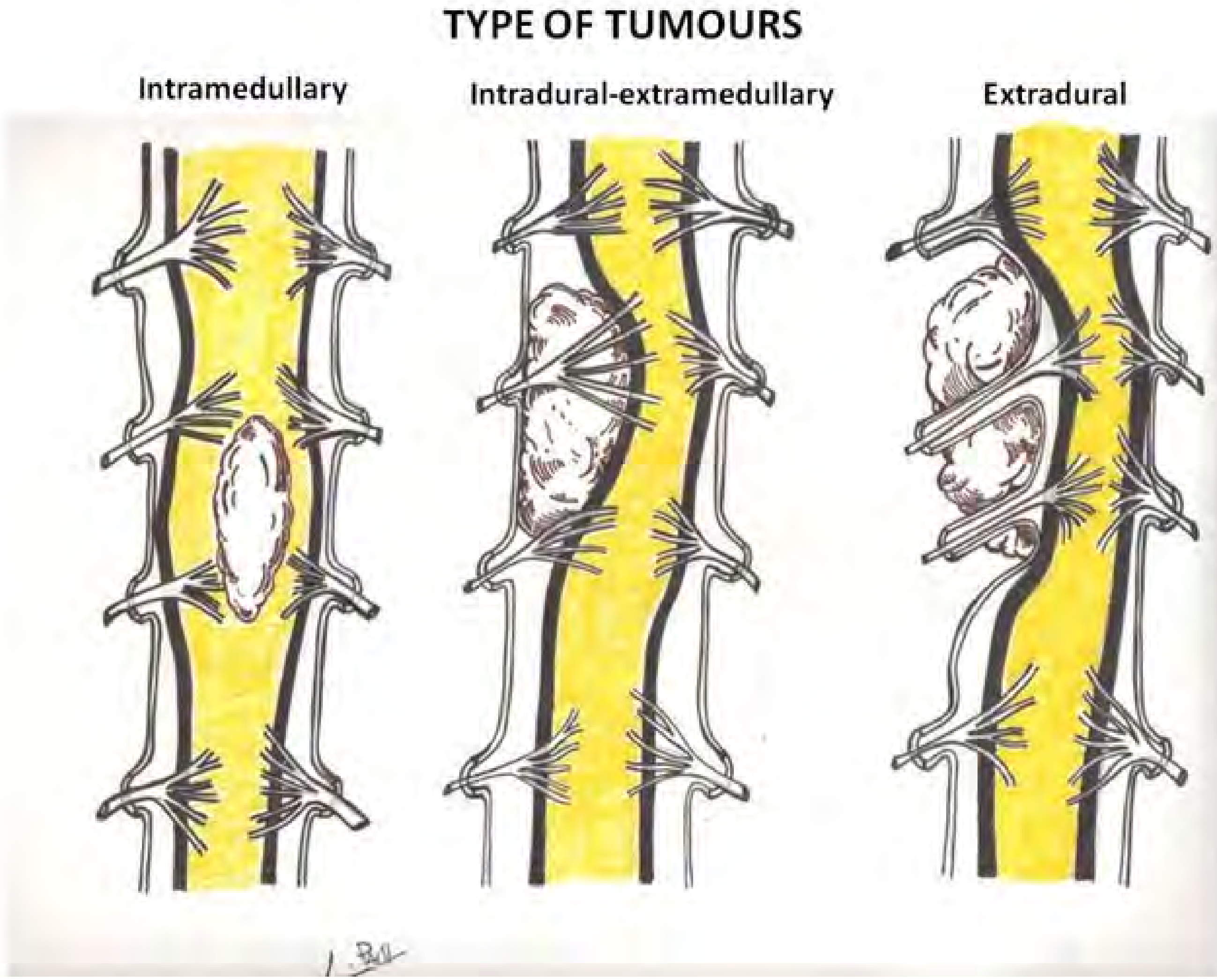
Mauch JT, Carr CM, Cloft H, Diehn FE. Review of the Imaging Features of Benign Osteoporotic and Malignant Vertebral Compression Fractures. AJNR Am J Neuroradiol. 2018;39(9):1584–1592.

