

Lumbar Disc Classification

Steven J. Gould, D.C., D.A.C.B.R.

Central Plains Radiologic Services, P.A.

P.O. Box 190 / 126 N. Main
Cheney, KS. 67025
316-542-3400

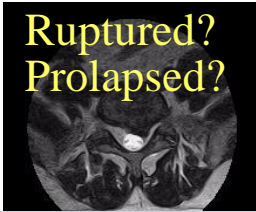
1

Bulging?



How would you describe these disc configurations?

**Ruptured?
Prolapsed?**



**Herniated?
Protrusion?
Extruded?
Sequestered?**

Free fragment?

2

Controversies;

- Lack of pathologic or morphologic definitions limits comparison of research study results.
- Use of terms like “ruptured” disc may be alarming to patients where surgical intervention may not be the best option.
- Legal settlements have been based on defined morphology of disc derangements.

3

Classification of Lumbar Disc Pathology

- Discussion:
 - Importance of using reliable terms for defining normal and pathologic changes of lumbar discs.
 - Terms that can be interpreted accurately, consistently, and with precision for communicating impressions from imaging for clinical diagnostic and therapeutic decision making.

4

Principles guiding standardization

- Definitions should be based upon anatomy and pathology.
- Definitions of diagnoses...
 - ...should not be dependent upon or imply value of specific tests.
 - ... should not define or imply external etiologic events such as trauma.
 - ... should not imply relationship to symptoms.
 - ...should not define or imply need for specific treatment.

5

AJNR

Nomenclature and Classification of Lumbar Disc Pathology
Recommendations of the Combined Task Forces of the
North American Spine Society, American Society of Spine Radiology,
and American Society of Neuroradiology
David F. Fardon, MD, Chairperson, Clinical Task Force

Clinical Task Force Members	Imaging Task Force Members
Tom Faciszewski, MD	Brigitte Appel, MD
David F. Fardon, MD	Jean-François Bonneville, MD
Steven R. Garfin, MD	Marco Leonardi, MD
Scott Halderman, MD, PhD	Pierre C. Milette, MD
Neil Kabanovitz, MD	Jeffrey S. Ross, MD
Volker K.H. Sonntag, MD	Alan L. Williams, MD
	Jan T. Wilmsink, MD, PhD

FEBRUARY 2003 UPDATE
Since its initial publication, in March 2001, the terminology proposed in this work has been endorsed by other societies. It is now officially supported, recommended or web-linked by the following American and European professional organizations and scientific societies:

American Academy of Orthopaedic Surgeons (AAOS)
American Academy of Physical Medicine and Rehabilitation (AAPM&R)
American College of Radiology (ACR)
American Society of Neuroradiology (ASNR)
American Society of Spine Radiology (ASSR)
Joint Section on Disorders of the Spine and Peripheral Nerves of the American Association of Neurological Surgeons (AANS) and Congress of Neurological Surgeons (CNS)
European Society of Neuroradiology (ESNR)
North American Spine Society (NASS)
Physiatric Association of Spine, Sports and Occupational Rehabilitation (PASSOR)

<http://www.asnr.org/spine>

6



Review Article

Lumbar disc nomenclature: version 2.0

Recommendations of the combined task forces of the North American Spine Society, the American Society of Spine Radiology and the American Society of Neuroradiology

David F. Fardon, MD¹, Alan L. Williams, MD², Edward J. Dohring, MD^{3,d,e}, F. Reed Murtagh, MD⁴, Stephen L. Gabriel Rothman, MD⁵, Gordon K. Sze, MD⁶

¹Department of Orthopaedics, Malvern Orthopaedics at Rush, Rush University Medical Center, Third Floor, 1611 W. Harrison, Chicago, IL 60612, USA

²Medical College of Wisconsin, 9200 West Wisconsin Ave., Milwaukee, WI 53226, USA

³Malvern University School of Medicine, 19189 N 59th Ave, Glendale, AZ 85308, USA

⁴Spine Institute of Arizona, 9714 N. 96th Pl., Scottsdale, AZ 85258, USA

⁵Moffitt Cancer Center and Research Institute, University of South Florida College of Medicine, 3801 USF Alumni Dr., Tampa, FL 33612, USA

⁶Keck School of Medicine of the University of Southern California, 1975 Zonal Ave., Los Angeles, CA 90089, USA

^dDepartment of Radiology, Yale University School of Medicine, 20 York St., New Haven, CT 06510, USA

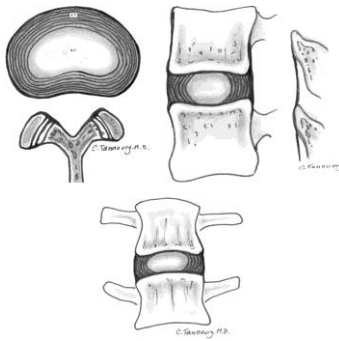
Received 23 July 2013; revised 17 March 2014; accepted 14 April 2014



Terms and Conditions

7

Fig. 1



Terms and Conditions

8



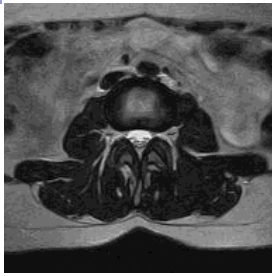
Axial T2



Sagittal T2

Anatomy Review

9



Annulus Fibrosus: Multilaminated ligament surrounding the periphery of each disc space, attaching craniad and caudad to the end-plate cartilage and ring apophyseal bone and blending centrally with the nucleus pulposus.

