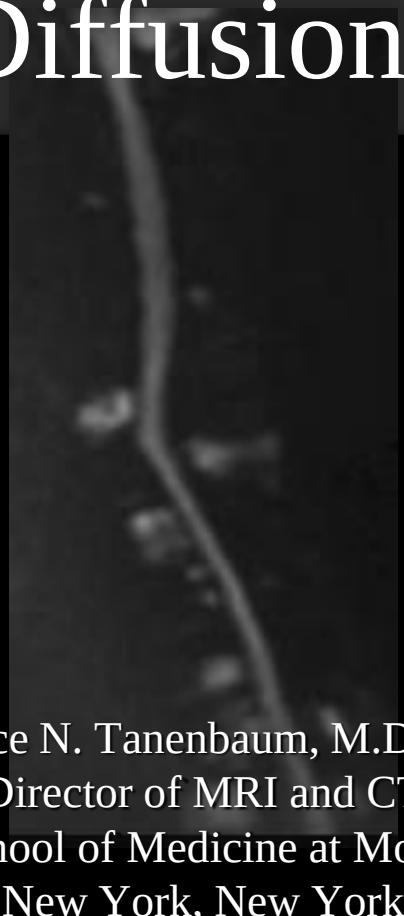
Spine Diffusion Imaging



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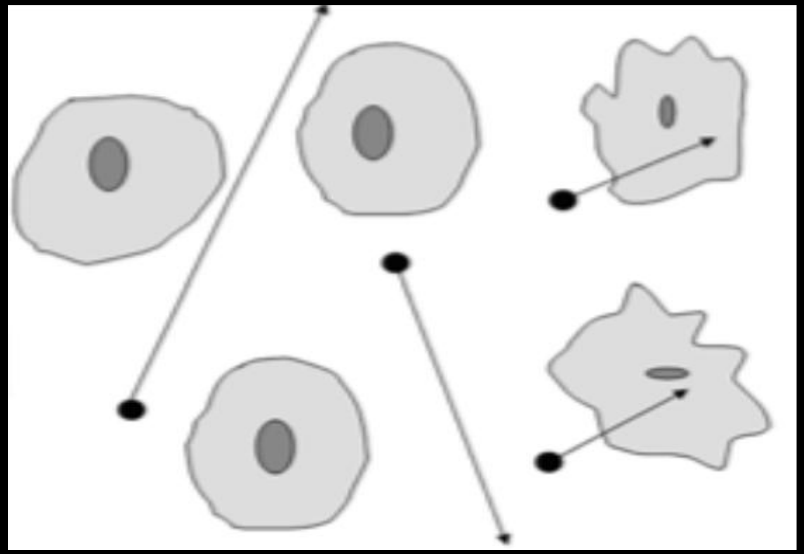
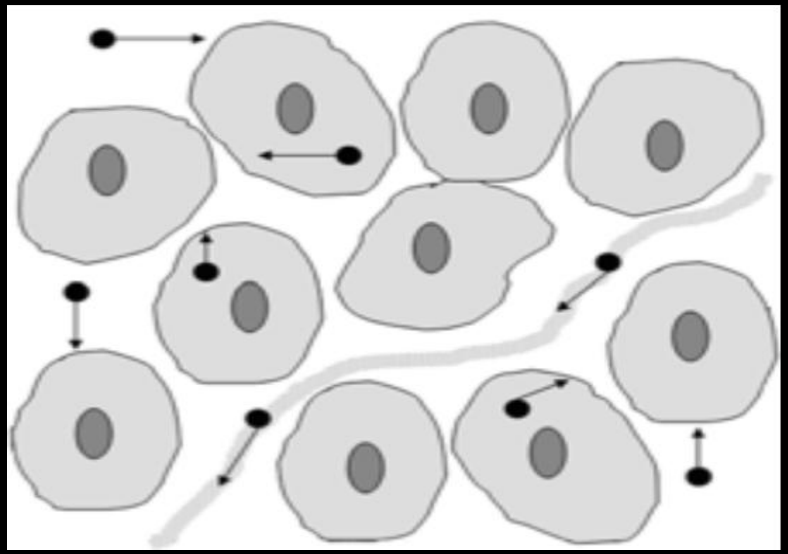
Free Diffusion



Normal marrow

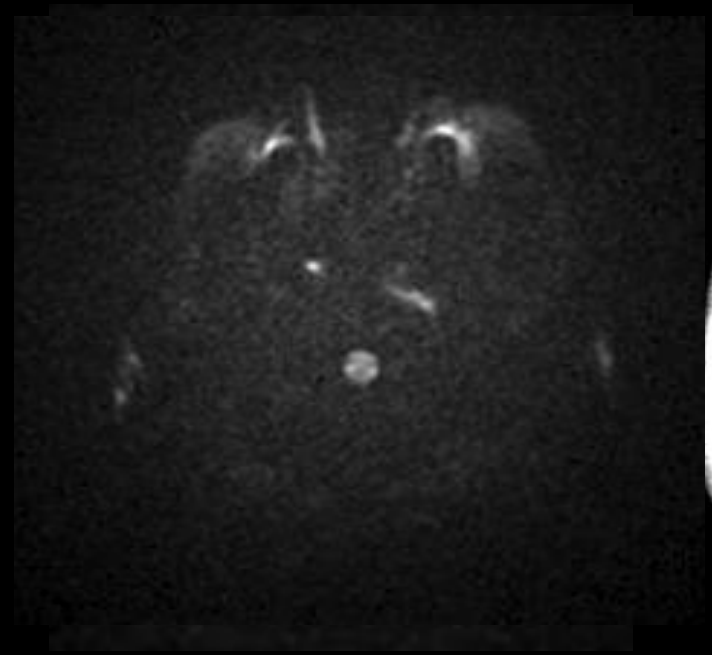
Restricted Diffusion

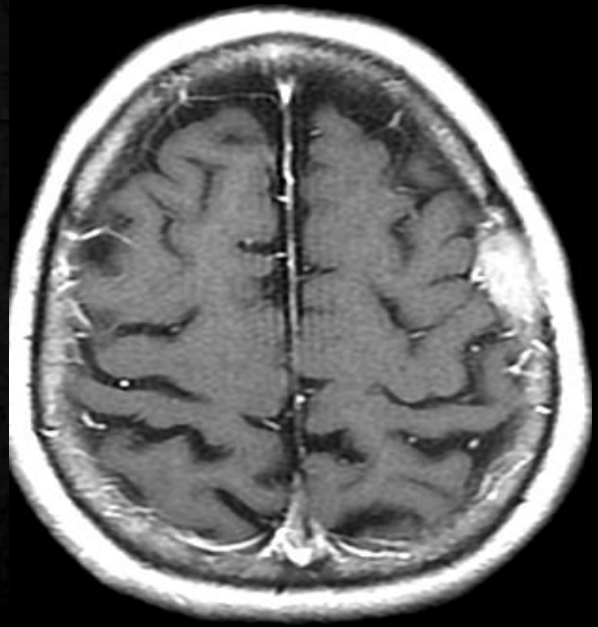


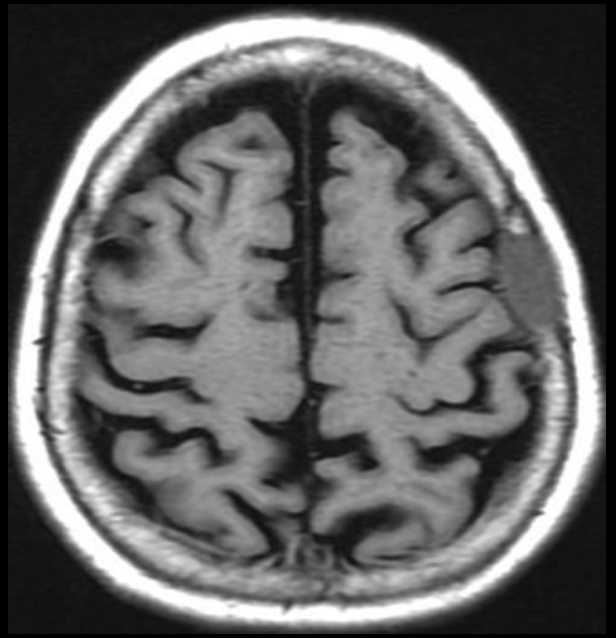
Infiltrated marrow

Dow-Mu Koh et al. Diffusion Weighted MR in the Body: Applications and challenges in oncology. AJR 188. 1622-34

metastatic disease







Diffusion and spine metastases

- Dietrich O, Biffar A, Reiser MF, Baur-Melnyk A. Diffusion-weighted imaging of bone marrow. Semin Musculoskelet Radiol. 2009 Jun;13(2):134-44
- Karchevsky M, Babb JS, Schweitzer ME. Can diffusion-weighted imaging be used to differentiate benign from pathologic fractures? A meta-analysis. Skeletal Radiol. 2008 Sep;37(9):791-5
- Castillo M. Diffusion-weighted imaging of the spine: is it reliable? AJNR Am J Neuroradiol. 2003 Jun-Jul;24(6):1251-33
- Balliu E, Vilanova JC, Peláez I, Puig J, Remollo S, Barceló C, Barceló J, Pedraza S. Diagnostic value of apparent diffusion coefficients to differentiate benign from malignant vertebral bone marrow lesions. Eur J Radiol. 2009 Mar;69(3):560-6
- Baur A, Dietrich O, Reiser M. Diffusion-weighted imaging of the spinal column. Neuroimaging Clin N Am. 2002 Feb;12(1):147-60
- Castillo M, Arbelaez A, Smith JK, Fisher LL. Diffusion-weighted MR imaging offers no advantage over routine noncontrast MR imaging in the detection of vertebral metastases. AJNR Am J Neuroradiol. 2000 May;21(5):948-53

Diffusion weighted imaging facilitates detection of spinal metastases

Parag* Y, Delman B, Pawha P, Tanenbaum L

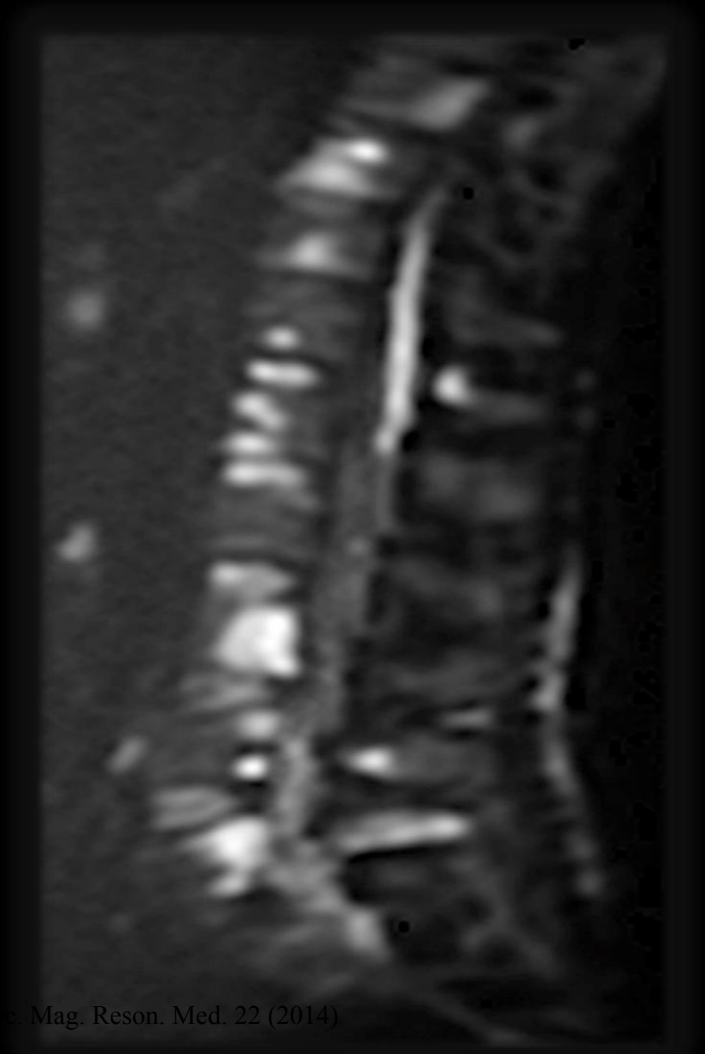
Mount Sinai School of Medicine

New York, NY

American Society of Spine Radiology 2010 Annual meeting

European College of Radiology 2010 Annual Meeting

American Society of Neuroradiology 2010 Annual meeting



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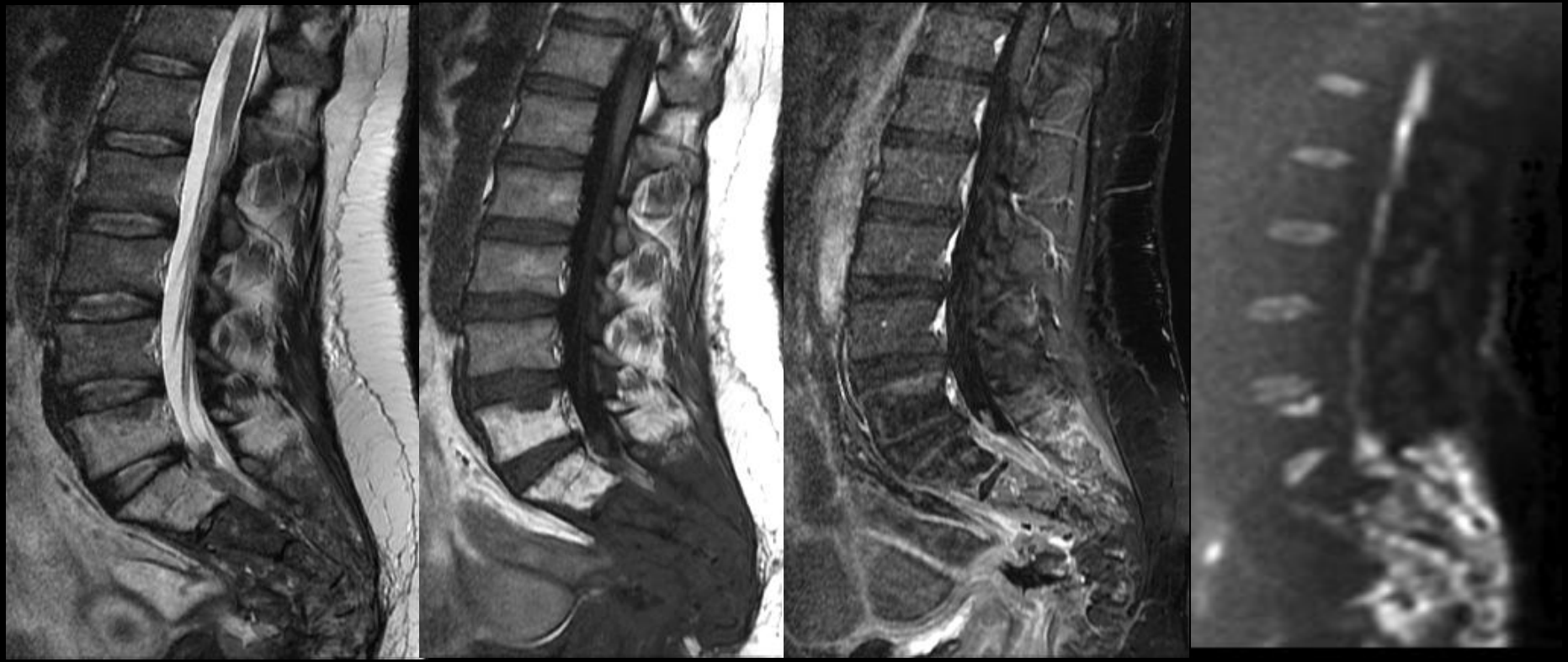
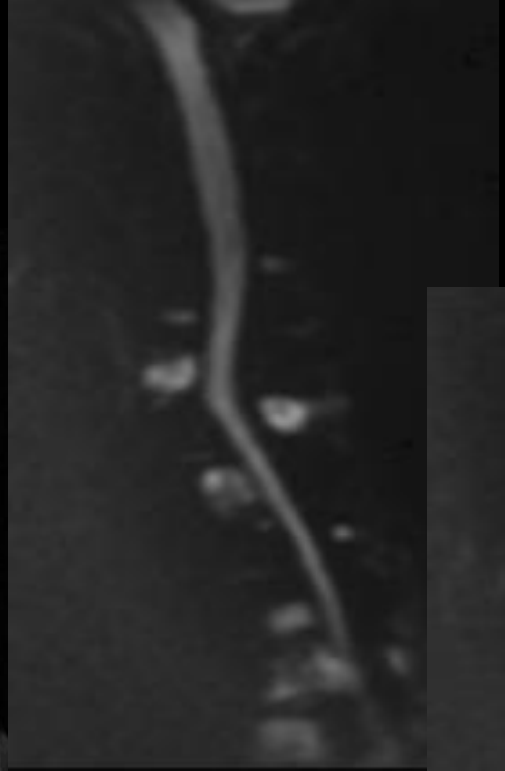
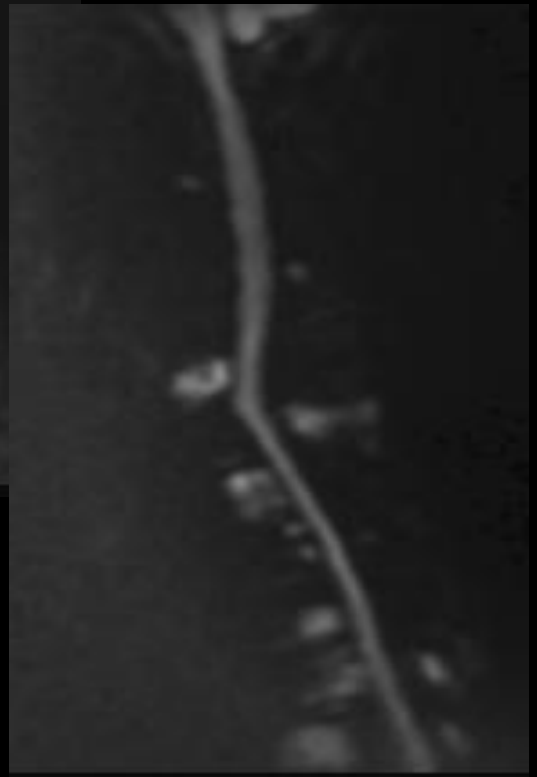
spine DWI
in
metastatic disease