67yoF with new onset back pain radiating into right side

Case 2


T12
L1
L2
L3
T12
L1
L2
L3
L2

Spinal Tumors



https://epos.myesr.org/posterimage/esr/ecr2013/117021/mediagallery/501324?deliveroriginal=1

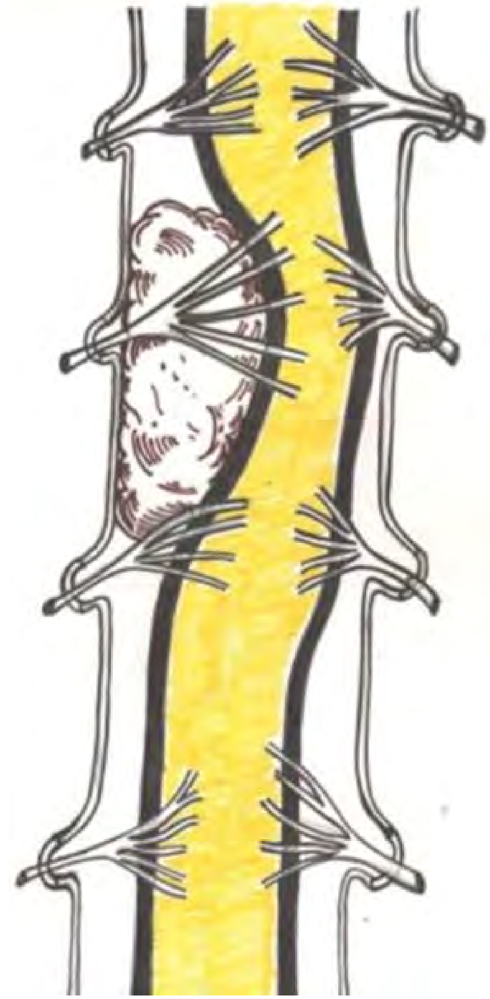
Intramedullary Tumors

- Rare
- Long duration of symptoms prior to dx
- Cord expansion
- Perilesional cysts / syrinx
- DDx
  - Neuroepithelial tumors (70%)
    - Ependymoma – adult
    - Astrocytoma – child
  - Metastatic disease
    - Well-defined
    - Edema out of proportion to lesion size

Shih RY, Koeller KK. Intramedullary Masses of the Spinal Cord: Radiologic-Pathologic Correlation. RadioGraphics. 2020;40(4):1125–1145.

Extramedullary Intradural Tumors

- Majority of spinal tumors (80%)
- Compresses spinal cord
- DDx
  - Meningioma (dural tail)
  - Peripheral Nerve Sheath Tumors (extend into neural foramina; "dumbbell")
    - Schwannoma
    - Neurofibroma



Shih RY, Koeller KK. Intramedullary Masses of the Spinal Cord: Radiologic-Pathologic Correlation. RadioGraphics. 2020;40(4):1125–1145.

Extradural Lesions

- Tumors are rare and predominantly osseous origin
  - ABC, GCT, Hemangioma
- Epidural hematoma or abscess
- Mass effect on thecal sac
- Osseous enhancement or erosion
- Involvement of paraspinal soft tissues