10

Definitions; The Intervertebral disc

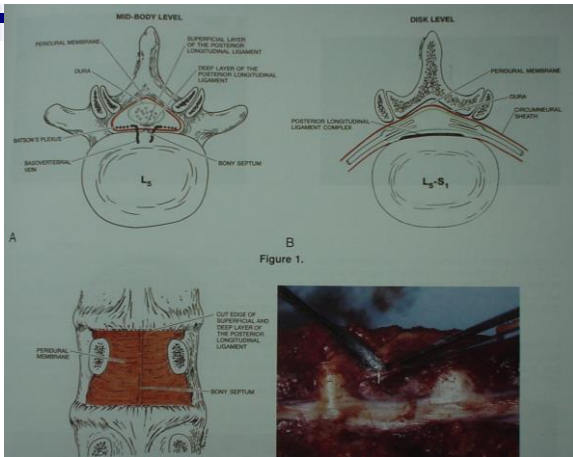


Nucleus Pulposus: Collagen and hydrophilic proteoglycans. Demarcation of the nucleus and annular fibers becomes more indistinct with age.

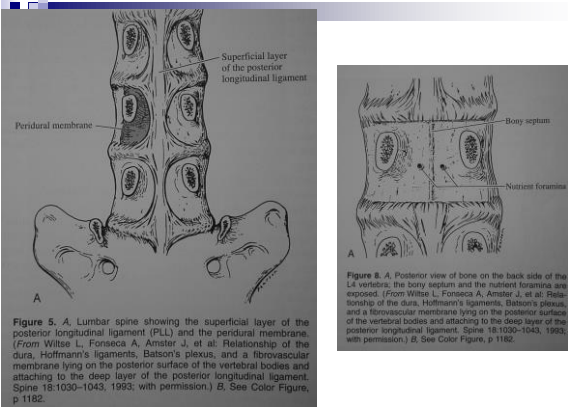
11

Peridural Membrane: A delicate, translucent membrane that attaches to the undersurface of the deep layer of the PLL, and extends laterally and posteriorly, encircling the bony spinal canal outside the dura. The veins of Batson's plexus lie on the dorsal surface of the peridural membrane and pierce it ventrally. AKA lateral membrane, epidural membrane.

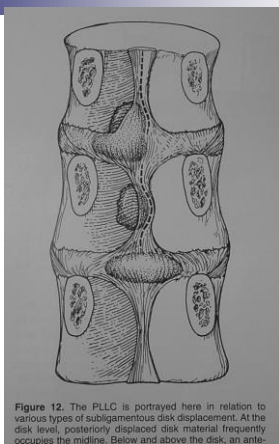
12



13



14

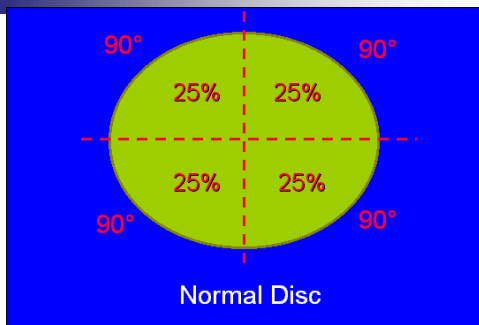


15

Definitions related to disc configuration

- Bulge
- Herniation
- Protrusion
- Extrusion
- Sequestration
- Annular tear/ fissure
- High Intensity Zone (HIZ)

16



For classification purposes, the intervertebral disc is considered as a two dimensional round or oval structure having four 90° quadrants. By convention, a herniation is a "localized" process involving less than 50% (180°) of the disc circumference

17



Normal L3/L4 disc



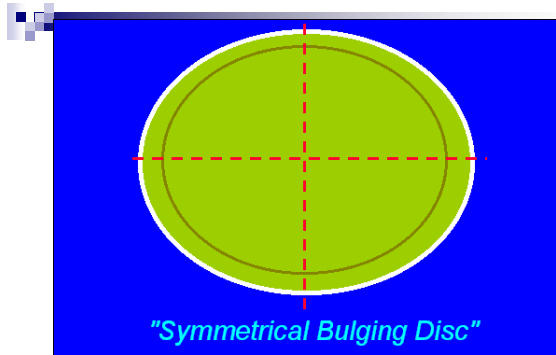
18

Definitions related to disc configuration

■ Bulge

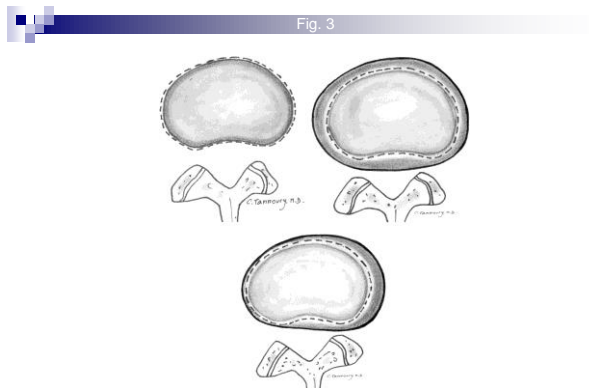
■ Disc bulge; 1. A disc in which the contour of the outer annulus extends, or appears to extend, in the horizontal plane, beyond the edges of the disc space. Involves more than 50% of the circumference of the disc and usually less than 3 mm beyond the edges of the vertebral body apophyses.