May 2012







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Diffusion and spine metastases
lesion conspicuity

- 23/85 (27%) similar on conventional and DWI
- 40/85 (47%) more conspicuous on the diffusion sequence
- 16/85 (19%) more conspicuous on conventional sequences
- 6 (7%) lesions identified on DWI were initially missed on conventional sequence evaluation

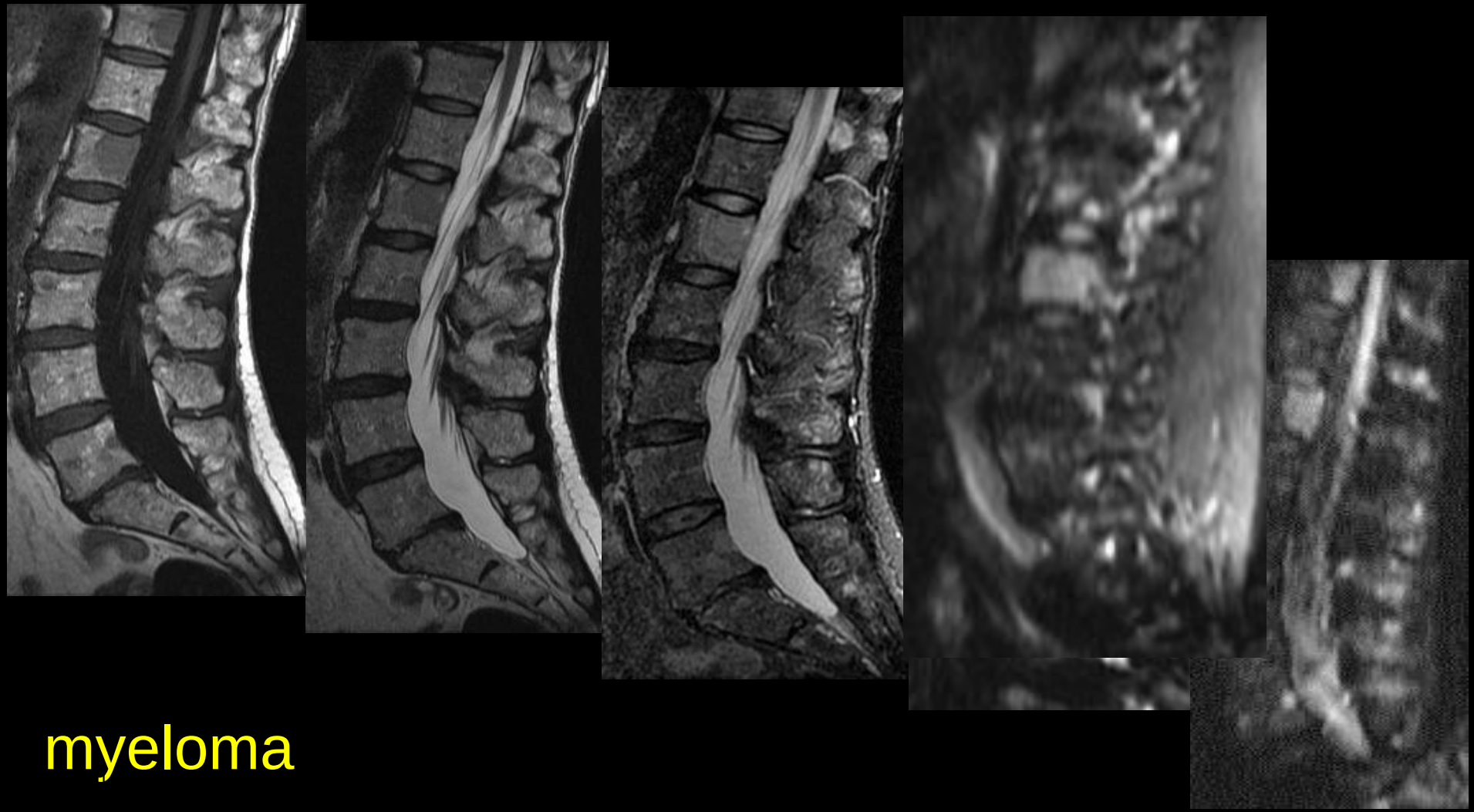
Diffusion weighted imaging facilitates detection of spinal multiple myeloma

James Kessler, Puneet S. Pawha,
Katya Shpilberg, Lawrence N. Tanenbaum

Mount Sinai School of Medicine

New York, NY

American Society of Spine Radiology 2011 Annual Meeting
American Society of Neuroradiology 2011 Annual Meeting



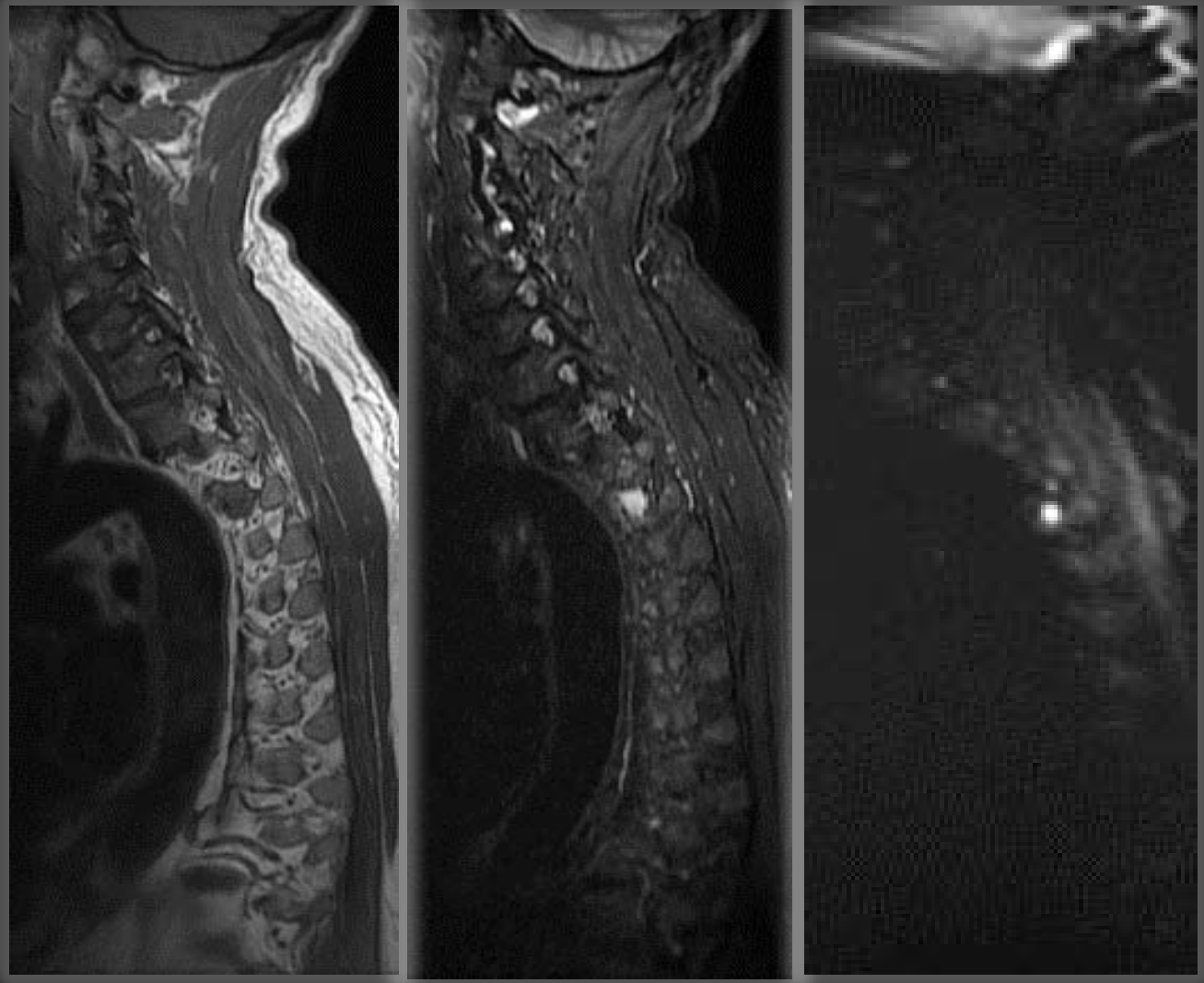
myeloma

Lesion Conspicuity

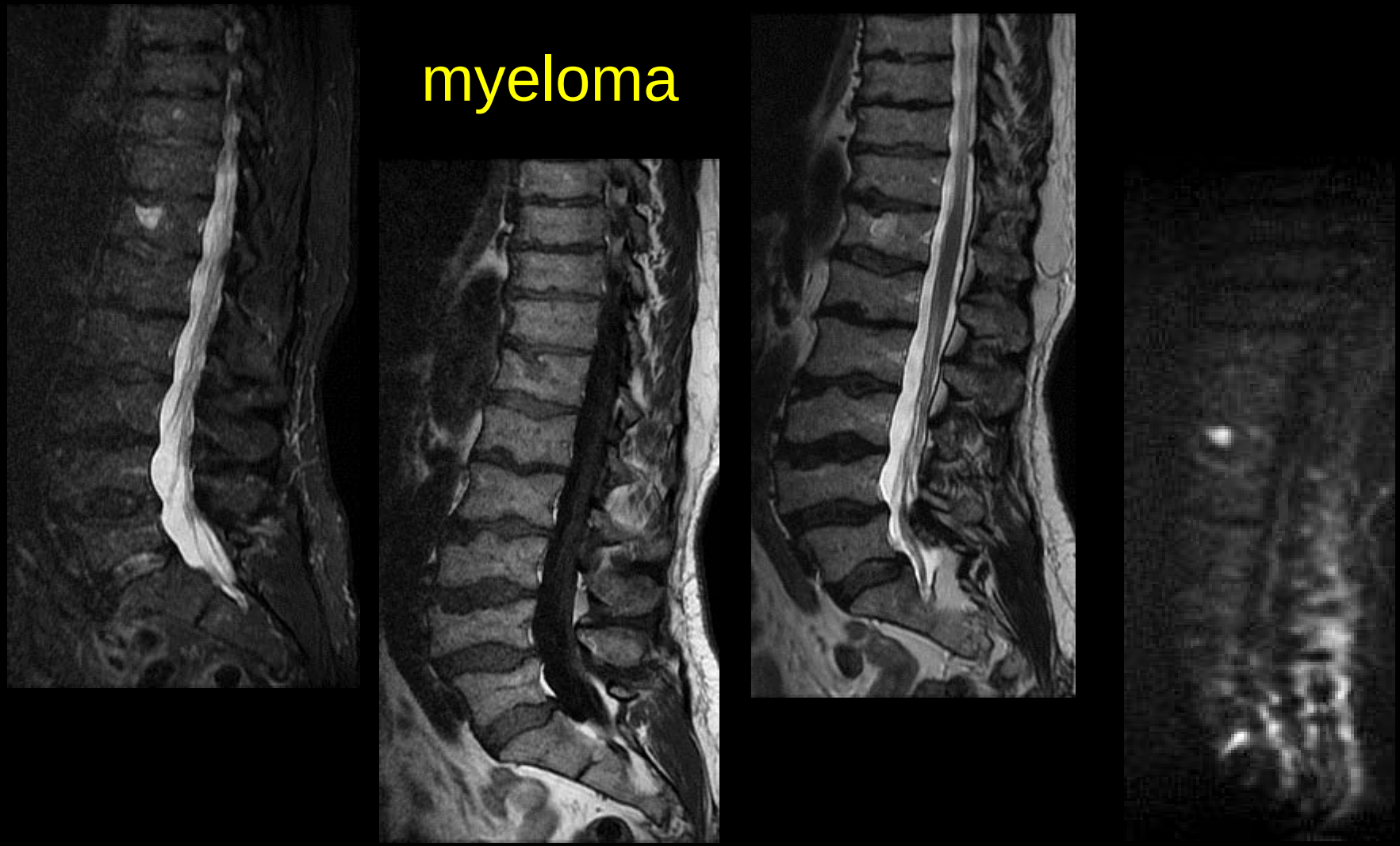
- 32 of 105 lesions (30%) were deemed similar in conspicuity between traditional sequences and DWI
- 51 of 105 lesions (49%) were more conspicuous on DWI
- 22 of 105 lesions (21%) were more conspicuous on traditional sequences
- 11 of 105 lesions (10%) were missed on conventional sequences and detected on DWI