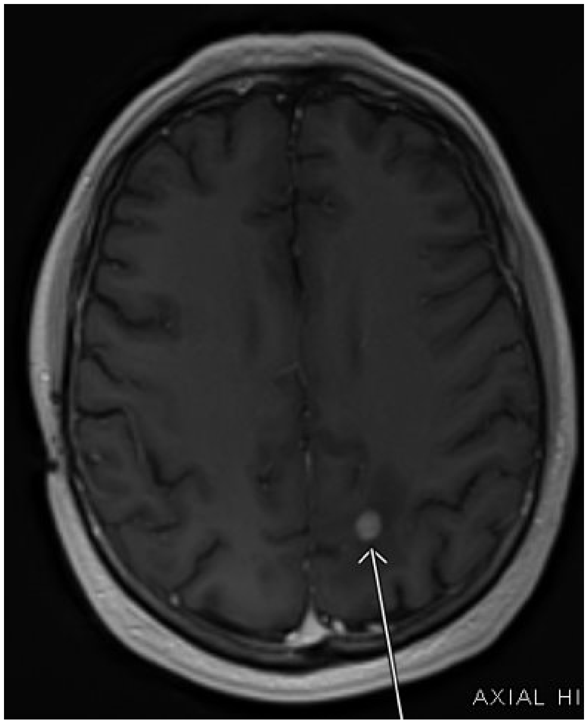
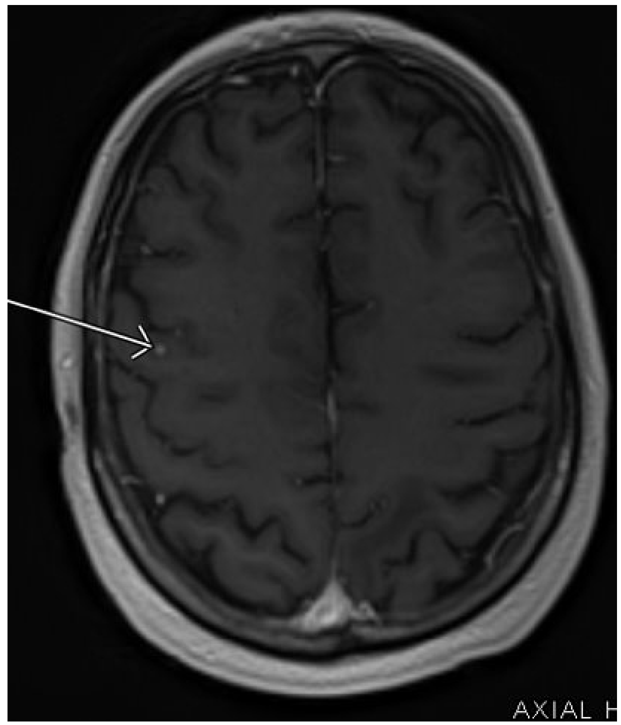
Lam FC, Arle JE, Glazer PA, Kasper EM. Primary Extradural Tumors of the Spine – Case Review with Evidence-guided Management. Surg Neurol Int. 2014;5(Suppl 7):S373–S375.

50yoM bilateral upper extremity weakness for several weeks

Case 3


T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
T1
T2
T3
T4
T5
T6
T7
T8
T9
T10
T11
T12
L1
T8
T8