19



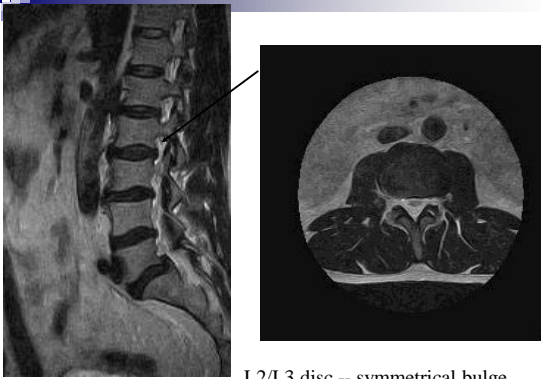
Symmetrical presence (or apparent presence) of disc tissue "circumferentially" (50-100%) beyond the edges of the ring apophyses may be described as a "bulging disc" or "bulging appearance", and is not considered a form of herniation. Furthermore, "bulging" is a descriptive term for the shape of the disc contour and not a diagnostic category.

20



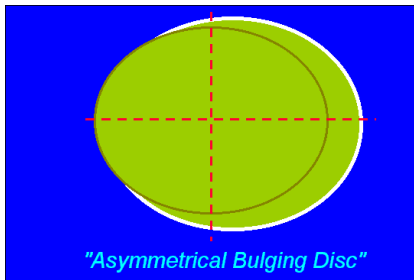
Terms and Conditions

21



L2/L3 disc -- symmetrical bulge

22



Asymmetrical bulging of the disc margin (50%-100%), such as is found in severe scoliosis, is also not considered a form of herniation.

23

Asymmetric Bulge



24

Definitions related to disc configuration

■ Herniation

■Herniation; 1.Localized displacment of disc material beyond the normal margins of the intervertebral disc space. (Localized means, by way of convention, less than 50% of the disc circumference). Disc material may include nucleus, cartilage, fragmented apophyseal bone, or fragmented annular tissue.

■The normal margins of the intervertebral disc space are defined, craniad and caudad, by the vertebral body end-plates and peripherally by the edges of the vertebral body ring apophyses, exclusive of osteophytic formations.

25

Definitions related to disc configuration

■ Herniation, continued...

■Herniated disc generally refers to displacement of disc tissues through a disruption in the annulus, the exception being the intravertebral herniations (Schmorl's Nodes) in which the displacement is through the vertebral end-plate.

■Herniated discs in the horizontal plane may be further subcategorized as protruded or extruded.

■Herniated disc is sometimes referred to as "herniated nucleus pulposus", but the term herniated disc is preferred because displaced disc tissues often include cartilage, bone fragments, or annular tissues.

26

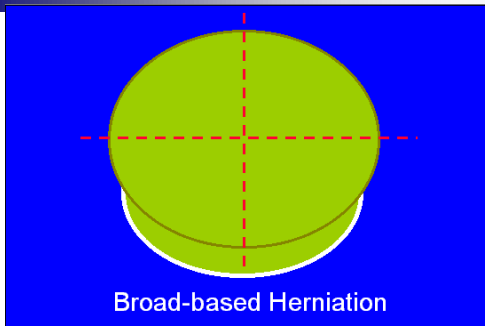
Herniation, continued...

■The term "ruptured disc" is used synonymously with herniated disc, but is more colloquial and can be easily confused with violent, traumatic rupture of the annulus or end-plate.

■The term "prolapse" has also been used as a general term for disc displacement, but its use has been inconsistent.

■The term herniated disc does not infer knowledge of cause, relation to injury or activity, concordance with symptoms, or need for treatment.

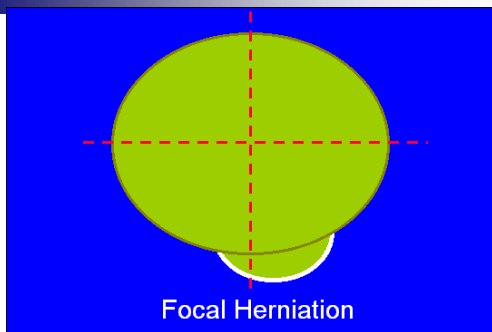
27



Broad-based Herniation

By convention, a "broad-based" herniation involves between 25% and 50% (90°-180°) of the disc circumference.

