Disc Lesions and Standing MRI

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Introduction

- Chiropractors leadership
  - Improve diagnosis
  - Collect data for research

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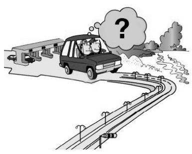
Where Are We Going?

- Role of General & Low Field MRI
- Basic MRI Physics
- MRI Interpretation
  - Correlate imaging with clinical findings including Modic changes
- Upright MRI
- Questions



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Different types of MR scanners

- **High-field** superconductive magnet closed bore (tunnel) design.
- Magnet strength above 1 Tesla - typically 1.5T or 3T

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Different types of MR scanners

- **Mid-field** hybrid superconductive or permanent/resistive magnet open design.
- Magnet strength typically 0.5T to 1T

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Different types of MR scanners

- **Low-field** permanent magnet open design.
- Magnet strength 0.1T to 0.5T

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Role of General & Low-Field MRI

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Role of General & Low-Field MRI

- When to order an MRI?
  - Acute Spine Pain
  - Chronic Spine Pain

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Acute Spine Pain

- Pain at night & not altered by changes in posture/movement
- Significant neurological deficit
- Suspicion of sinister pathology
- Over the age of 50 years

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Chronic Spine Pain

- Not improving after 4-6 weeks of conservative care
- Unexplained weight loss
- Suspected spinal instability
- Prolonged use corticosteroids/NSAIDs

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Low-Field Diagnostic Capability

- As with all types of imaging modalities, each type of MRI scanner has advantages and limitations

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Low-Field Diagnostic Capability

- high-field (>/= 1 Tesla) images do appear crisper, however this does not translate to increased diagnostic power in biomechanical imaging

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Lee R, et al. (2015)

Spine
SPINE Volume 40, Number 6, pp 382-391

DIAGNOSTICS

Diagnostic Capability of Low- *Versus* High-Field Magnetic Resonance Imaging for Lumbar Degenerative Disease

Ryan K. L. Lee, FRCR,* James F. Griffith, MD,* Yvonne Y. O. Lau, FRCS (Orth),† Joyce H. Y. Leung, FRCR,* Alex W. H. Ng, FRCR,* Esther H. Y. Hung, FRCR,* and S. W. Law, FRCS (Orth)†

Lee R, et al. (2015)

- low- versus high-field MRI for lumbar degenerative disease
- cohort study; 100 patients with neurogenic claudication or sciatica symptoms

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Lee R, et al. (2015)

- excellent reliability for disc herniation and stenosis – canal, lateral recess, exit foramen
- good agreement for nerve compression; longer scan times with low-field may have contributed to slightly reduced correlation

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Lee R, et al. (2015)

- "little reason why (low-field) 0.25T imaging systems should not be used to routinely investigate the degenerative lumbar spine."

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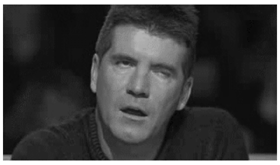
MRI Physics



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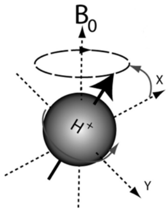
The 8 Key Concepts

- Spin
- Precession
- High / Low Energy State
- B0 Direction
- Resonance
- RF Pulse
- Parallel vs. Perpendicular magnetization
- Analogue to Digital Conversion



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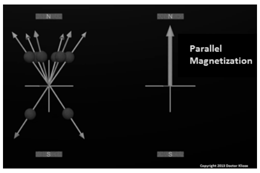
Energy State

- Net magnetization of H+ points with the main magnetic field
- This alignment is called parallel magnetization
- The parallel magnetization cannot be detected



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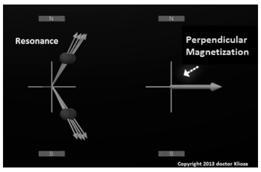
Influence of a RF Pulse

- Under the influence of a Radiofrequency Pulse, the magnetic moments of a % of H+ nuclei gain enough energy to be able to oppose the influence of the MRI magnet.
- This also creates perpendicular magnetization, which generates a small detectable electric current – MRI Signal



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Receiver Coil

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Different types of Pulse Sequences

- T1 weighted
- T2 weighted
- PD weighted
- STIR

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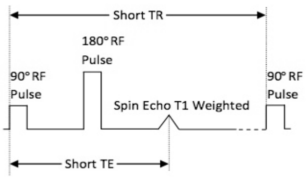
T1-W Pulse Sequence Example



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MRI Interpretation

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Correlating Imaging with Clinical Findings

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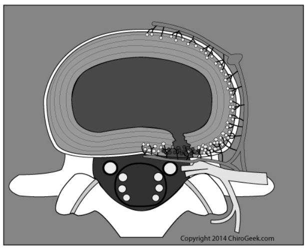
Discogenic Pain

