강 창 호
고려대학교 안암병원 영상의학과

Spine Imaging

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Contents

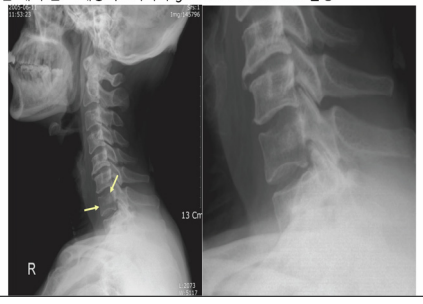
- Imaging modality used in spine;
1) Radiography
2) CT
3) MRI
4) Advanced imaging technique
- Imaging findings of degenerative spinal disease
1) Discovertebral joint
2) Facet/uncovertebral joint
3) Spinal stenosis
4) Spinal cord and spinal nerves

Radiography

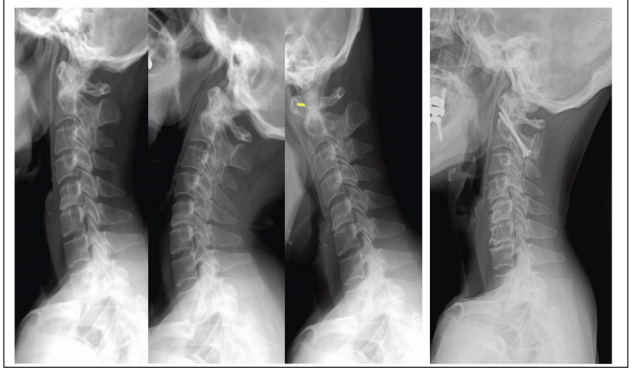
- Basic review
- R/O red flags (tumor, **fracture**, infection, ...)
- Bony structures
- Dynamic study
- Fx., Alignment, Anomaly vs Bone marrow, Cord, Disc.

59-yo male

- Left shoulder & arm pain
- Disc 라는 얘기 듣고 대증치료하다가 generalized weakness 발생



60-yo female with RA



Radiography

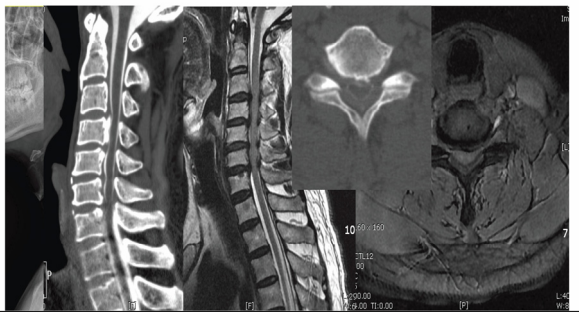
CT

- More details in bony structures
- 3D imaging with MDCT
- Image-guided
- CT myelography/discography
- Fx., Alignment, Anomaly, Disc vs Bone marrow, Cord

CT

CT

- 52세 남자; 고개를 숙이면 양측 팔과 등으로 '전기 오는 증상'

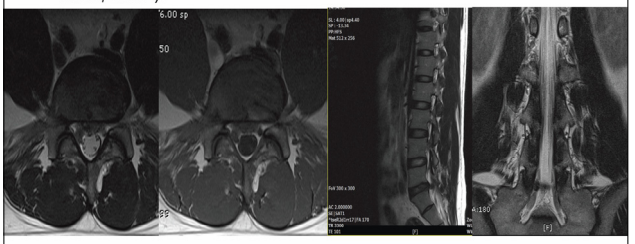


MRI

- Imaging modality of choice
- Comprehensive evaluation with tissue characterization

MRI

- 25세 남자; Right sciatica (3m, 1w-aggravation, radiating below knee, SLR+).

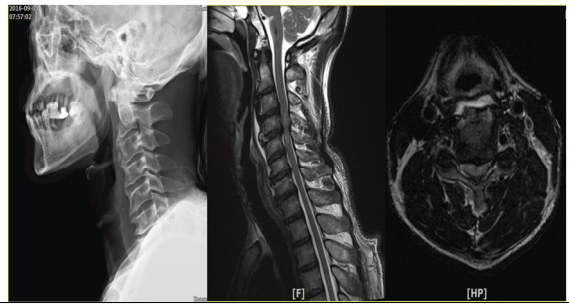


MRI

• 70세 여자, 1년 전부터 LBP, 최근 2-3 개월 전부터 심해짐. 양측 하지에 radiating pain 있음 (R>L).