28

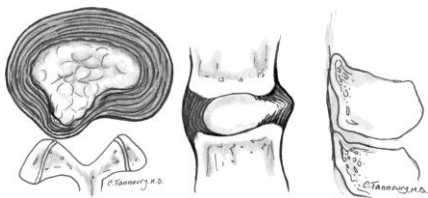


Focal Herniation

By convention, a "focal herniation" involves less than 25% (90°) of the disc circumference.

29

Fig. 4





Terms and Conditions

30

Jelly Donut Senario



31



The interspace is defined, peripherally, by the edges of the vertebral ring apophyses, exclusive of osteophytic formations. The line drawing schematically illustrates a localized extension of disc material beyond the intervertebral disc space, in a left posterior direction, which qualifies as a disc herniation.

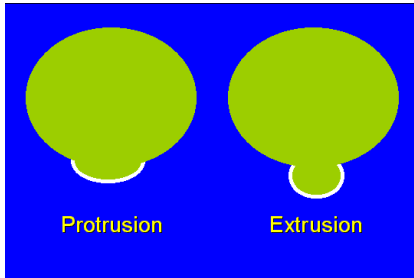
32

Definitions related to disc configuration

■ Protrusion

•Protrusion;1. 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. Note: The test of protrusion is that there must be a localized (less than 50% or 180 degrees of the circumference of the disc) displacement of disc tissue so that the distance between the edges of the displaced portion must not be greater than the distance between the corresponding edges of the base. A disc that has broken through the outer annulus at the apex, but maintains a broad continuity at the base, is protruded and uncontained. While sometimes used as a general term in the way herniation is defined here, the use of the term protrusion is best reserved for sub-categorization of herniations meeting the above criteria.

33



Herniated discs may take the form of protrusion or extrusion, based on the shape of the displaced material

34

Definitions related to disc configuration

■ Extrusion

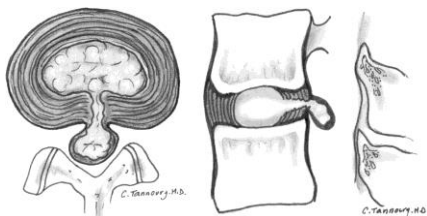
When a relatively large amount of disc material is displaced, distinction between protrusion and extrusion will generally only be possible on sagittal MR sections or sagittal CT reconstructions. On sagittal images an extrusion is defined when the greatest cranio-caudal diameter of the displaced disc material is greater than the cranio-caudal diameter of its base at the level of the parent disc.

In any situation, the distance between the edges of the base, which serves as reference for the definition of protrusion and extrusion, may differ from the distance between the edges of the aperture in the annulus.

In the cranio-caudal direction, the length of the base cannot exceed, by definition, the height of the intervertebral space.
(Adapted from Milette PC. Classification, diagnostic imaging and imaging characterization of a lumbar herniated disc. Radiol Clin North Am 2000; 38:1267-1292)

35

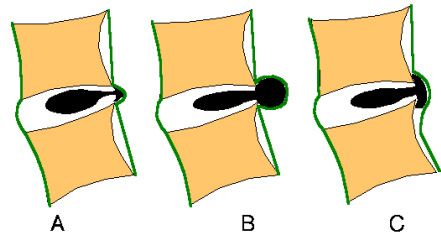
Fig. 5





Terms and Conditions

36



When a relatively large amount of disc material is displaced, distinction between protrusion and extrusion will generally only be possible on sagittal MR sections or sagittal CT reconstructions. In Figure C, although the shape of the displaced material is similar to that of a protrusion, the greatest cranio-caudal diameter of the fragment is greater than the cranio-caudal diameter of its base at the level of the parent disc, and the lesion therefore qualifies as an extrusion. In any situation, the distance between the edges of the base, which serves as reference for the definition of protrusion and extrusion, may differ from the distance between the edges of the aperture in the annulus, which cannot be assessed on CT images and is seldom appreciated on MR images. In the cranio-caudal direction, the length of the base cannot exceed, by definition, the height of the intervertebral space (Adapted from Milette PC. Classification, diagnostic imaging and imaging characterization of a lumbar herniated disc. *Radiol Clin North Am* 2000; 38:1267-1292)

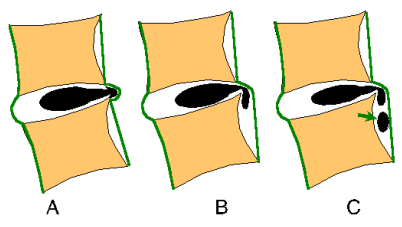
37

Definitions related to disc configuration

■ Sequestration

Sequestered disc; An extruded disc in which a portion of the disc tissue has become displaced from the disc space of origin and lacks any continuity with the parent disc.