- Internal disc architecture disruption
- SVN sensitization
  - Annulus
- BVN sensitization
  - Vertebral endplates



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Discogenic Pain Syndrome

- Painful change within the Disc
  - DDD
  - HIZ or other sign of annular fissure
  - Small protrusion: low back pain > leg pain

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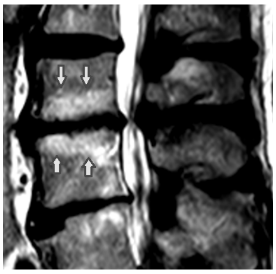
Discogenic Pain Syndrome

- Changes of the Vertebral Body
  - Modic Changes
  - Endplate Oedema
  - Schmorl's nodes



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Discogenic pain: Diagnosis

- Annular fissure on T2
- Small contained disc herniation
- + Provocative discography
- Negative Facet blocks
- Failed conservative care
- May or may not have isolated disc resorption

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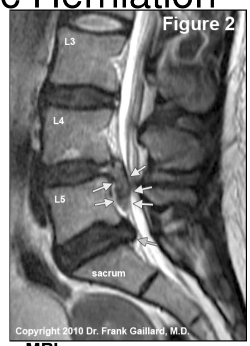
Lumbar Disc Herniation

- Nucleus escapes through the annulus



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HNP: Levels

- Most Common Local
  - L4/5
  - L5/S1
  - C5/6
  - C6/7
- Rare Locations
  - L2/3
  - L1/2

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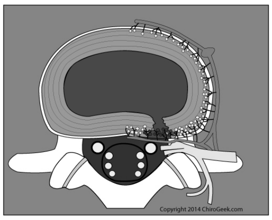
HNP: Locations/Zones

- Central/paracentral
- Subarticular/lateral recess
- Foraminal(intraforaminal /lateral)
- Extraforaminal(far lateral)
- Anterior



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Disc Defect Morphology

Herniation Type	Morphology	Symptoms	T1 Intensity	T2 Intensity
Diffuse Bulge	extends >2mm symmetrically/circumferentially beyond adjacent vertebral body margins	Nil		
Broad-based Protrusion (Focal Bulge)	extends >2mm beyond adjacent vertebral body margin in localised area	Nil typically	Decreased	Decreased
Focal Protrusion	AP < ML dimension: contained. Possible high intensity zone - lumbar	Possibly	Decreased	Decreased
Extrusion	1. AP >/= ML dimension: non-contained. 2. Disc migrates above &/or below disc of origin, but maintains continuity with it. 3. High Intensity Zone - lumbar	Yes	Decreased	Increased Decreased
Sequestration	Fragment separate from disc of origin	Yes	Decreased	Increased Decreased

Adapted from Helms C, et al. Musculoskeletal MRI. 2nd Ed

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HNP: Different Types

- Protrusion
  - AKA: contained disc herniation, subligamentous herniation
- Extrusion
  - AKA: non-contained disc herniation
- Sequestration
  - Fragmented disc, sequestered disc, free fragment

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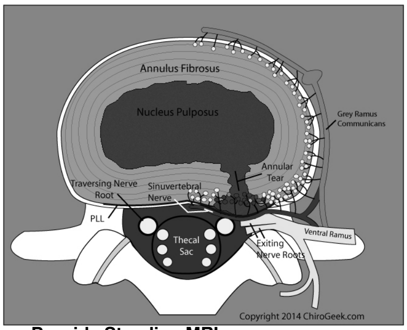
Lumbar Disc Protrusion



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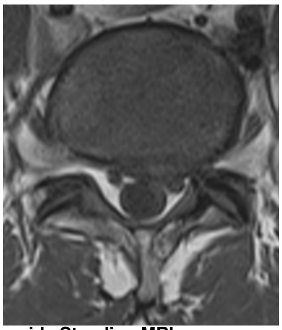
Disc Protrusion



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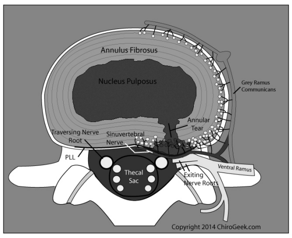
Disc Protrusion

- A.K.A.: subligamentous disc herniation, contained disc herniation
- Typically less than 5 mm
- Base > Outpouching
- Often poor discectomy result
- Poor chance at natural resorption



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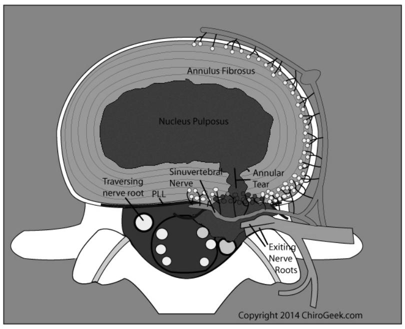
Lumbar Disc Extrusion