B400
Myeloma
B0
3 in 1

myeloma



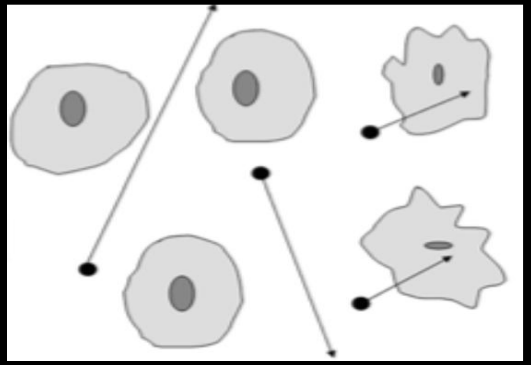
myeloma

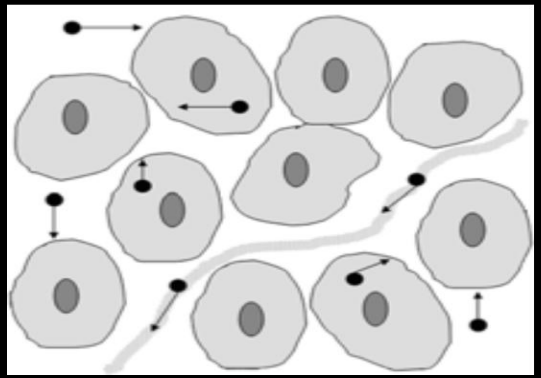


Compression fracture

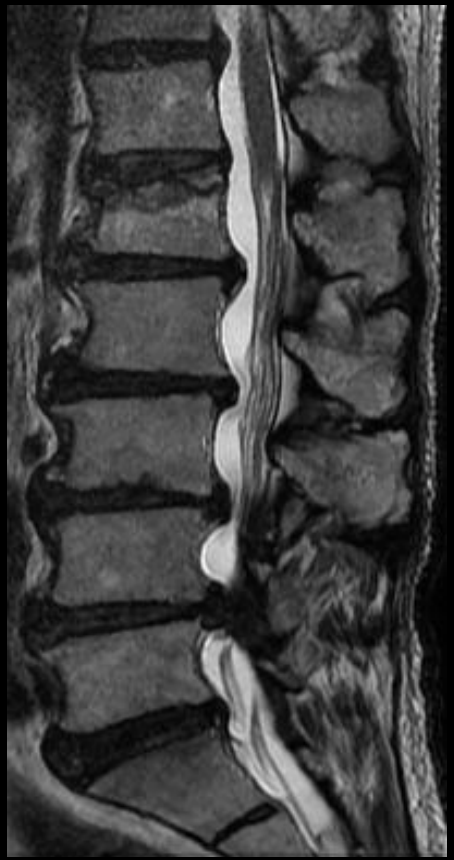
Sensecent vs. pathologic

- theory
  - benign fracture
    - “edema” *freely* diffusing in bone interstices
    - **low** signal on DWI (high ADC)
  - malignant fracture
    - water *in* tumor cells infiltrating bone
    - **high** signal on DWI (low ADC)







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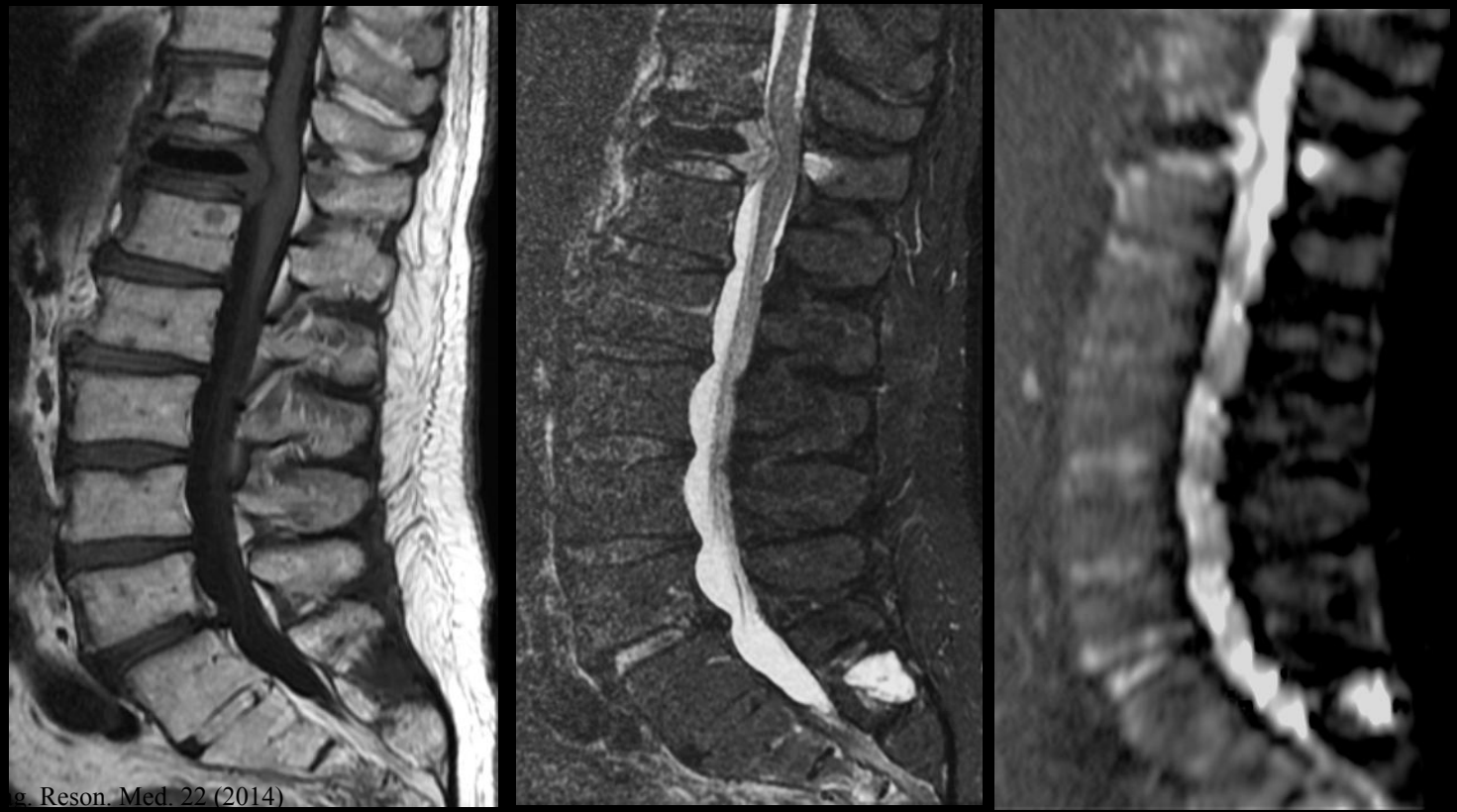
multiple myeloma



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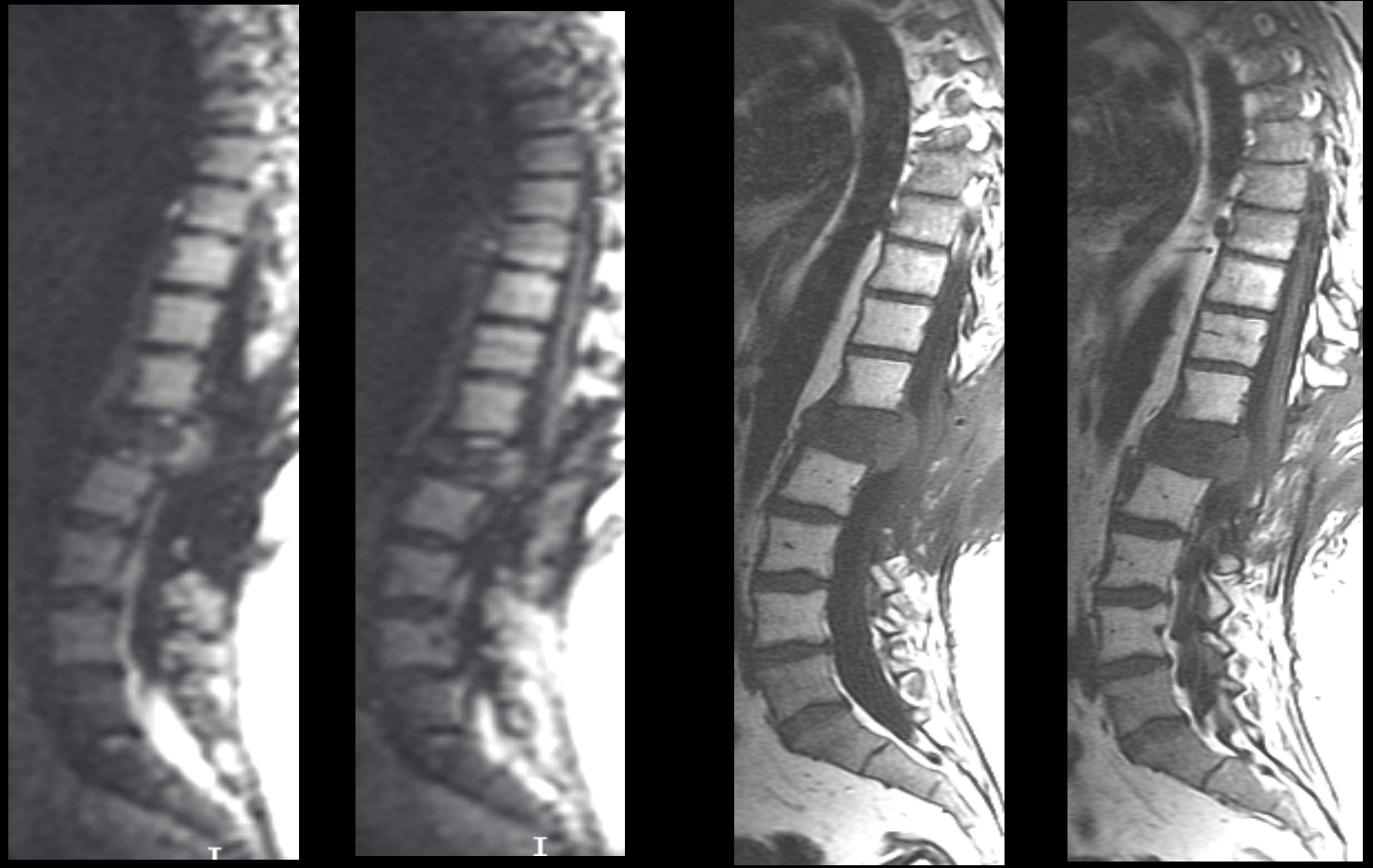
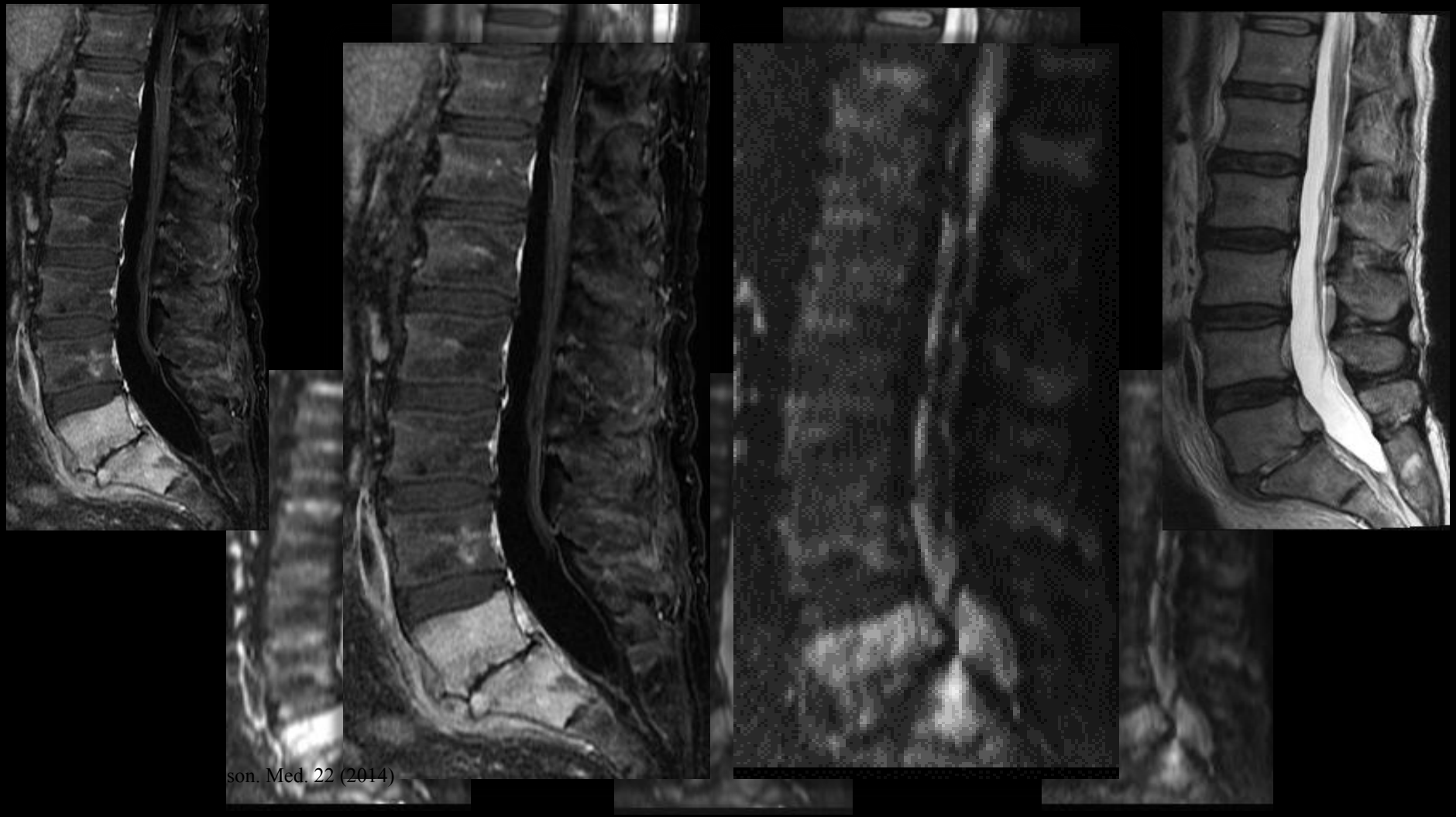