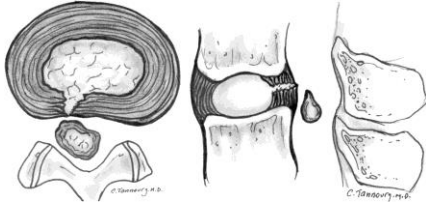
38



(Figure 13) Schematic representation of various types of posterior central herniations. A. Small sub-ligamentous herniation (or protrusion) without significant disc material migration. B. Sub-ligamentous herniation with downward migration of disc material under the posterior longitudinal ligament (PLL). C. Sub-ligamentous herniation with downward migration of disc material and sequestered fragment (arrow). (From Milette PC. Classification, diagnostic imaging and imaging characterization of a lumbar herniated disc. *Radiol Clin North Am* 2000; 38:1267-1292)

39

Fig. 6





Terms and Conditions

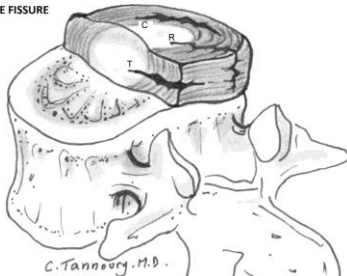
Definitions related to disc configuration

- Annular tear/ fissure:
- High Intensity Zone (HIZ)

Concentric annular tear; Tear or fissure of the annulus characterized by separation/ break, of annular fibers, in a plane parallel to the curve of the periphery of the disc, creating fluid-filled spaces between adjacent annular lamellae.

Fig. 2

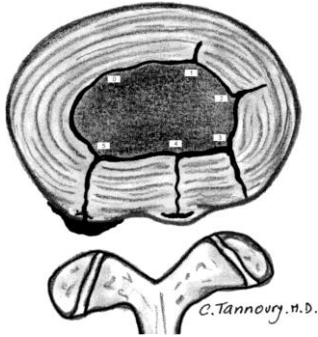
C: CONCENTRIC FISSURE
R: RADIAL FISSURE
T: TRANSVERSE FISSURE





Terms and Conditions

Fig. 9



Terms and Conditions

43

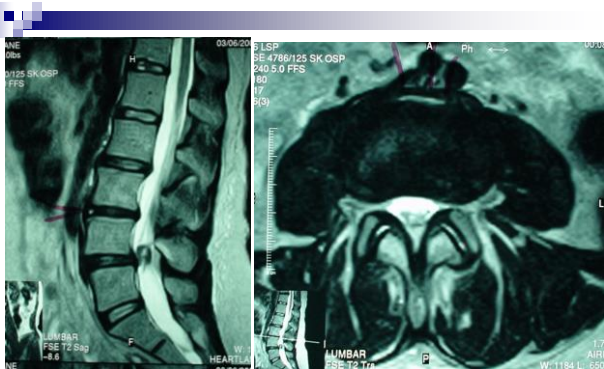
Definitions related to disc configuration

- Annular tear/ fissure:
- High Intensity Zone (HIZ)

Radial annular tear; Disruption of annular fibers extending from the nucleus outward toward the periphery of the annulus, usually in the vertical plane, with occasional transverse component.

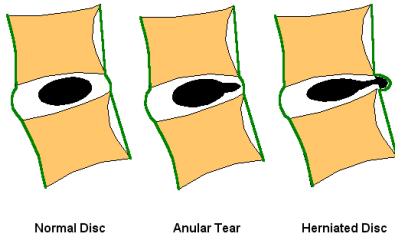
Transverse tear; Tear or fissure of the annulus, running in the axial plane (horizontally), usually limited rupture of the outer annular attachments to the ring apophysis. (May be gas filled on C.T. and may be early manifestation of spondylosis deformans.)

44



Concentric Annular Tear/ Fissure, noted on sagittal exam by the high intensity zone (HIZ)

45



(Figure 2) Schematic sagittal anatomical sections showing the differentiating features of an annular tear (radial tear in this case) and a disc herniation. The term "tear" is used to refer to a localized radial, concentric, or horizontal disruption of the annulus without associated displacement of disc material beyond the limits of the intervertebral disc space. Nuclear material is shown in black, and the annulus (internal and external) corresponds to the white portion of the intervertebral space. The same convention is used in Figures 3, 12, 13, and 14. (Adapted from Milette PC. The proper terminology for reporting lumbar intervertebral disk disorders. AJNR. Am J Neuroradiol 1997; 18:1829-46; with permission)

46

Definitions: Pathology of the disc

- Spondylosis Deformans;
Degenerative process of the spine involving the annulus fibrosus and characterized by anterior and lateral marginal osteophytes arising from the vertebral body apophyses, while the intervertebral disc height is normal or only slightly decreased. Usually, generally termed "spondylosis"

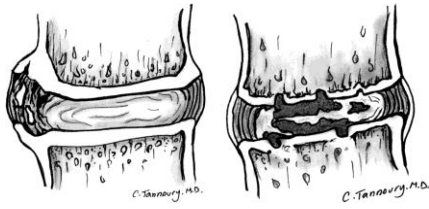
47

Definitions: Pathology of the disc

- Intervertebral Osteochondrosis
Degenerative process of the spine involving the vertebral body end-plates, the nucleus pulposus, and the annulus fibrosus, which is characterized by disc space narrowing, vacuum phenomenon, and vertebral body reactive changes.