MRI

• 49세 남자; 음주 후 Quadriparesis



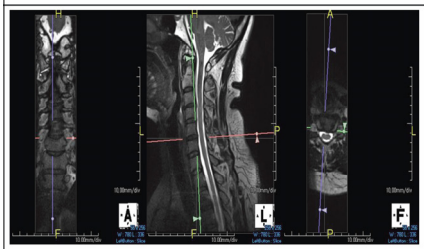
Radiography + MRI

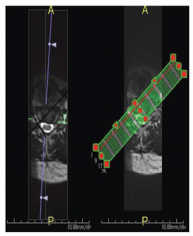
• Postoperative evaluation

Advanced technique

• 3D MRI
• DTI
• MR neurography

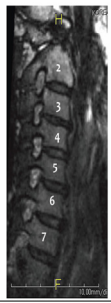
3D MRI



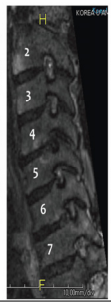


3D MRI

• 3D isotropic MRI showed substantial to excellent interobserver agreement in evaluation of cervical neural foraminal stenosis, with substantial agreement in 2D MRI.



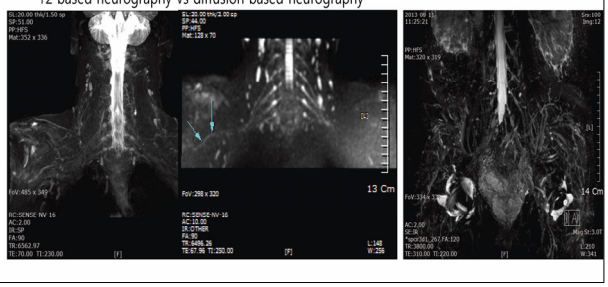
Level	Obs. 1	Obs. 2	Obs. 3
C2-3	0	0	0
C3-4	1	1	1
C4-5	0	0	0
C5-6	0	0	0
C6-7	0	0	0
C7-T1	0	0	0



Level	Obs. 1	Obs. 2	Obs. 3
C2-3	0	0	0
C3-4	0	1	1
C4-5	3	3	3
C5-6	2	1	2
C6-7	1	1	2
C7-T1	0	1	0

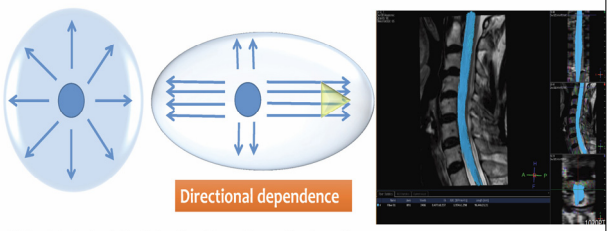
MR neurography

- Magnetic resonance neurography (MRN) is the direct imaging of nerves in the body by optimizing selectivity for unique MRI water properties of nerves.
- T2 based neurography vs diffusion based neurography



DTI

Isotropic diffusion **Anisotropic diffusion**



DTI is able to tract the integrity of long linear structure → more sensitive to early change

Rajasekaran S et al. Diffusion tensor Imaging of the spinal cord and its clinical applications. J Bone Joint Surg Br. 2012 Aug;94(8):1024-31.

DTI

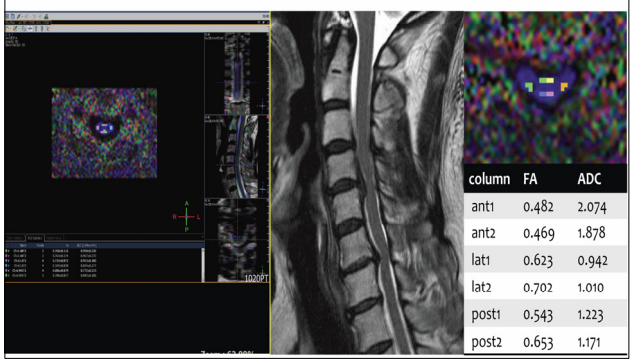
DTI parameters **FA** **ADC**

$$FA = \frac{1}{\sqrt{2}}\sqrt{\frac{(\lambda_1-\lambda_2)^2+(\lambda_2-\lambda_3)^2+(\lambda_1-\lambda_3)^2}{\lambda_1^2+\lambda_2^2+\lambda_3^2}}$$

$$MD = (\lambda_1+\lambda_2+\lambda_3)/3$$

Anisotropic diffusion	Magnitude of diffusion of water molecules
0 → isotropic diffusion	Low → organized structure
1 → infinite anisotropy	High → disorganized due to injury