Diffusion imaging

spine indications

- infection
  - –detection
  - –surveillance
  - –problem solving

Melbourne 2012



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Osteomyelitis and discitis

Epidural abscess

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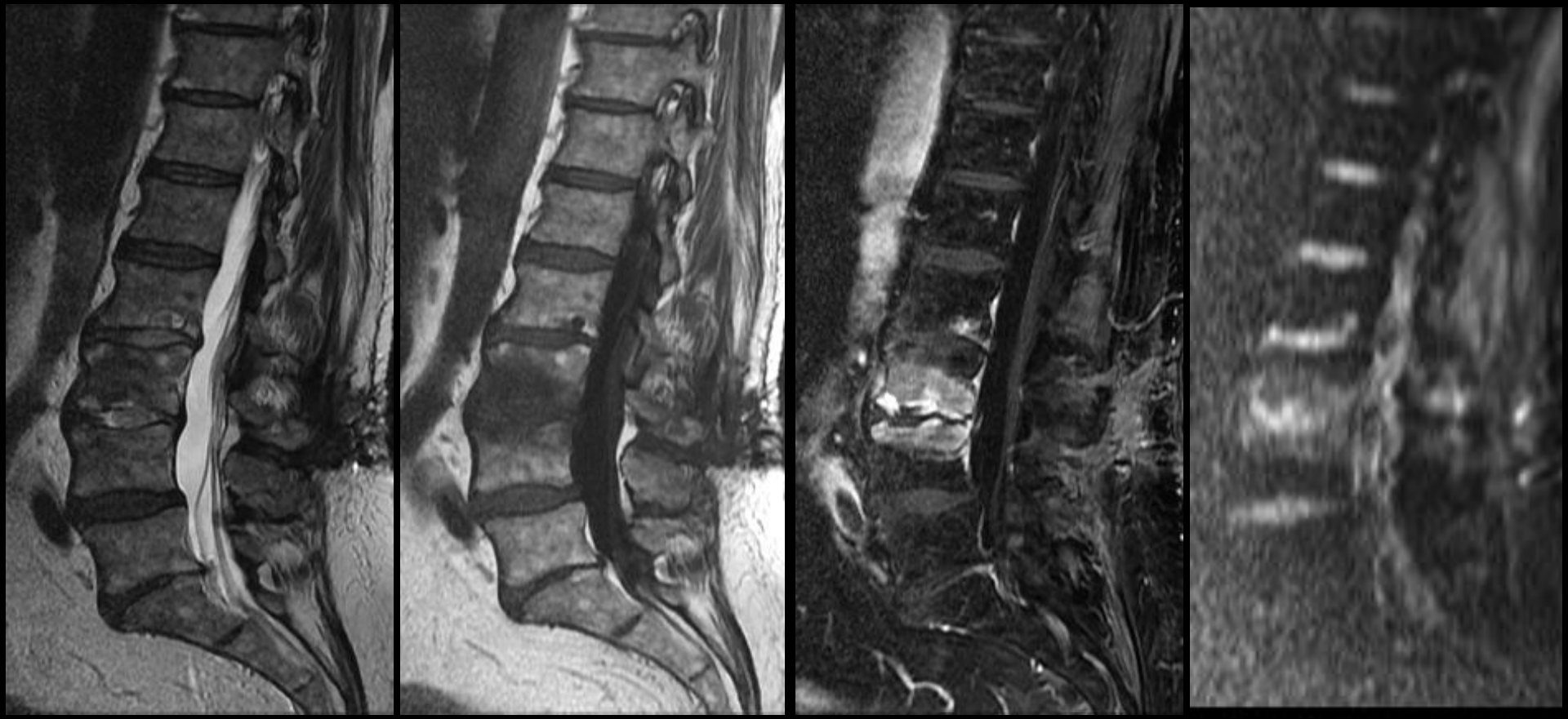
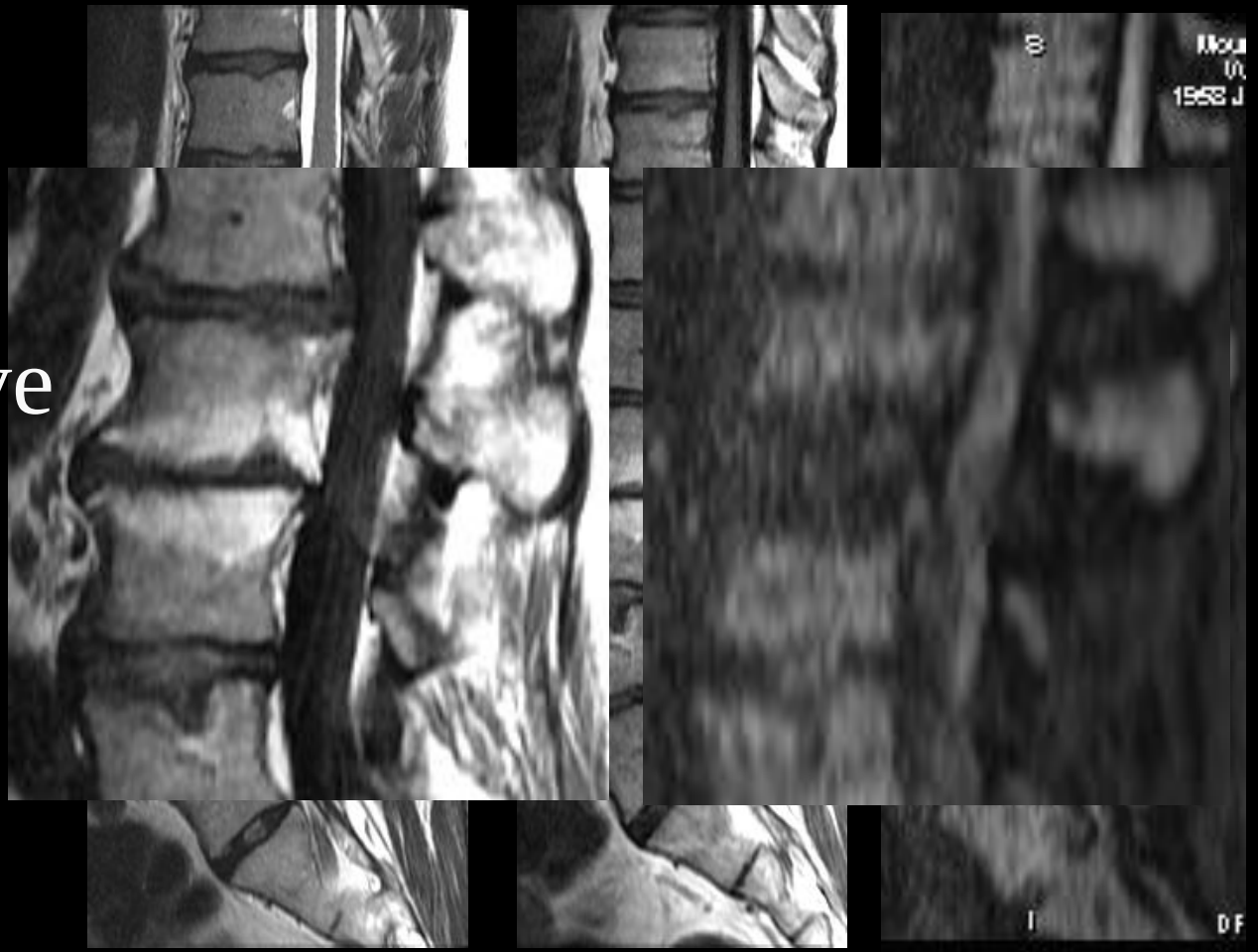


- Degenerative Disc Disease



Diffusion imaging

spine indications

DWI
Type I
degenerative
disc disease
changes

Problem solving

- Modic et al. characterized and classified signal changes in vertebral body marrow adjacent to the endplates of degenerative discs

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

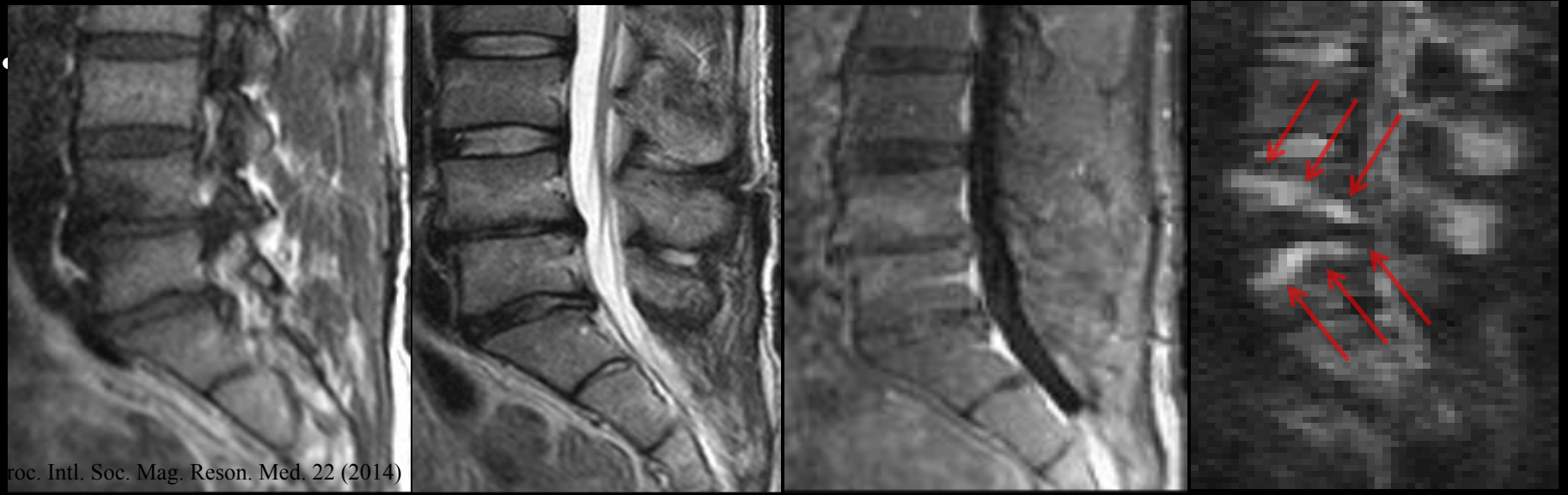
Degenerative disk disease: assessment of changes in vertebral body marrow with MR imaging.
M T Modic, P M Steinberg, J S Ross,
T J Masaryk and J R Carter
January 1988 Radiology, 166, 193-199.

Problem solving

- Type I Modic signal difficult to differentiate from osteomyelitis/discitis
- more likely to be clinically symptomatic

DWI “claw sign”

- well marginated, linear, typically paired regions of high signal on trace/combined DWI
- seen at the boundary of the vascularized bone marrow and/or edema and the normal marrow



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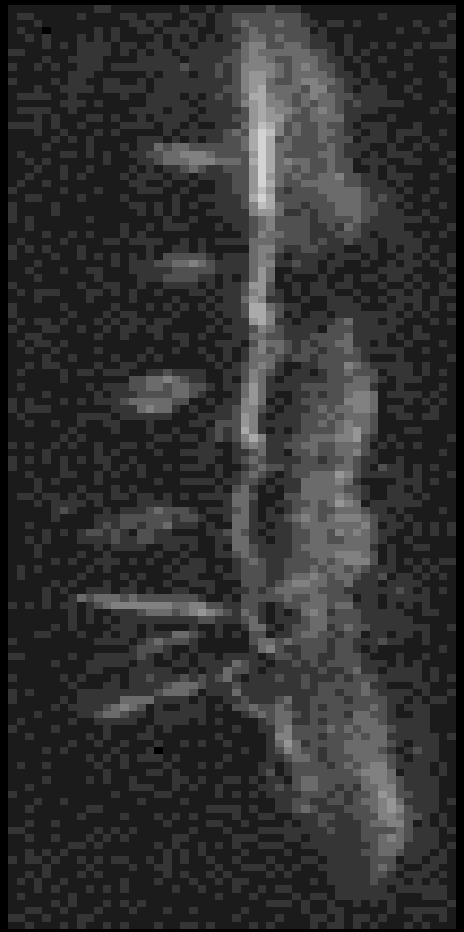
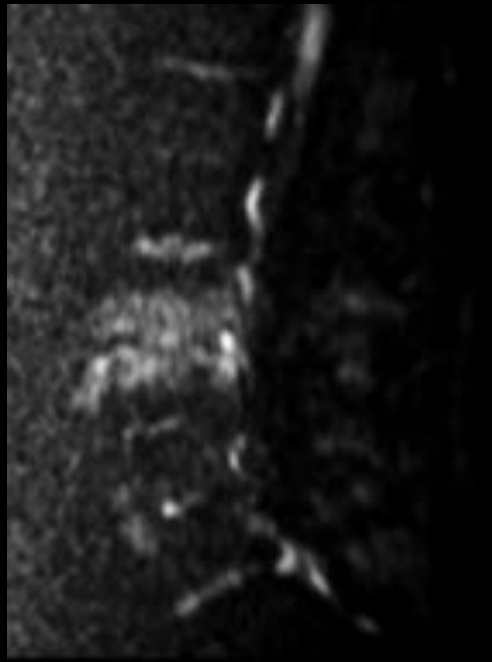
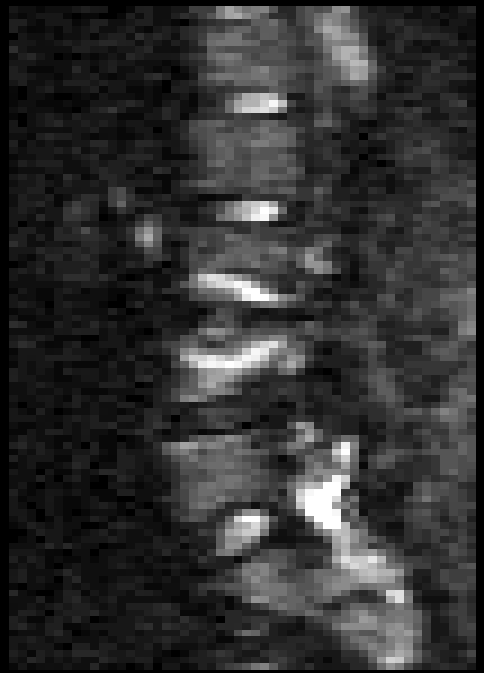
Type I degenerative signal changes



Diffusion-weighted MRI “claw sign” in differentiation of infectious from degenerative disease





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Michael Poplawski, PhD
Puneet Pawha MD
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Mount Sinai School of Medicine
New York , NY

Design- subject population

Study groups:

1. **Modic I**
   - type I pattern on MR imaging
   - no suggestion of infection in original report
   - no clinical evidence of infection

2. **Suggested infection (disproved)**
   - type I pattern on MR imaging
   - signal changes suggestive of discitis in original report
   - no clinical evidence of infection
   - minimal change, resolution, or evolution to type II on follow-up MR (if available)

3. **Infection (confirmed)**
   - type I pattern on MR imaging
   - signal changes highly suggestive of discitis in original report
   - evidence of infection (e.g. positive biopsy, PET, laboratory findings, blood culture)

Group characteristics:

Group	n	Age	Male%	Female%	Affected spine level	% studies w/contrast
Modic I	33	58.7±15	58	42	C (0); T (1); L (32)	64
Suggested Infection	20	63.2±17	50	50	C (0); T (1); L (19)	40
Infection (confirmed)	20	53.5±14	65	35	C (3); T (5); L (12)	65