48

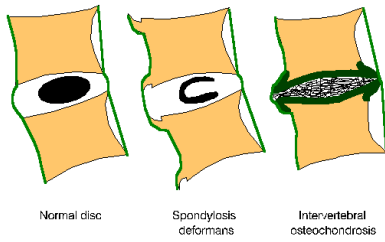
Fig. 8





Terms and Conditions

49



(Figure 3) Schematic sagittal anatomical sections showing the differentiating characteristics of the normal disc, spondylosis deformans, and intervertebral osteochondrosis. The distinction between these three entities is usually possible on all imaging modalities, including conventional radiographs. (Adapted from Milette PC. The proper terminology for reporting lumbar intervertebral disk disorders. AJNR. Am J Neurorad 1997;18:1859-66, with permission.)

50



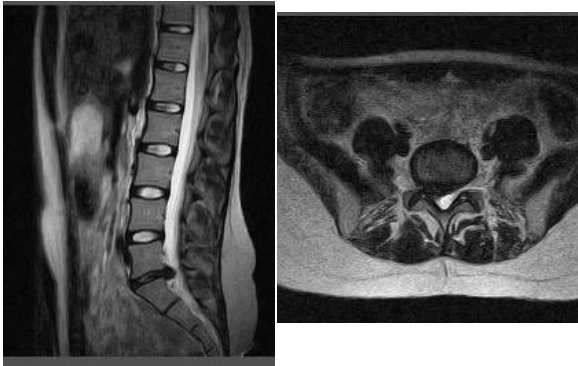
51

General Classification of Disc Lesions

- Normal (excluding aging changes)
- Congenital/Developmental variant
- Degenerative/traumatic lesion
 - Anular tear Annular fissure
 - Herniation Protrusion/Extrusion
 Intravertebral
 - Degeneration Spondylosis deformans
 Intervertebral osteochondrosis
- Inflammation/Infection
- Neoplasia
- Morphologic variant of unknown significance

General classification of disc disorders. In the proposed model, the use of the "normal" category is restricted to discs free of any degenerative changes, whether age related or pathologic. (Adapted from Milette PC. Classification, diagnostic imaging and imaging characterization of a lumbar herniated disc. Radiol Clin North Am 2000; 38:1267-1292)

52



53



54

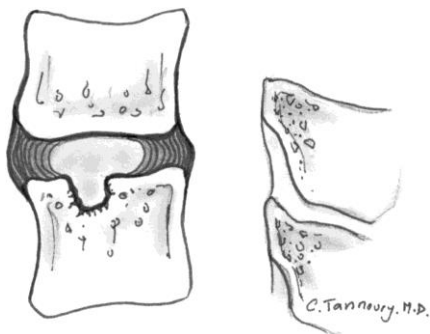
Intervertebral disc space

Intravertebral Herniations

The term "herniated disc", as defined in this work, refers to localized displacement of nucleus, cartilage, fragmented apophyseal bone, or fragmented anular tissue beyond the intervertebral disc space (disc space, interspace). The interspace is defined, craniad and caudad, by the vertebral body end-plates. Two intravertebral herniations, one with an upward orientation and the other with a downward orientation with respect to the disc space, are illustrated schematically.

55

Fig. 7



Terms and Conditions

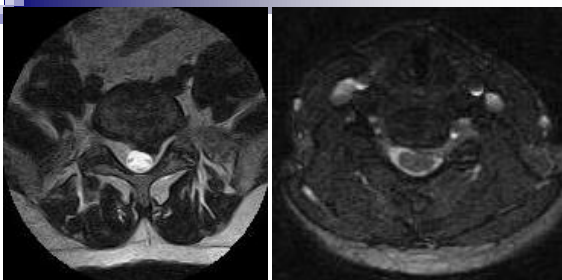
56



57



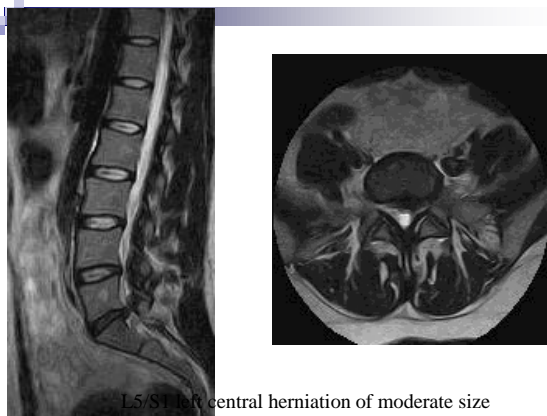
58



Left paracentral lumbar disc protrusion

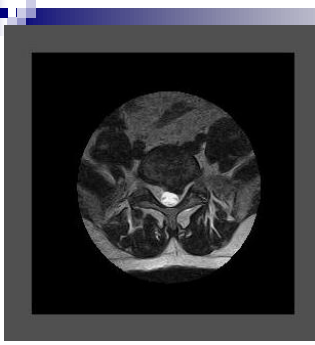
Left paracentral cervical disc protrusion