DTI



column	FA	ADC
ant1	0.482	2.074
ant2	0.469	1.878
lat1	0.623	0.942
lat2	0.702	1.010
post1	0.543	1.223
post2	0.653	1.171

DTI

- In terms of 3 group comparison of control, mild, and severe patients with cervical spondylosis, FA and ADC showed statistically significant correlations with clinical severity.

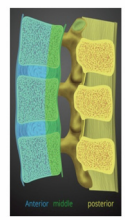
	control (n=11)	mild subgroup (n=38)	moderate/severe subgroup (n=36)	p-value
FA_C3/4-C6/7	0.71±0.04	0.70±0.05	0.67±0.05	.008
AD_C3/4-C6/7	0.96±0.07	1.02±0.11	1.11±0.16	.001
FA_MCL	0.73±0.05	0.69±0.07	0.63±0.09	.001
ADC_MCL	0.91±0.09	1.04±0.17	1.21±0.29	.000

Imaging findings of degenerative spinal disease

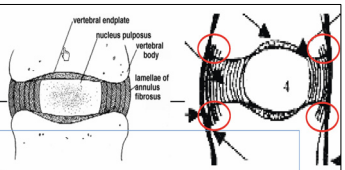
Degenerative changes in the anterior elements
- Intervertebral osteochondrosis
- Spondylosis deformans
- Disc herniation
- Degenerative endplate changes
- Degenerative changes of the uncovertebral joints

Degenerative changes in the posterior elements
- Degenerative changes of the facet joints
- Degenerative changes of the interspinous ligaments

Complication of degenerative spinal disease
- Scoliosis and kyphosis
- Segmental instability
- Spinal stenosis and neural foraminal stenosis
- Spinal cord (e.g. CSM) and nerves compromise



Discovertebral joint



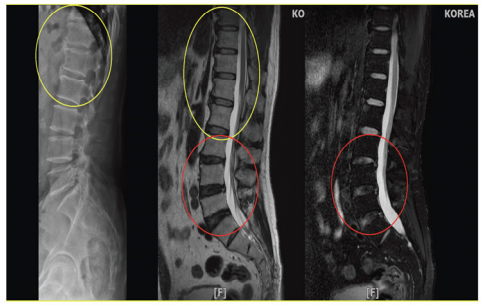
- **Intervertebral osteochondrosis**

❖Degeneration of the nucleus pulposus

❖Decreased disc height, annular tears, and disc herniation.

- **Spondylosis deformans**
- Degeneration of the anulus fibrosus
- Osteophytes: secondary to chronic traction stress at attachment sites of the Sharpey's fibers

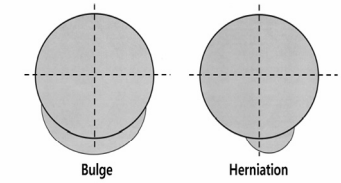
Spondylosis deformans+Intervertebral osteochondrosis

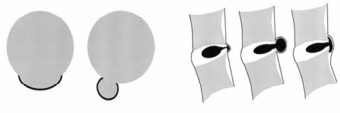


Classification of disc degeneration

- Distinction of nucleus and anulus, signal intensity, height of intervertebral disc
- Grade I
- Grade II
- Grade III
- Grade IV
- Grade V

Disc herniation





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

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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, MD[1], Alan L. Williams, MD[2], Edward J. Dohring, MD[3,4,5], F. Reed Murtagh, MD[6], Stephen L. Gabriel Rothman, MD[7], Gordon K. Sze, MD[8]