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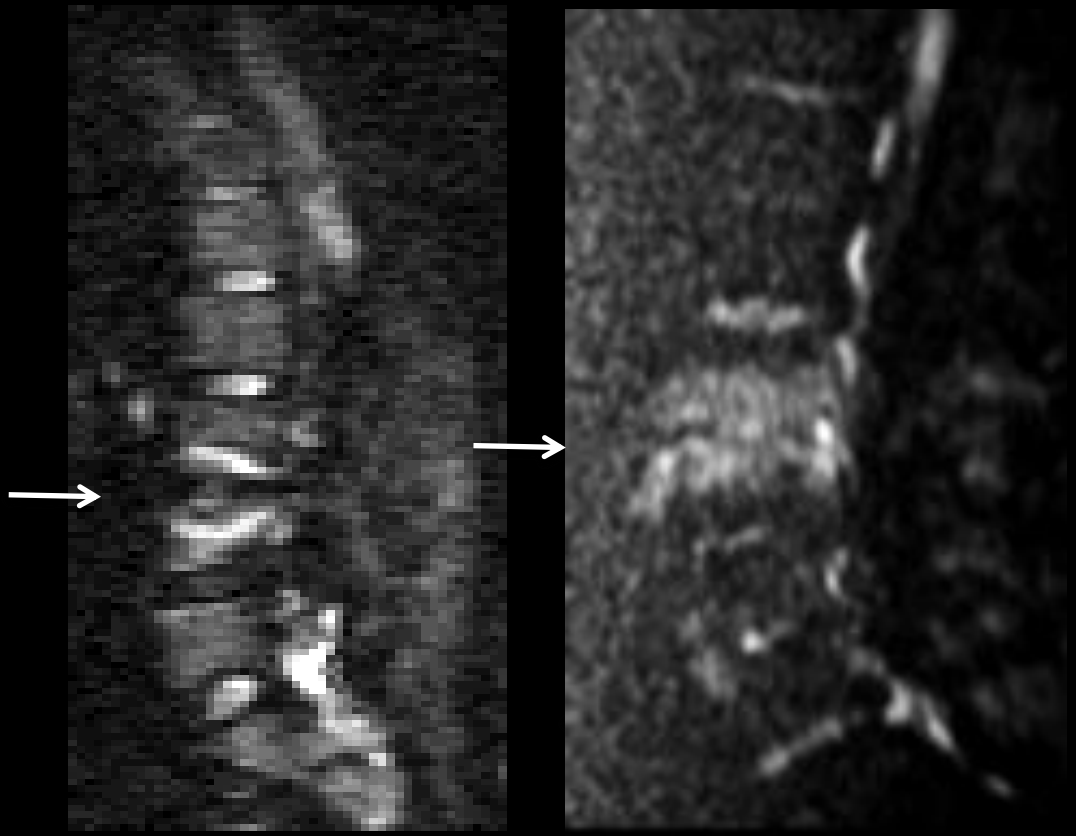
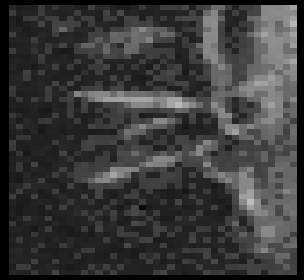
Definite “claw” - 1

Absent “claw” - 4

52yo M with Modic I degenerative change



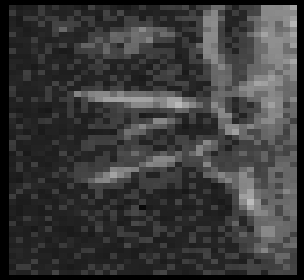
57yo M with confirmed osteomyelitis



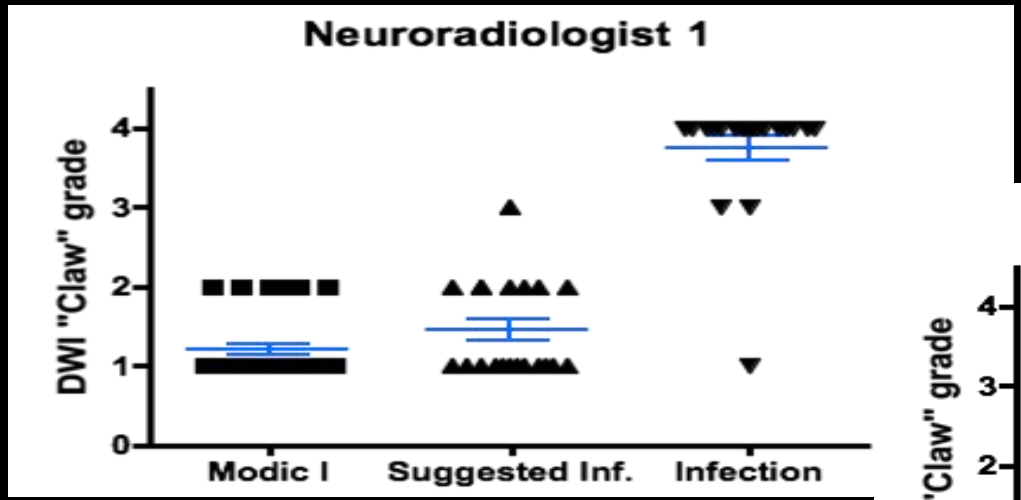
Results – DWI “claw”

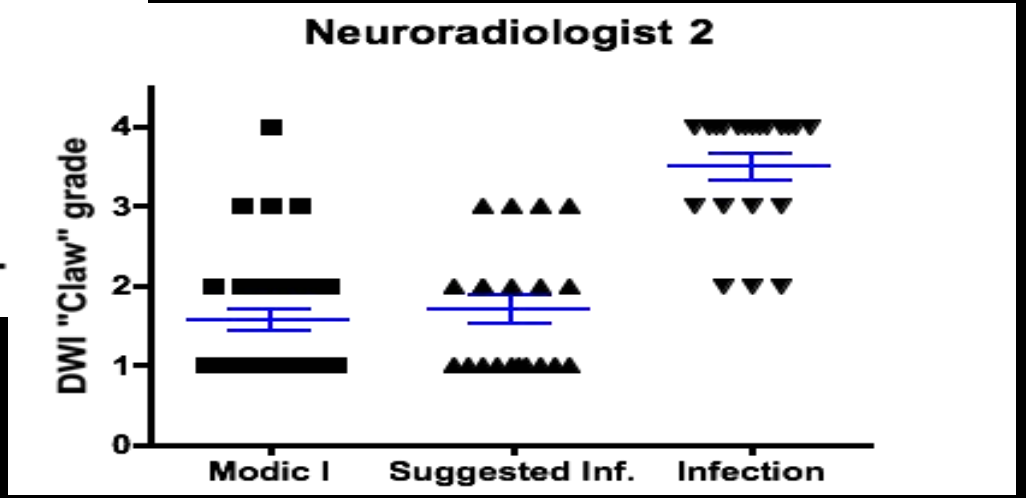
	Reader 1	Reader 2
	Claw score (ave±SE)	**Claw score (ave±SE)**
Modic I	**1.21±0.07**	**1.58±0.14**
Suggested Infection	**1.45±0.13**	**1.70±0.18**
Infection (confirmed)	**3.75±0.16 Ψ**	**3.50±0.17 Ψ**

Rating scale: 1 –definite, 2 probable, 3 doubtful, 4 absent



Results – DWI “claw”





Results

Utility of the ***absence*** of the "claw sign" (grade 3 and 4) for predicting discitis

All groups

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
95	85	98	85

NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
98	94	95	68

Infection suggested or suspected

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
95	85	95	80

NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
95	84	95	81

Results

Utility of *high T2 disc signal* for predicting discitis

All groups

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
95	85	62	70

NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
97	93	49	52

Infection suggested or suspected

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
95	85	25	45

NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
83	75	56	50

2014)

Results – disc C+ enhancement

Utility of moderate-severe disc enhancement for predicting discitis:

All groups

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
23	37	93	87

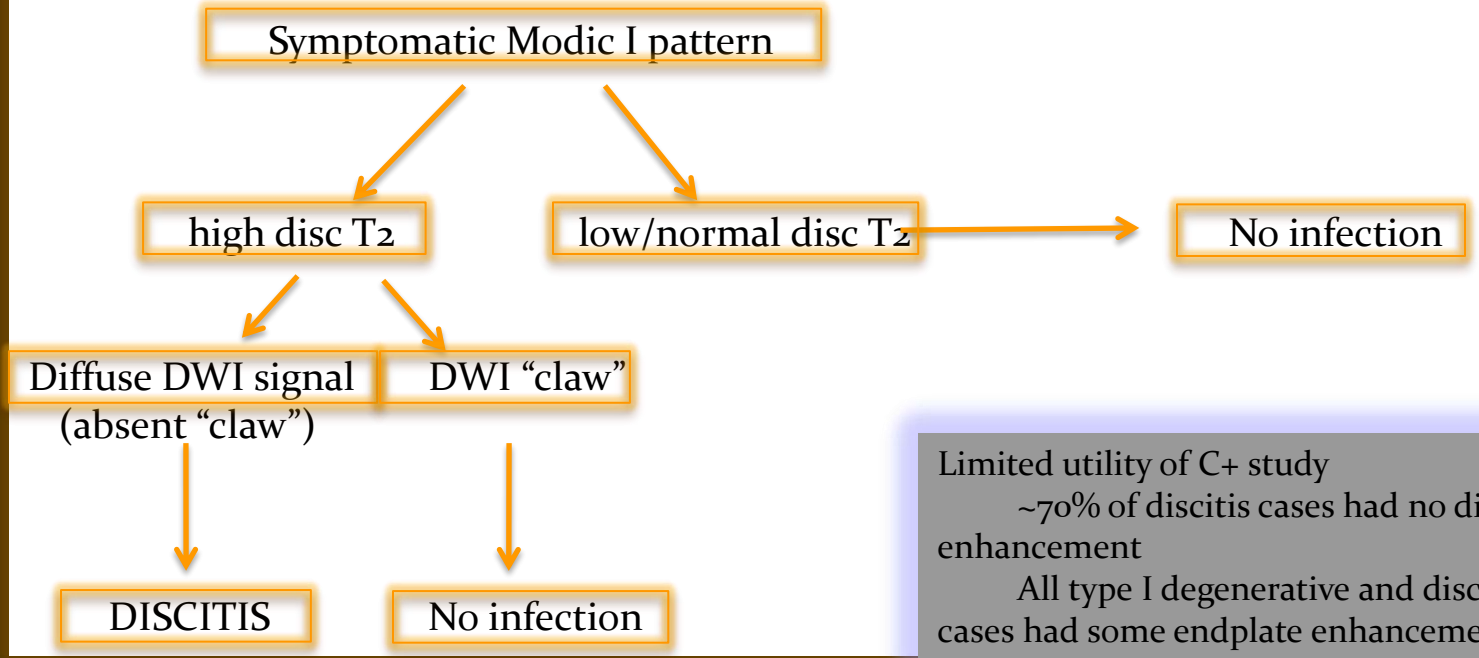
NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
73	73	60	60

Infection suggested or suspected

Sensitivity		Specificity	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
23	38	75	60

NPV		PPV	
Neurorad #1	Neurorad #2	Neurorad #1	Neurorad #2
38	38	60	60

Proposed algorithm



Limited utility of C+ study

~70% of discitis cases had no disc enhancement

All type I degenerative and discitis cases had some endplate enhancement

Conclusions
Potential cost benefits

- Avoid:
  - routine use of contrast in suspected infection
  - characterization C+ study
    - contrast agent
    - scanning sequences
    - interpretation
  - follow-up exams generated by concern
- avoid patient anxiety, diagnostic aspiration, lab testing