59

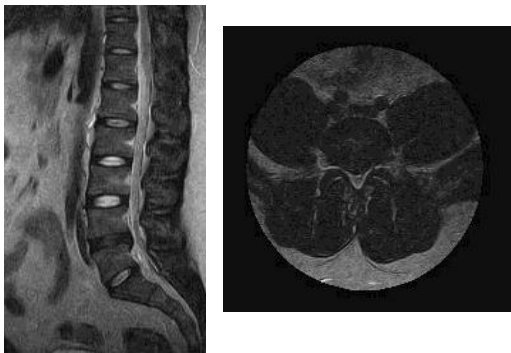


L5/S1, R central herniation of moderate size

60



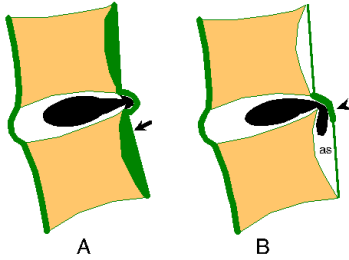
61



62



63



(Figure 14)
 Relationship of typical posterior disc herniations with the posterior longitudinal ligament. A, Midline sagittal section: unless very large, a posterior midline herniation usually remains entrapped underneath the deep layer of the PLL and sometimes a few intact outer annulus fibers joining with the PLL to form a "capsule." The deep layer of the PLL (arrow) also attaches to the posterior aspect of the vertebral body so that no potential space is present underneath. B, Sagittal para-central section: the PLL extends laterally at the disc level (arrowhead) but, above and below the disc, an anterior epidural space (as), where disc fragments are frequently entrapped, is present between the lateral membranes (peridural membrane) and the posterior aspect of the vertebral bodies. (Adapted from Milette PC. Classification, diagnostic imaging and imaging characterization of a lumbar herniated disc. Radiol Clin North Am 2000; 38:1267-1292)

64

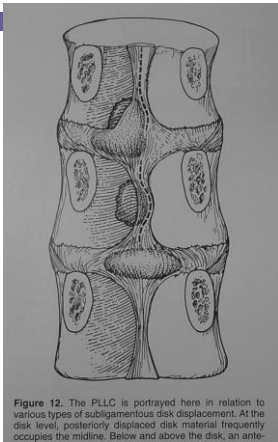
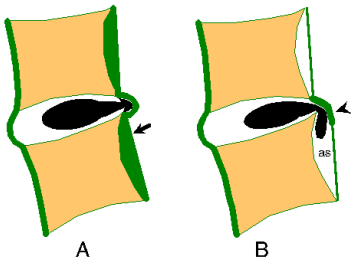


Figure 12. The PLL is portrayed here in relation to various types of subligamentous disk displacement. At the disk level, posteriorly displaced disk material frequently occupies the midline. Below and above the disk, an ante-

65



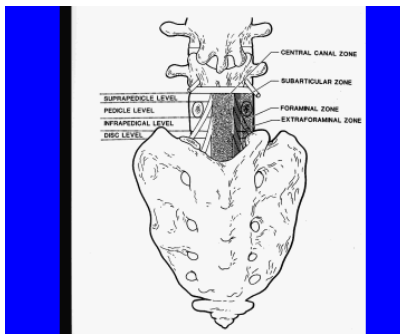
(Figure 15)
 Proposed categories for the description and classification of disc herniations. Some distinctions may not be possible with currently available non-invasive imaging modalities

66

Description of a Disc Herniation

- Morphology
 - Protrusion
 - Extrusion
 - Intravertebral
- Containment
- Continuity
- Relation with PLL complex
- Volume
- Composition
- Location

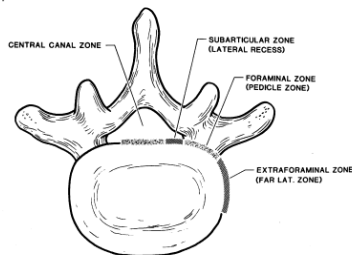
67



(Figure 16) Coronal drawing illustrating the main anatomical "zones" and "levels". (From Wiltse LL, Berger PE, McCulloch JA. A system for reporting the size and location of lesions of the spine. Spine 1997;22:1534-37)

68

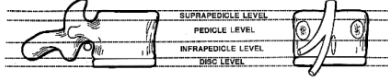
In the axial image, the sagittal and parasagittal planes are called zones.



(Figure 17) Schematic representation of the anatomical "zones" identified on axial images. The anterior zone (not illustrated) is delineated from the extra-foraminal zone by an imaginary coronal line in the center of the vertebral body. (Adapted from Wiltse LL, Berger PE, McCulloch JA. A system for reporting the size and location of lesions of the spine. Spine 1997;22:1534-1537)

69

In the caudocranial direction visualized on sagittal and coronal images, we have chosen the term levels.