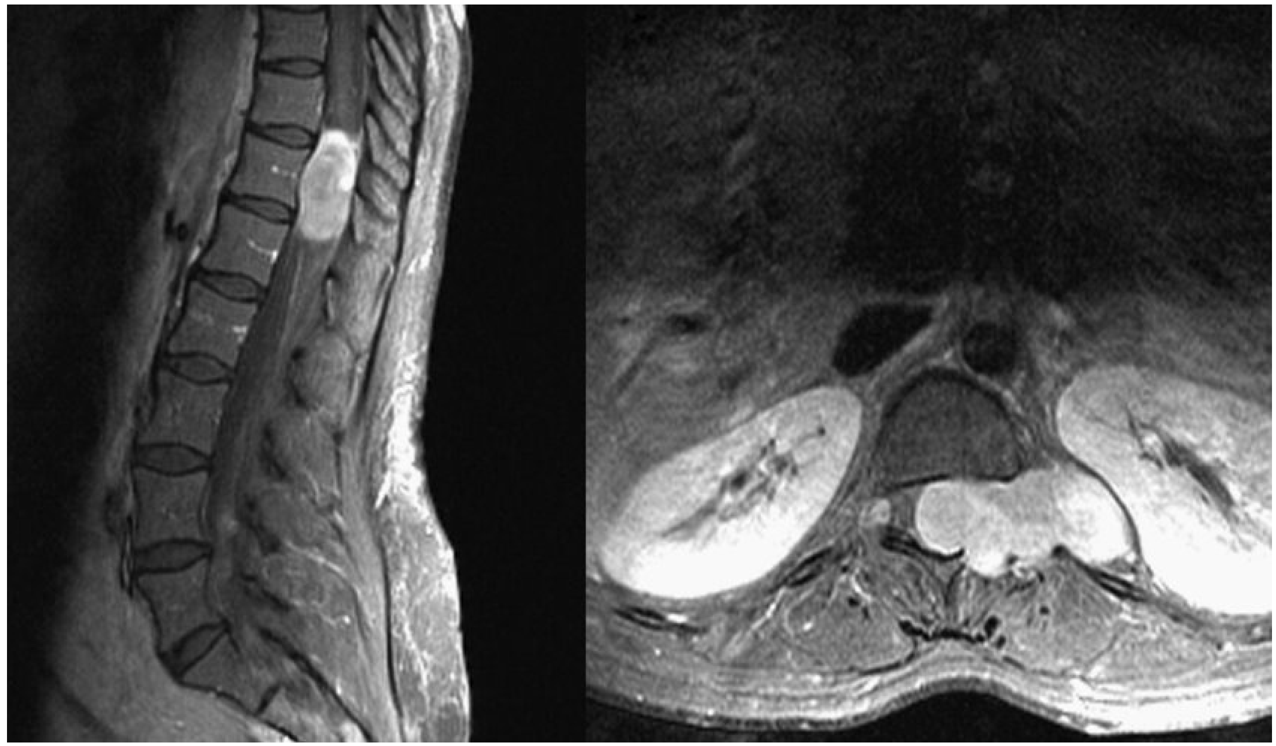

30mm


AXIAL HI

AXIAL H


"Dural Tail Sign" - Meningioma

Case courtesy of Assoc Prof Frank Gaillard, Radiopaedia.org, rID: 19692

"Dumbbell-shaped" - Neurofibroma



Dham BS, Kwa DM, Campellone JV. Postpartum paraparesis from spinal neurofibroma.
The Spine Journal. Elsevier; 2012;12(7):e5–e8.

Summary

- Basic sequences, orientation, and anatomy of spine MRI
- Degenerative disc disease – natural history, nomenclature, correlating history with imaging findings
- Spinal trauma – differentiating benign vs malignant compression fracture
- Classification and typical imaging findings of spinal tumors

References

- Granado AMQ, Roselló EG, Sala GL, et al. A Comprehensive Review of Intraspinal tumors: Diagnostic, classification and radio-pathologic correlation. ECR 2013 EPOS. European Congress of Radiology - ECR 2013; 2013. https://epos.myesr.org/poster/esr/ecr2013/C-2112. Accessed November 25, 2021.
- Koeller KK, Shih RY. Intradural Extramedullary Spinal Neoplasms: Radiologic-Pathologic Correlation. RadioGraphics. 2019;39(2):468–490. doi: 10.1148/rg.2019180200.
- Shih RY, Koeller KK. Intramedullary Masses of the Spinal Cord: Radiologic-Pathologic Correlation. RadioGraphics. 2020;40(4):1125–1145. doi: 10.1148/rg.2020190196.
- Modic MT, Ross JS. Lumbar Degenerative Disk Disease. Radiology. Radiological Society of North America; 2007;245(1):43–61. doi: 10.1148/radiol.2451051706.
- Fardon DF, Williams AL, Dohring EJ, Murtagh FR, Gabriel Rothman SL, Sze GK. Lumbar disc nomenclature: version 2.0. The Spine Journal. 2014;14(11):2525–2545. doi: 10.1016/j.spinee.2014.04.022.
- Roudsari B, Jarvik JG. Lumbar Spine MRI for Low Back Pain: Indications and Yield. American Journal of Roentgenology. 2010;195(3):550–559. doi: 10.2214/AJR.10.4367.
- Uetani M, Hashmi R, Hayashi K. Malignant and benign compression fractures: differentiation and diagnostic pitfalls on MRI. Clinical Radiology. Elsevier; 2004;59(2):124–131. doi: 10.1016/j.crad.2003.07.005.
- Dham BS, Kwa DM, Campellone JV. Postpartum paraparesis from spinal neurofibroma. The Spine Journal. Elsevier; 2012;12(7):e5–e8. doi: 10.1016/j.spinee.2012.07.006.
- Lam FC, Arle JE, Glazer PA, Kasper EM. Primary Extradural Tumors of the Spine – Case Review with Evidence-guided Management. Surg Neurol Int. 2014;5(Suppl 7):S373–S375. doi: 10.4103/2152-7806.139673.
- Mauch JT, Carr CM, Cloft H, Diehn FE. Review of the Imaging Features of Benign Osteoporotic and Malignant Vertebral Compression Fractures. AJNR Am J Neuroradiol. 2018;39(9):1584–1592. doi: 10.3174/ajnr.A5528.
- Kumar Y, Hayashi D. Role of magnetic resonance imaging in acute spinal trauma: a pictorial review. BMC Musculoskelet Disord. 2016;17:310. doi: 10.1186/s12891-016-1169-6.
- Burns JE, Yao J, Summers RM. Vertebral Body Compression Fractures and Bone Density: Automated Detection and Classification on CT Images. Radiology. 2017;284(3):788–797. doi: 10.1148/radiol.2017162100.

Thank You

Wassim Malak, MD
malakw@summahealth.org