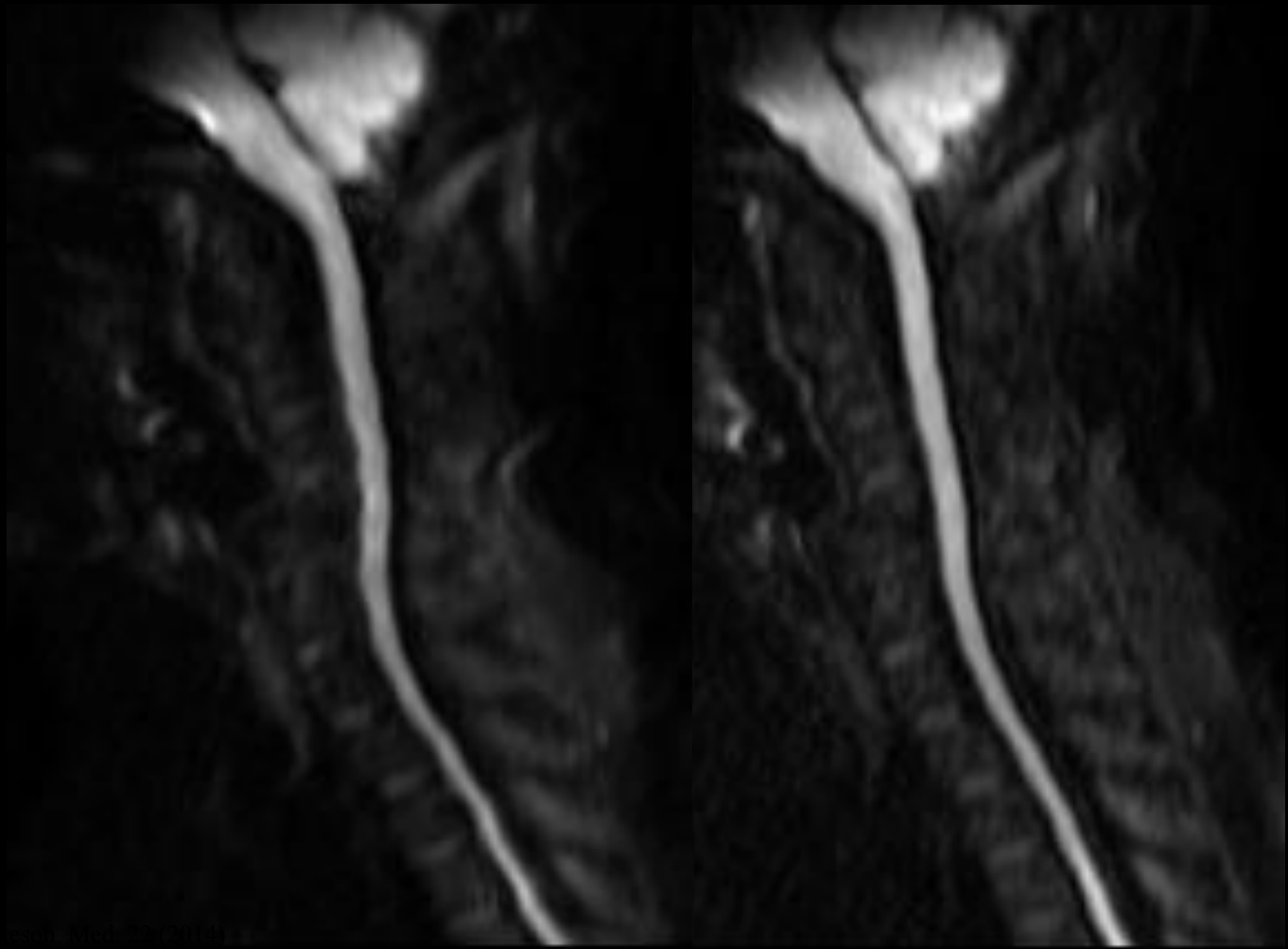
New Diffusion Techniques

- Parallel imaging
- 3 in 1
- Restricted FOV
  - –FOCUS
- Multishot
  - –RESOLVE

New Diffusion Techniques

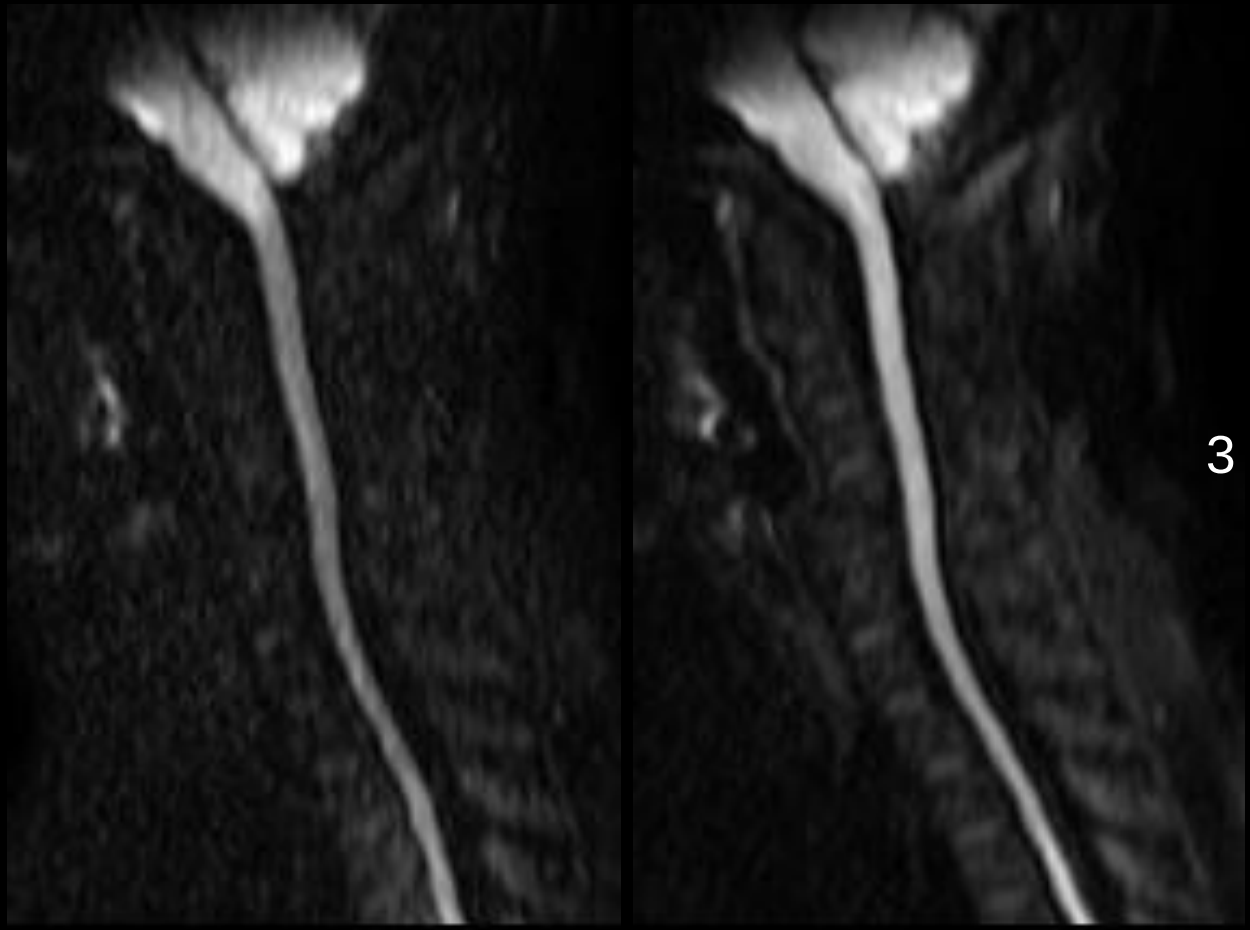
- Parallel imaging
- 3 in 1
- Restricted FOV
  - –FOCUS
- Multishot
  - –RESOLVE

No PI



PI 2

Tensor DWI
1:30



3 in 1 DWI
0:38


S
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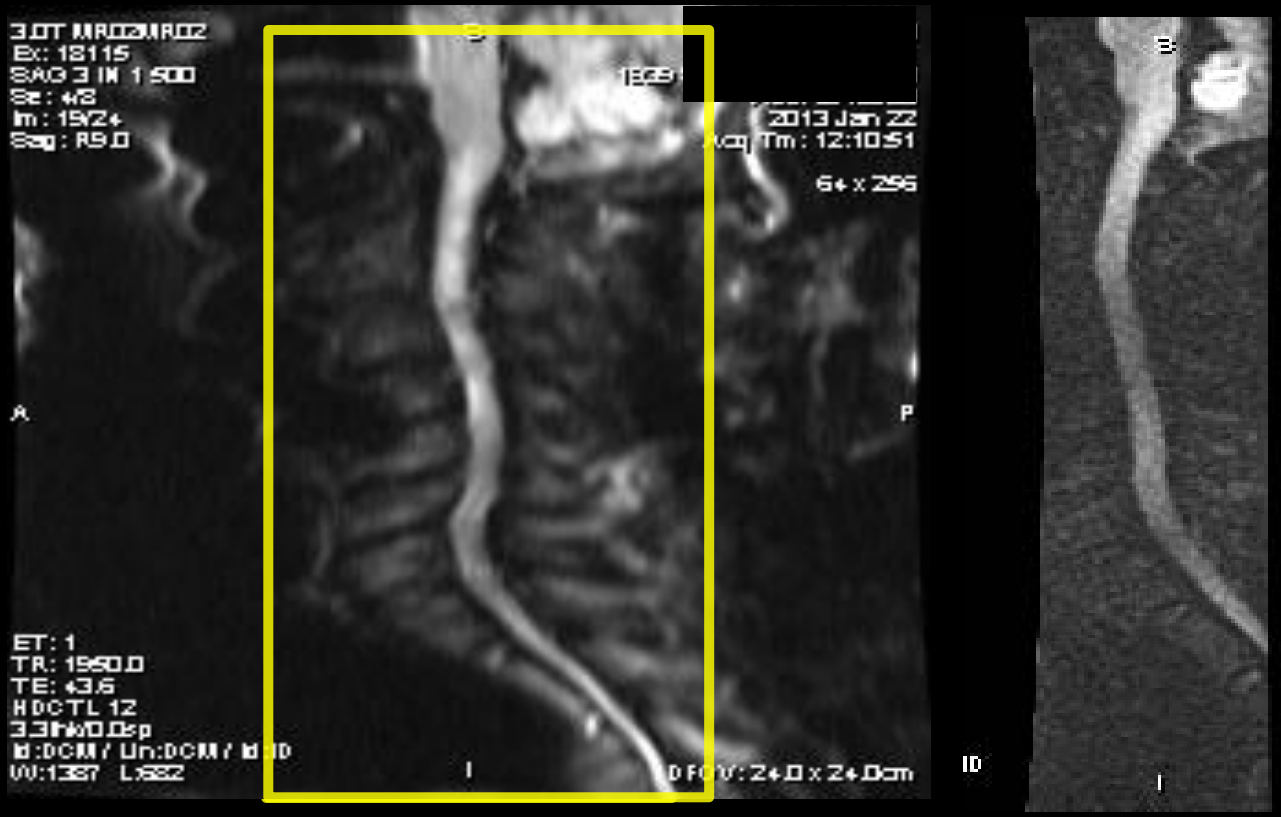
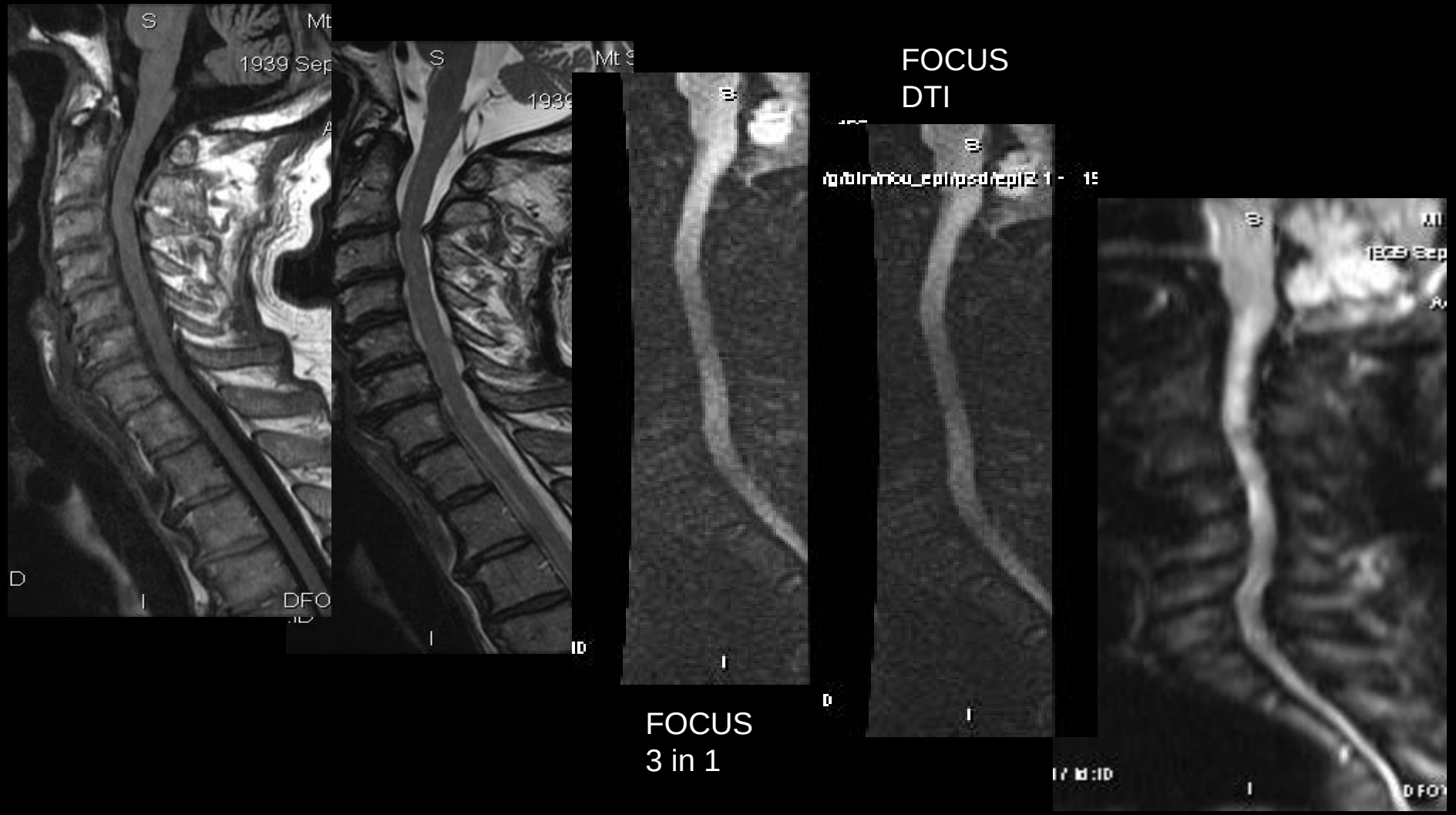
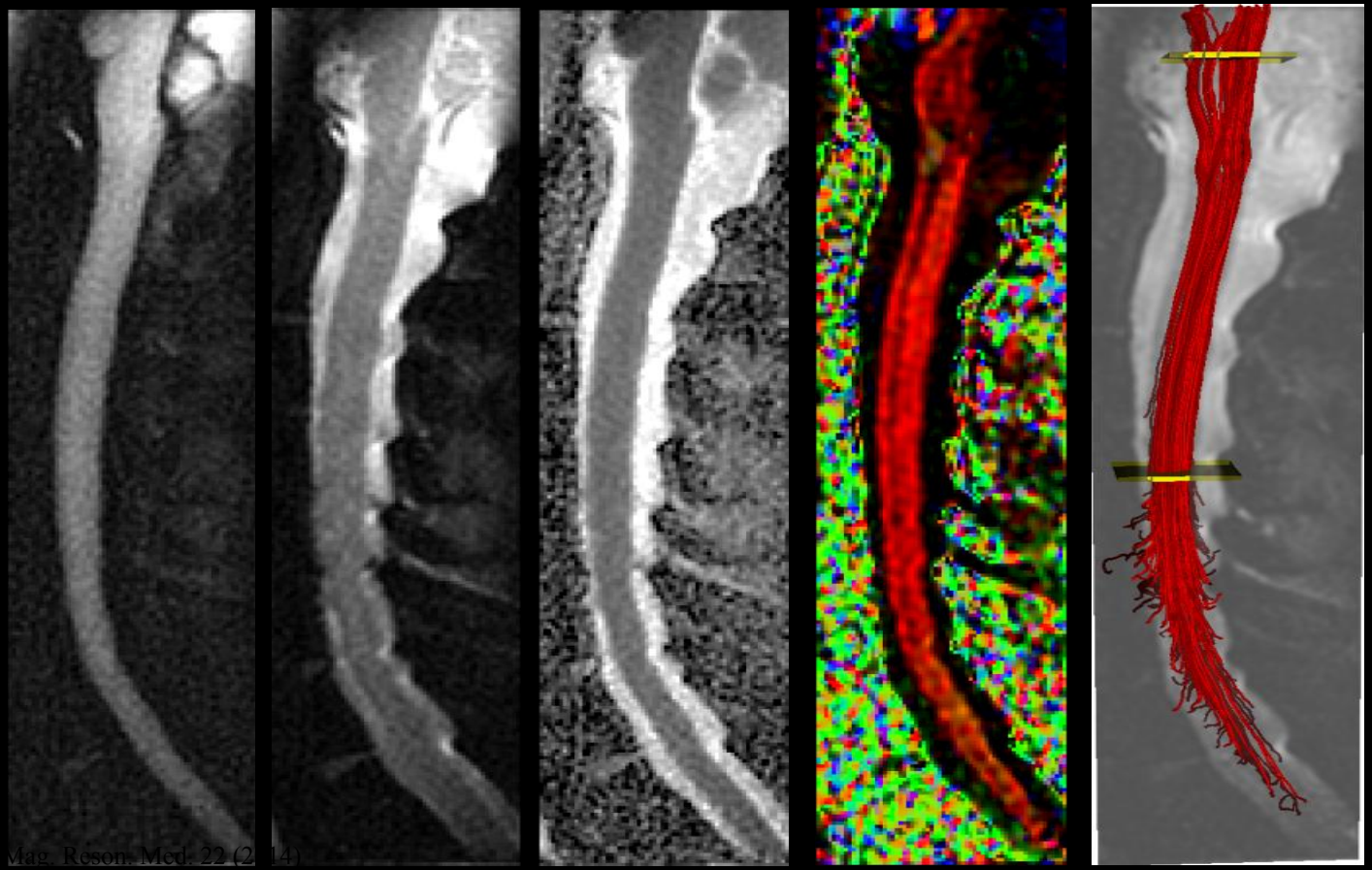


Restricted FOV

FOCUS


FOCUS
DTI
FOCUS
3 in 1

FOCUS 3T **Spine DTI** with 1.09x1.09mm in-plane resolution

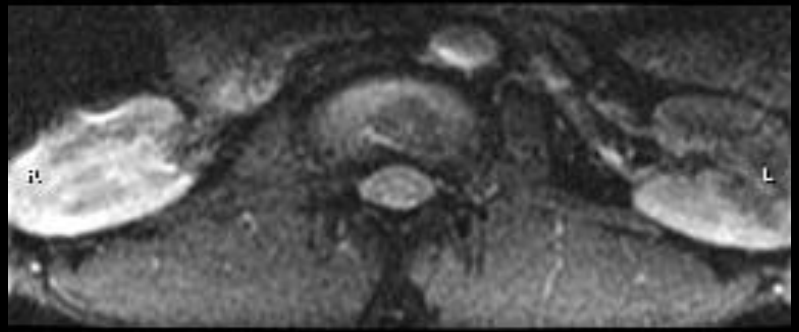


Mag. Reson. Med. 22 (2) 14)