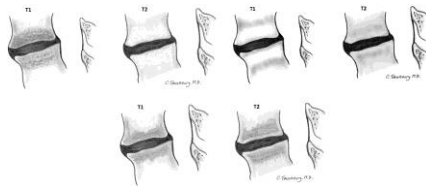
(Figure 18) Schematic representation of the anatomical "levels" identified on cranio-caudal images. (Adapted from Wiltse LL, Berger PE, McCulloch JA. A system for reporting the size and location of lesions of the spine. Spine 1997;22:1534-1537)

70

Modic Changes:

71

Fig. 10





Terms and Conditions

72

MRI

- Although disc abnormalities are common on MRI in asymptomatic persons, acute back pain with radiculopathy suggests the presence of demonstrable nerve root compression on MRI.
- MRI findings of Modic endplate change, especially type 1, anterolisthesis, or disc extrusion are more strongly associated with LBP than findings of disc degeneration without endplate change

73

Vertebral Endplate Changes

Modic System

Type 1 T1 ▼ ▲ T2 ▲ IR = Edema

Type 2 T1 ▲ ▲ T2 ▼ IR = fibrovascular

Type 3 T1 ▼ ▼ ▼ T2



74

Intravenous Contrast Agents

- Gadolinium pentetic acid (Gd-DPTA) has been studied in the hope that it may identify symptomatically related herniated nucleus pulposus.
- Dorsal root ganglion enhances normally and the nerve roots generally do not enhance.
- Animal experiments showed enhancement of nerve root after 30 gf and 60 gf pressure for 1 hour. There was also evidence of "Evans blue tracer" in the same distribution (in areas of endothelial damage).

75



Intravenous Contrast Agents

- Use of Gd has not clarified the relationship between disc herniation, inflammation, and symptoms. At present time it remains a prerequisite that clinical symptoms and signs of nerve root compression must be established and be the main guidance of therapeutic choices.

76



Pathomechanics of Sciatica

- Radiologic studies have demonstrated that the symptoms of sciatica are more commonly assoc. with presence of nerve root compression but less with nerve root displacement.
- Higher incidence of sciatica with extrusions vs. protrusions.
- Blood vessels of the nerve root and dorsal ganglia can be injured by compression, resulting in edema.

77



Pathomechanics of Sciatica

- Studies of nerve root nutrition have shown some nutrients are derived from CSF and intraneural capillaries.
- Blood-nerve barrier at nerve root disrupted by compression of 15 gram force for 1 hr.
- Edema decreased with removal of compression, but evidence of long standing edema causes fibrosis.

78



Comments:

- MRI serves to confirm the presence of HNP and define the disc level and nerve root involved.
- MRI also enables the exclusion of alternate pathologies such as a neurogenic tumor at the cauda equina or a schwannoma of the nerve root that may mimic symptoms of HNP.
- If doubt remains regarding the relationship to the disc pathology as demonstrated on MRI a local anesthetic nerve root block under CT or Fluoroscopic guidance may provide additional diagnostic information.

79



Comments:

- It is essential that the correlation of pain distribution, motor, and sensory deficits, and MRI or CT confirmation of disc herniation with nerve root compression are achieved before invasive therapy is instituted.

80



Natural History

- Weber's Series;
 - 126 pts w/ sciatica and radiculopathic confirmation of HNP
 - Tx of 14 days conservative. After initial 14 days the patients are randomized to continue conservative care or surgery.
 - At 1yr. Surgically treated patients had significantly better results.
 - At 4 yr. Differences were no longer significant
 - At 10 yr. Little difference between the two groups.

□ Weber H: Lumbar disc herniation: A controlled, prospective study with ten years of observation. Spine 8:131-140, 1983

81

Natural History

Saal; 11 pts; Radiculopathy and extruded discs on CT.

- Tx'd nonsurgically
- Repeat MRI between 8 and 77mths
- Showed decrease in size of HNP
 - 0-50% in 11% of pts.
 - 50-75% in 36%
 - 75-100% in 46%
 - Max shrinkage of discs occurred in the largest extrusions and in the cephalocaudal dimension.
 - There was no perithecal or perineural fibrosis.

Saal JS, et al: The natural history of lumbar intervertebral disc extrusions treated nonoperatively. Spine 15:683-686,1990

82

Natural History

- Maigne; Examined 47 pts with Acute Sciatica;
- Tx'd conservatively. Maigne JY et al: CT follow-up study of forty eight cases of nonoperatively treated lumbar intervertebral disc herniation. Spine 17:1017-1074, 1992
 - bed rest, lumbar support, epidural steroids, phsyiotherapy, and oral NSAID's.
- 5 of 47 pts conservative management failed.
- Repeat CT was performed 1 - 15 mths after initial study
- Disc size was shown to decrease by;
 - 25% in 9 pts
 - 50-75% in 8 pts
 - 75-100% in 31 pts
- Larger herniations were more likely to decrease in size.

83

Mechanisms of Resorption

- Neovascularization shown in 56% of HNP removed at surgery.
- Vessels around edge of nuclear material.
- Not present in controls taken from cadavers.
- Neovascularity greater in;
 - sequestered discs > extruded discs, and was unusual in protruded discs

84

Mechanisms of Resorption

- Macrophage infiltration noted in;
 - 16% of protrusions
 - 81% of subligamentous extrusions
 - 100% of transligamentous extrusions
 - 80% of sequestered discs
- No correlation between leg pain duration and the cellular infiltration.
- Inflammatory cells have been observed in herniated disc material when there is a preponderance of macrophages.

85



86



87