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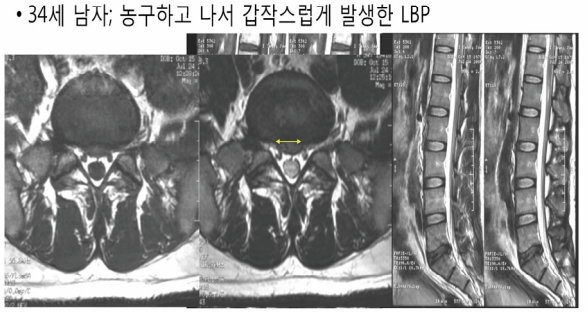
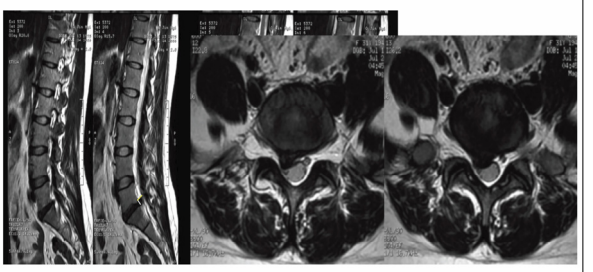
Protrusion

- 34세 남자; 농구하고 나서 갑작스럽게 발생한 LBP



Extrusion

- 31세 여자; 약 6개월 전부터 시작된 LBP+right L/E pain



Modic changes

- Modic MT, Steinberg PM, Ross JS, Masaryk TJ, Carter JR
- Degenerative disk disease:

assessment of changes in vertebral body marrow with MR imaging.

- Radiology (1998) 166:193–199

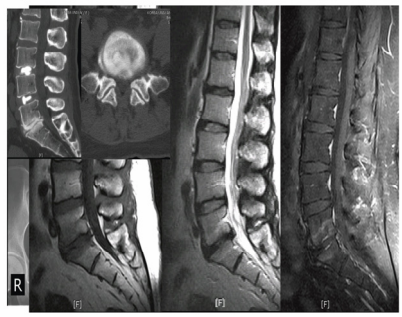
TABLE 1. MODIC CHANGES ACCORDING TO CHANGES IN MRI SIGNAL INTENSITY IN ADJACENT VERTEBRAL ENDPLATES

Modic classification	T1	T2	Represents
I	–	+	Vascularized bone marrow and/or edema
II	+	+	Proliferation of fatty tissue
III	–	–	Sclerotic bone

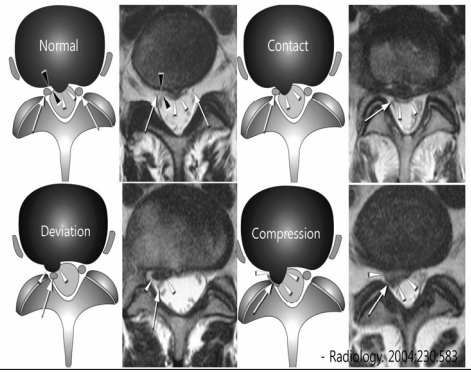
Eur Spine J (2008) 17:1289–1299

Discogenic LBP

- 47세 여자; Low back pain (7m) + left buttock pain + both leg pain (Lt>Rt)



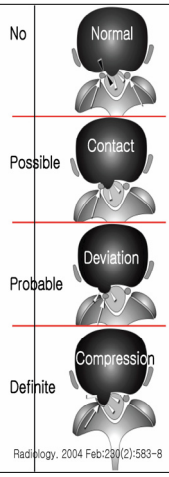
Nerve root compromise



- Radiology. 2004;230:583

Nerve root compression

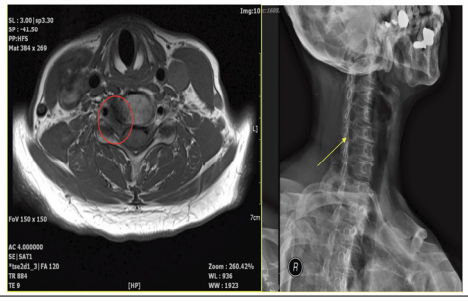
- No/Possible/Probable/Definite
- Perineural fat obliteration on T1WI
- Nerve swelling