E. Saritas & M Aksoy, Stanford University

3 in 1

FOCUS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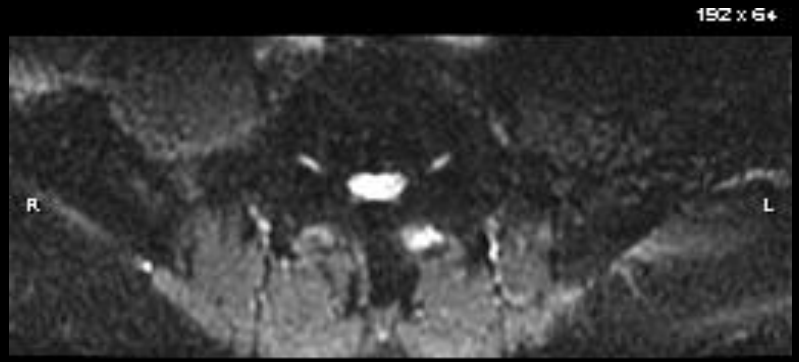
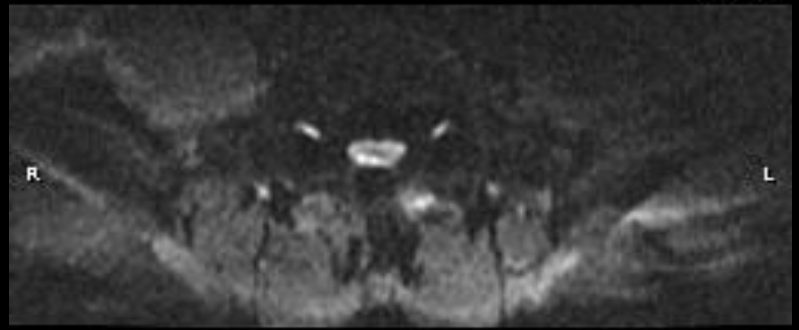
L


192 x 64
R
L


R
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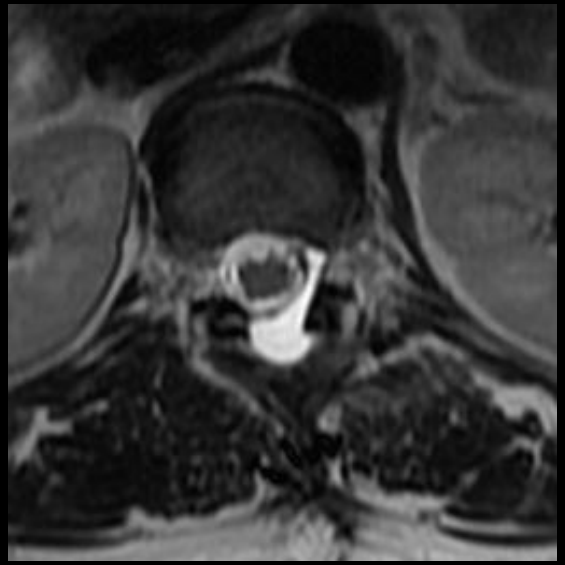
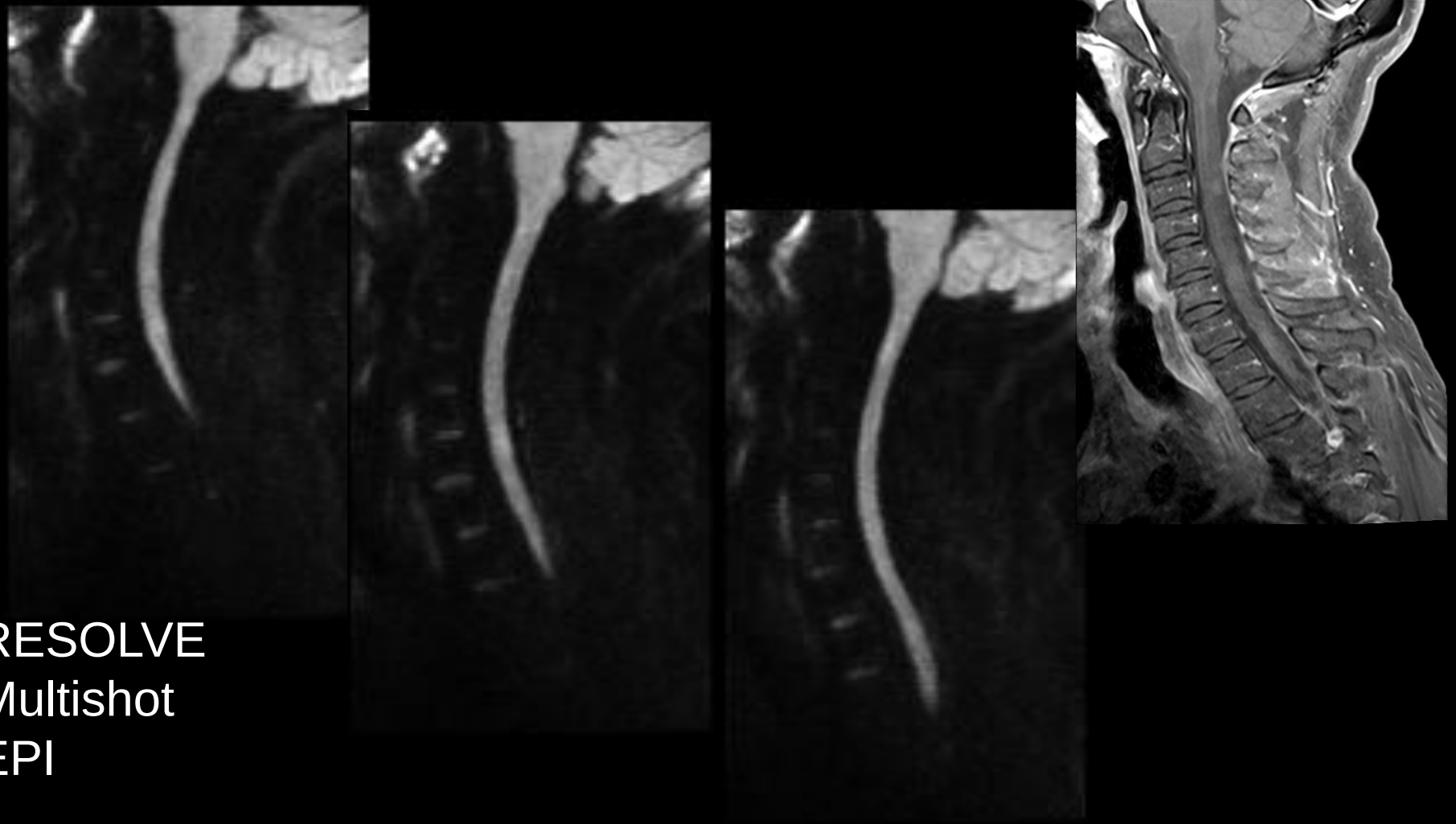


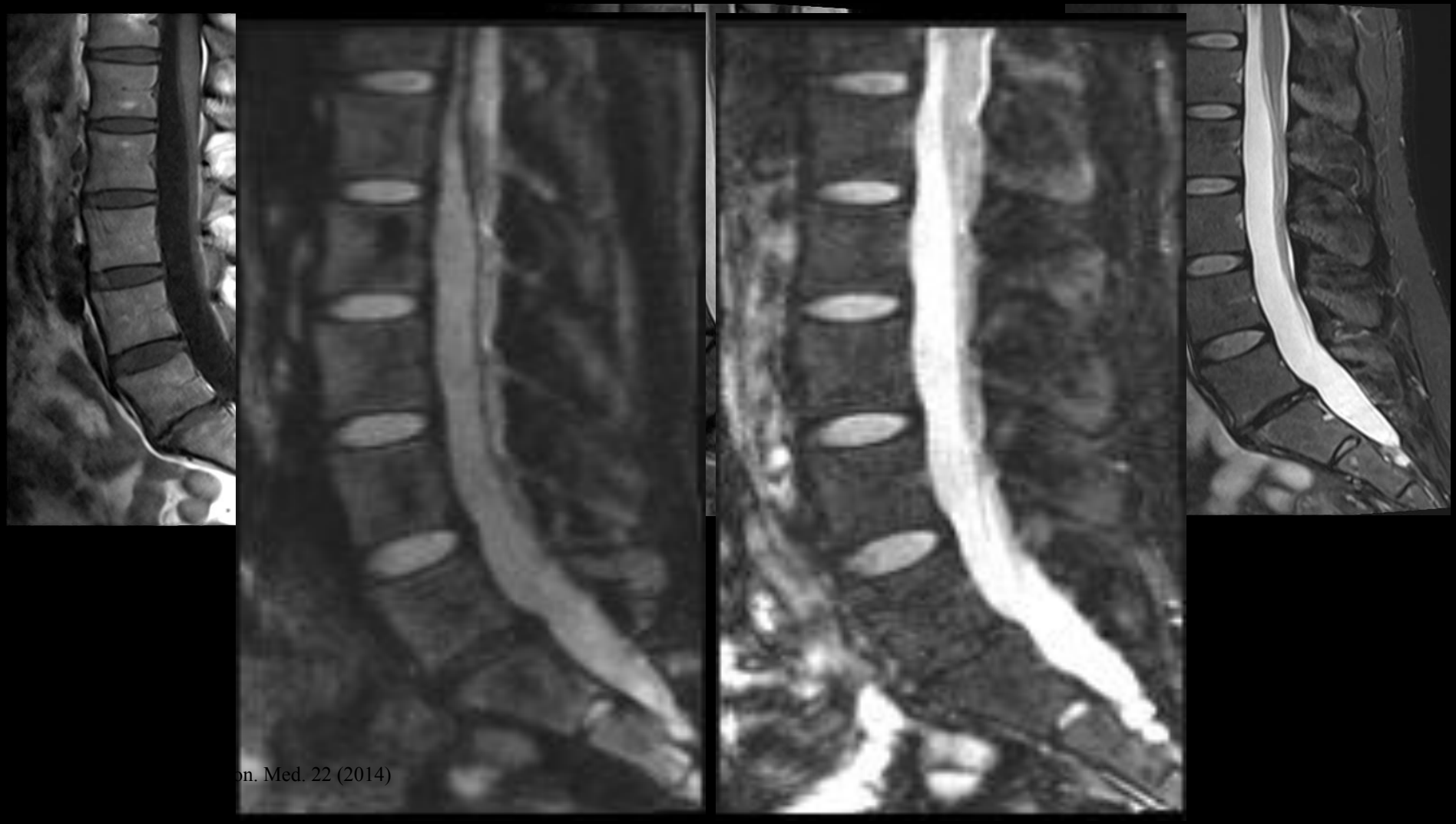
RESOLVE DWI

- High-quality, high-resolution DWI and DTI
- Readout-segmented, multi-shot EPI for reduced TE and encoding time
  - reduced susceptibility and blurring artifacts
- Parallel imaging (IPAT) compatible
- Motion correction with 2D phase navigator and real-time image reacqusition

High resolution diffusion-weighted imaging using readout-segmented echo-planar imaging, parallel imaging and a two-dimensionalnavigator-based reacquisition. Porter DA, Heidemann RM Magn Reson Med. 2009 Aug;62(2):468-75. V



RESOLVE
Multishot
EPI



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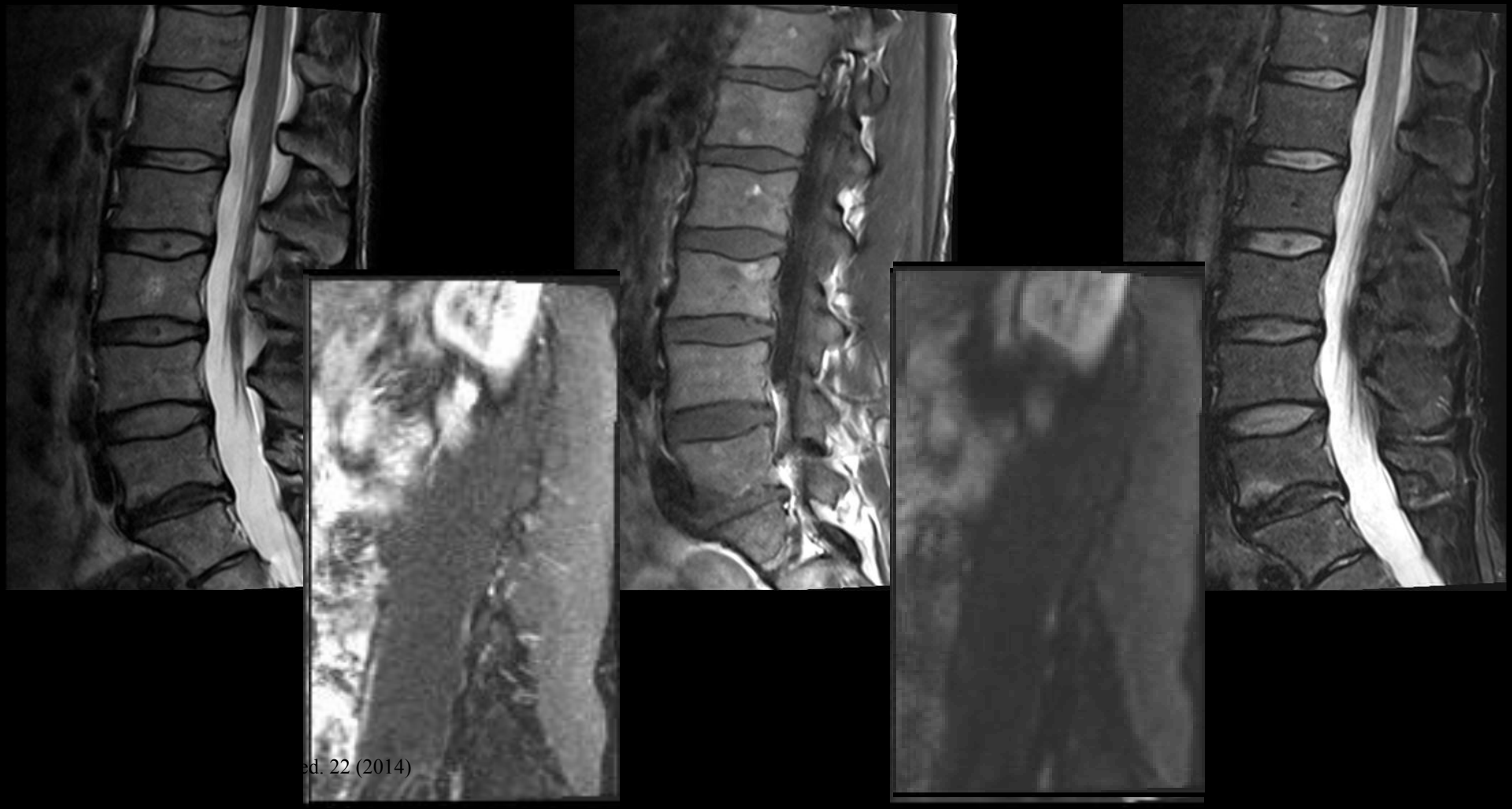