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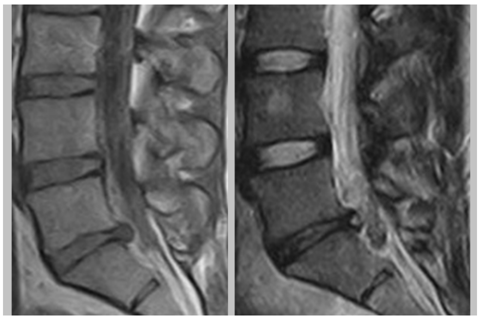
Lumbar Disc Extrusion



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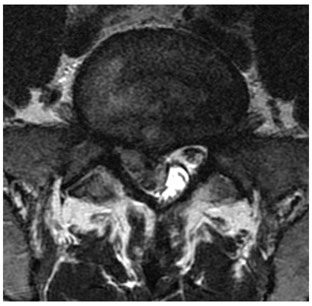
Disc Extrusion



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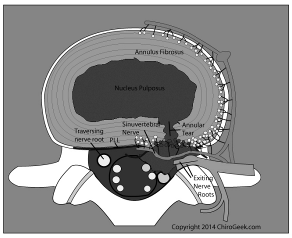
Disc Extrusion

- AKA: non-contained herniation
- typically greater than 5 mm
- Base is typically < outpouching
- Better chance of success via discectomy: <6/12
- Best chance at natural resorption



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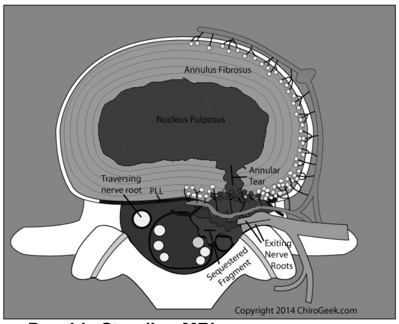
Lumbar Sequestration



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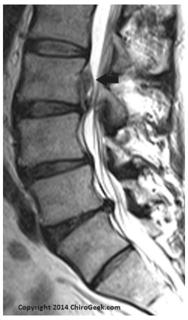
Disc Sequestration



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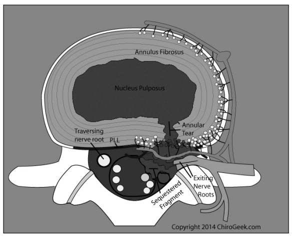
Disc Sequestration

- Fragment of disc herniation detaches
- May travel within the spinal canal
- Very good chance at natural resorption
- Often does well with discectomy



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High Intensity Zone

- HIZ seen on T2-weighted
- Intensity should match CSF
- Represents radial or transverse annular fissure
- Filled with granulation tissue
- Not always associated with lower back pain

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Modic Changes

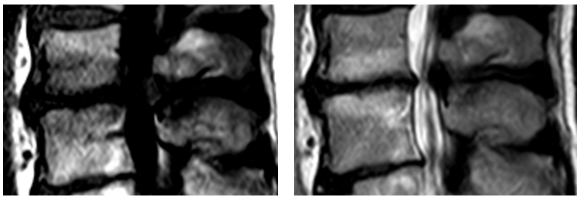
Rahme R, et al. (2008)

- Modic changes

Type I Modic Change

- Hypointense on T1W
- Hyperintense on T2W
- Bone marrow replaced
  - Oedema/adhesion-like lesions
  - Nociceptive fibre ingrowth
- Inflammatory stages of DDD
- Intersegmental instability

Type I Modic Change



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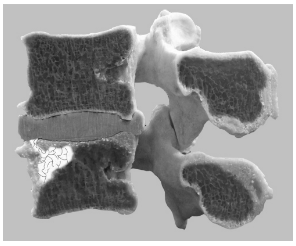
Type I Modic Change



Marrow Oedema

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Type I Modic Change

- Better fusion outcomes
- Worst discectomy outcomes
- Better intradiscal steroid outcomes

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Type II Modic Change

- Hyperintense on T1W
- Hypointense or isointense on T2W
- Marrow replaced by fat
- Fusion outcomes poor
- Intradiscal Steroid injection - poor

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Type II Modic Change

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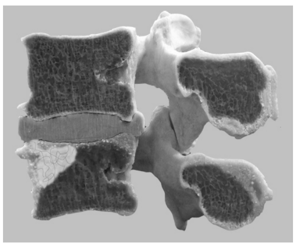
Type II Modic Change



Fatty Change

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Type III Modic Changes

- Hypointense on T1W and T2W
- Subchondral sclerosis
- Quite rare

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Bendix T, et al. (2012)