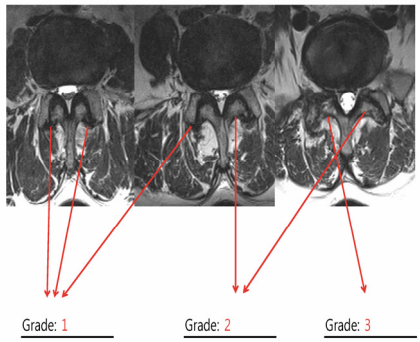
Radiology. 2004 Feb;230(2):583-8

Nerve root compromise A/W neural foraminal stenosis

- 59세 여자; 3개월 전부터 rt. upper arm, forearm radial side tingling sense 있어 내원



Facet joint osteoarthritis



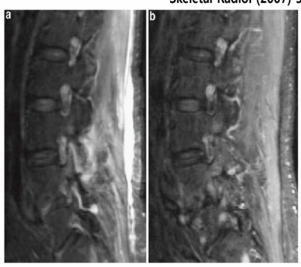
Facet joint edema

- Significant pain generator?

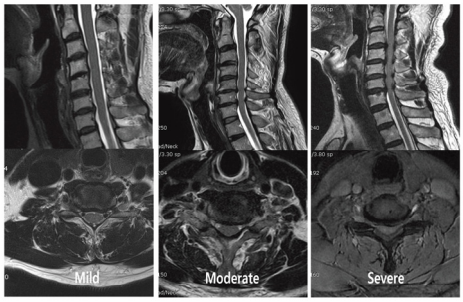
Facet joint edema

- In 21 of the 145 patients (14%) edema was found at the facet joints. The agreement between the change in pain score and intensity of edema within the follow-up group was "almost perfect" (kappa=0.81).

Skeletal Radiol (2007) 36:755–760

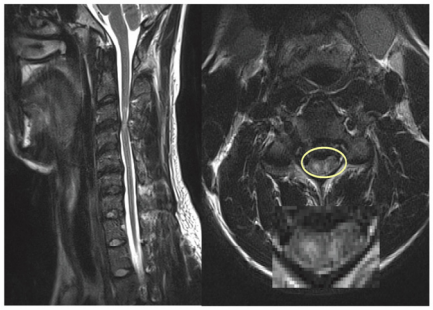


Cervical central spinal stenosis



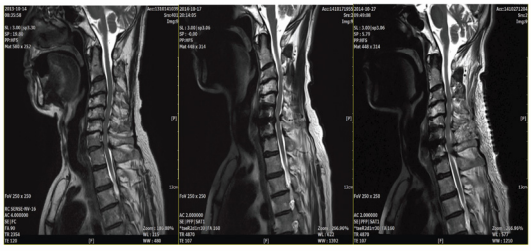
Cervical Spondylotic Myelopathy

- 28세 남자; 양측 손에 저린 감각과 우측 하지의 근력저하 발생

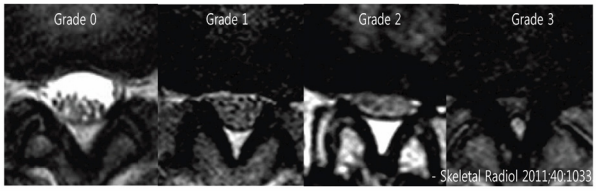


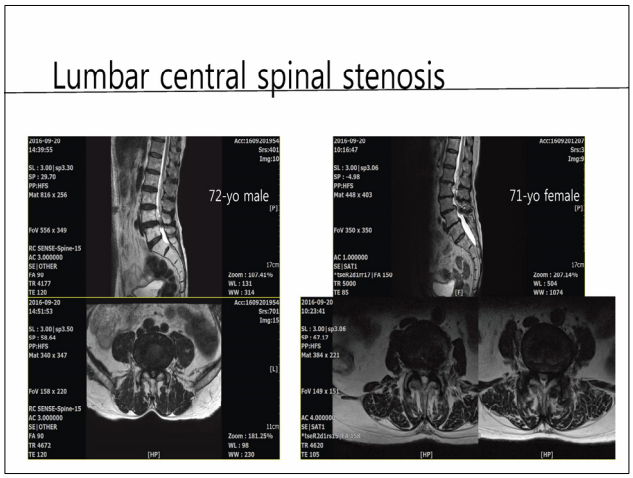
Cervical Spondylotic Myelopathy

- 66세 남자; R/O cervical spondylotic myelopathy
- 양쪽 발바닥이 저리고 무거워요. 외쪽 손가락이 저리고 오른쪽 손가락이 뻣뻣해요.



Lumbar central spinal stenosis




Lumbar central spinal stenosis
72-yo male
71-yo female