- Low-field MRI is better at detecting type I Modic change
- High-field MRI is better at detecting type II Modic change

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Correlating Imaging with Clinical Findings

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Upright MRI

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Upright MRI

- MSK practitioners – strong aid in DDx and Mx
- Researchers have noted significant differences in pathology as viewed on recumbent versus upright MRI*
- Some patients only have pain while in a certain position which now, because of positional and upright MRI, can be recreated during imaged to great potential benefit ^

**Lynton Giles, DC, PhD. 100 challenging spinal pain syndrome cases. 2009, Churchill Livingstone, Elsevier*

^ Michelle Wessely, DC, DACBR, et al. Essential musculoskeletal MRI: a primer for the clinician. 2011, Churchill Livingstone, Elsevier.

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Upright MRI

- Conventional MRIs are done in a supine position which unloads the spine
- Why place the patient in a position that may provide the least chance of observing an abnormality?*

*Gedroyc WM, M.D., radiologist. Upright positional MRI of the lumbar spine. Clin Radiol 2008; 63:1049-1050.

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Upright Case Examples

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Case Examples: supine versus standing imaging

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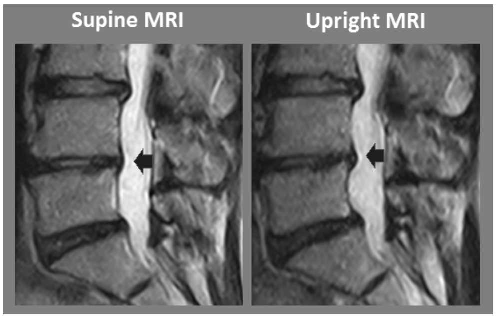
Disc Protrusion Comparison



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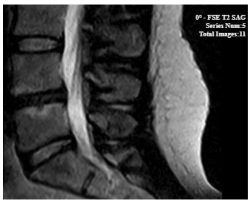
Disc Protrusion Comparison




Supine Standing

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Disc Protrusion Comparison


Supine Standing

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Disc Extrusion Comparison

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Upright MRI

Upright MRI Research

Tarantino U, et al. (2013)

- Upright MRI changes morphology compared to conventional MRI
  - Volume increase in disc herniations
  - More likely to ID extent of facet joint pathology
  - More likely to ID segmental instability
  - More likely to ID occult neuroforaminal stenosis
- Upright MRI complements conventional MRI for the diagnosis of spinal instability

Splendiani A, et al. (2014)

- Dynamic occult neural foraminal stenosis revealed by upright MRI
- Lumbar lordosis alteration
- Lumbosacral angle alteration

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Kim Y, et al. (2013)

- Facet arthrosis or synovial cyst may go undetected in conventional MRI
- Weight-bearing MRI may bring such causes of dynamic central stenosis to light
  - Weight-bearing may reduce facet joint effusion
- Neural foramen not affected by weight-bearing axial-loaded method

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Splendiani A, et al. (2016)

- 10 year retrospective study of 4305 patients
- 4 degenerative aspects of Lumbar spine evaluated between recumbent and standing

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Splendiani A, et al. (2016)

- Changes:
  - Disc protrusion upright only: 11%
  - Central stenosis increase or upright only: 9.2%
  - Lordosis >10 deg: 38.7%
  - Listhesis translation >3mm or upright only: 9.5%

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Hansen B, et al. (2018)

- Study of reliability & agreement of common lumbar degenerative findings in recumbent/standing MRI
- 56 LBP patients +/- sciatica
- Initial interpretation then re-interpretation 2 months later

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Hansen B, et al. (2018)

- 3 radiologists independent evaluation for herniation, stenosis, listhesis, HIZ lesions, facet joint effusion, nerve root compression

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Hansen B, et al. (2018)

- Acceptable absolute reproducibility & reliability
- Since fair to substantial reliability & lower inter- and intra-reader reliability between supine and standing changes -> further standardisation needed to aid reporting

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Point of view

- Correlate more accurately with patient clinical data

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Questions

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Resources

- www.chirogeek.com
- Wessely M, et al. Essential Musculoskeletal MRI: A Primer for the Clinician. Churchill Livingstone, Elsevier 2011.
- Giles L. 100 Challenging Spinal Pain Syndrome Cases. Churchill Livingstone, Elsevier 2009.
- MRI Essentials: 1 Day Seminar/Workshop

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Disc Lesions and Standing MRI. ACA Conference 2019

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14. Splendiani A, et al. *Magnetic resonance imaging of the lumbar spine with dedicated G-scan machine in the upright position: a retrospective study and our experience in 10 years with 4305 patients.* Radiol Med 2016;121:38-44.

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