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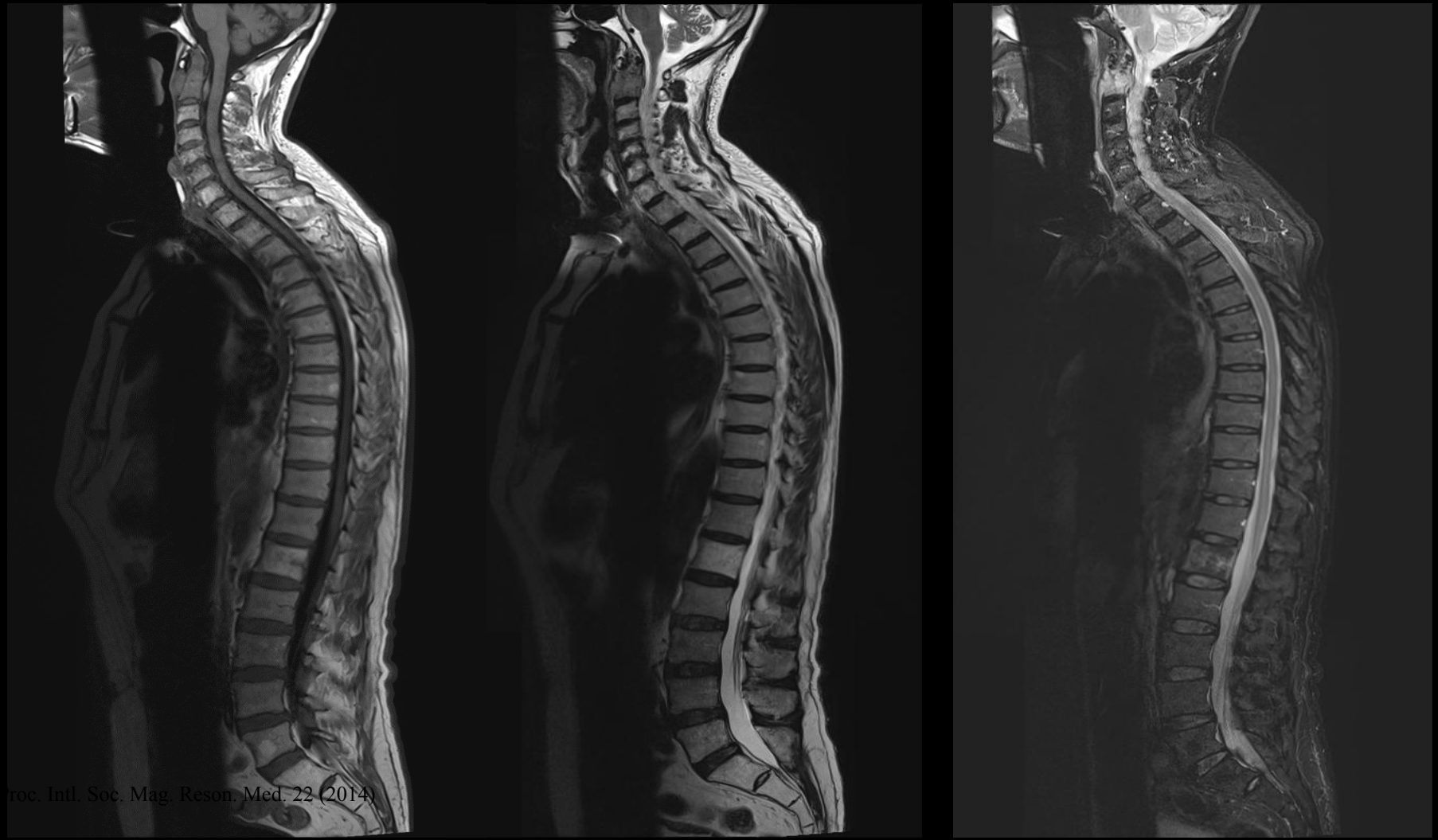

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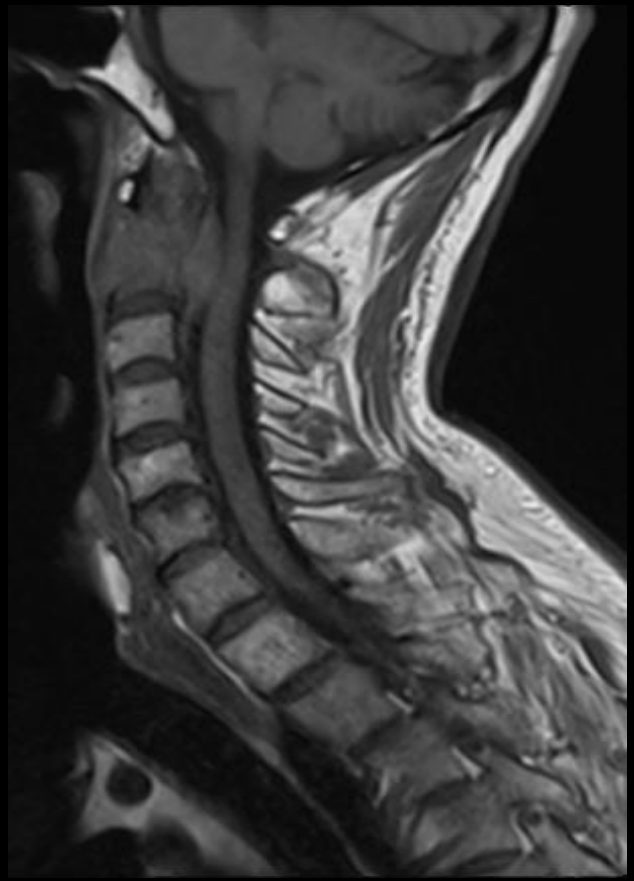

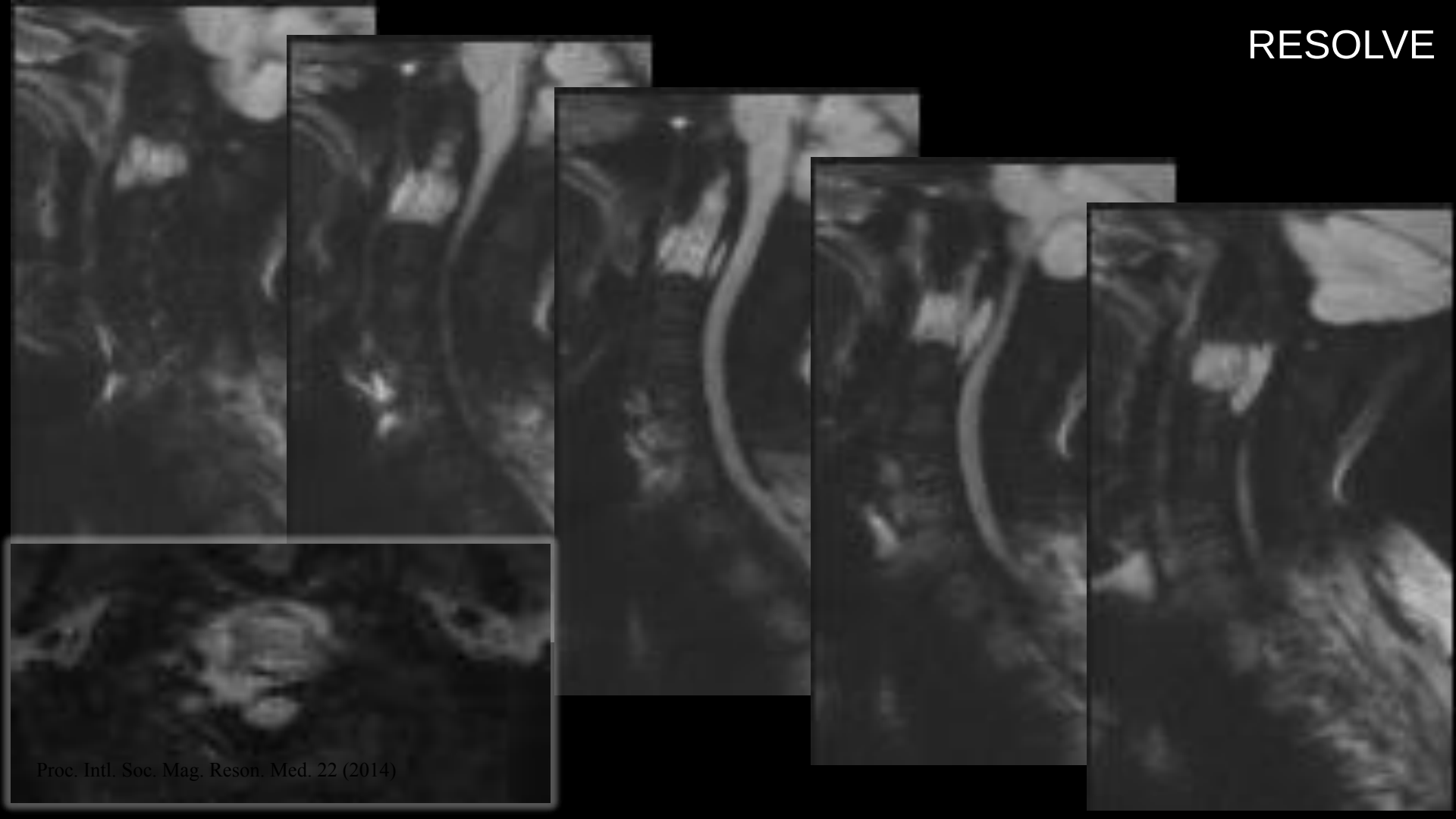
RESOLVE
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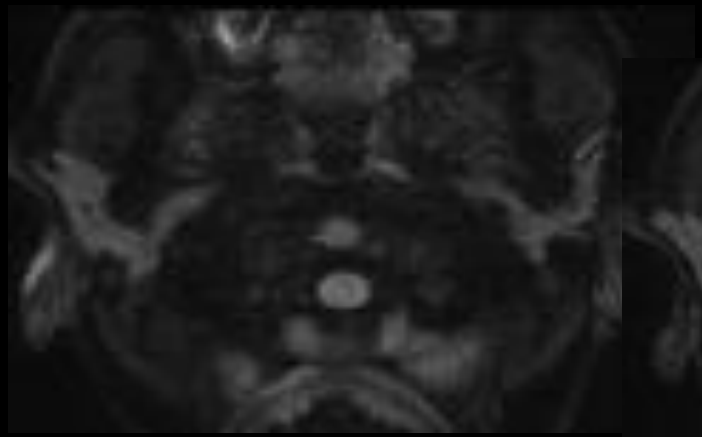
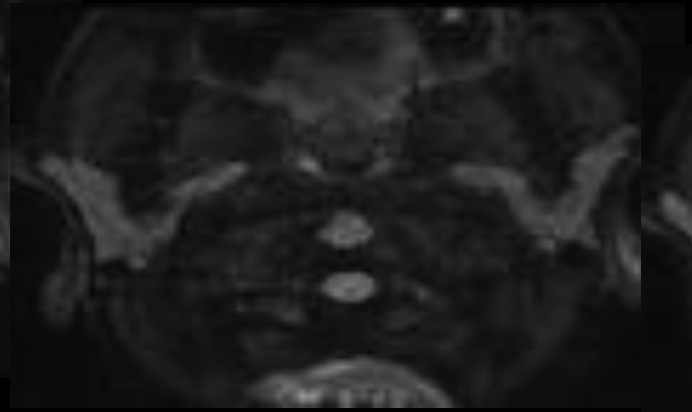
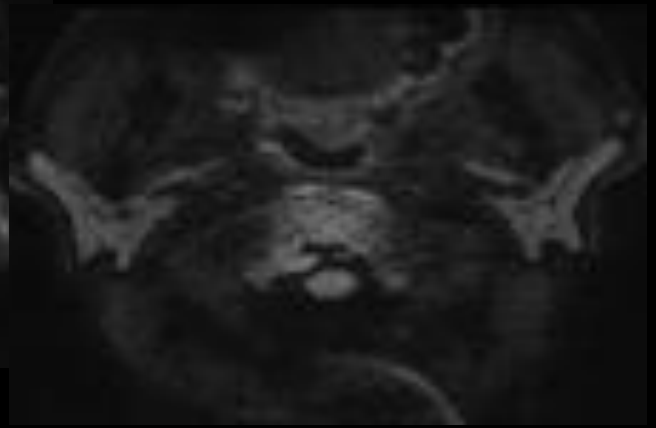
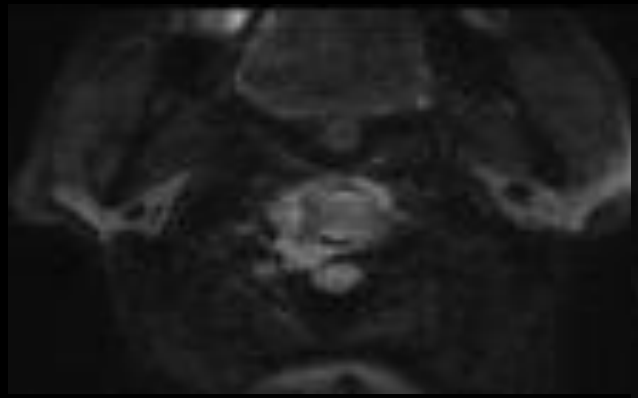
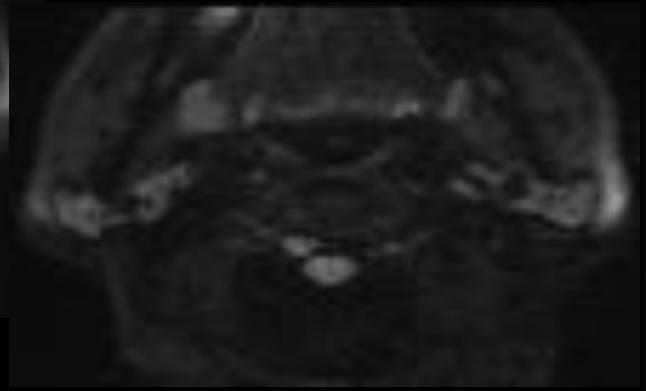
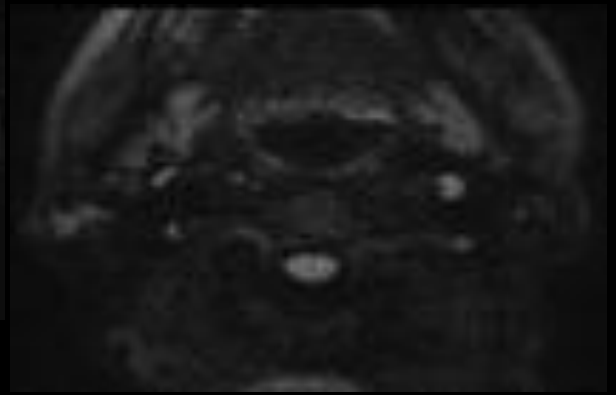
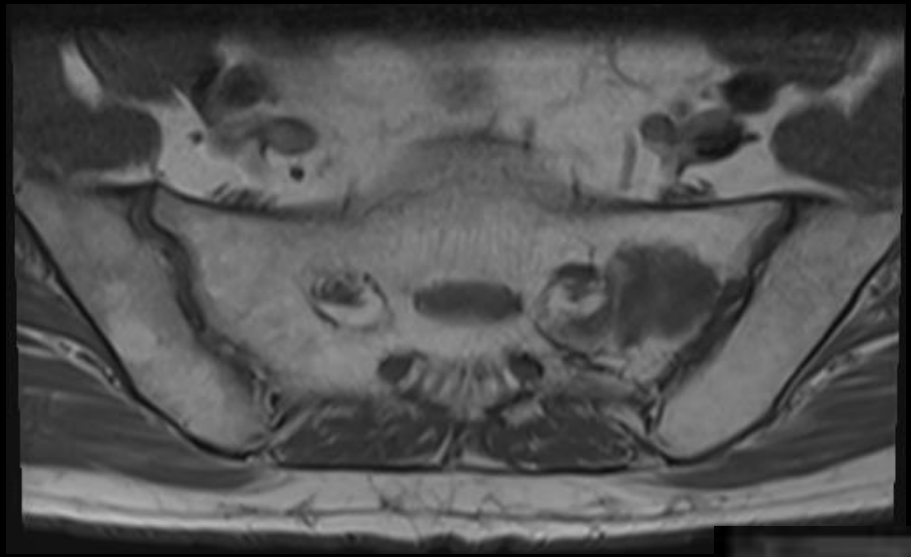
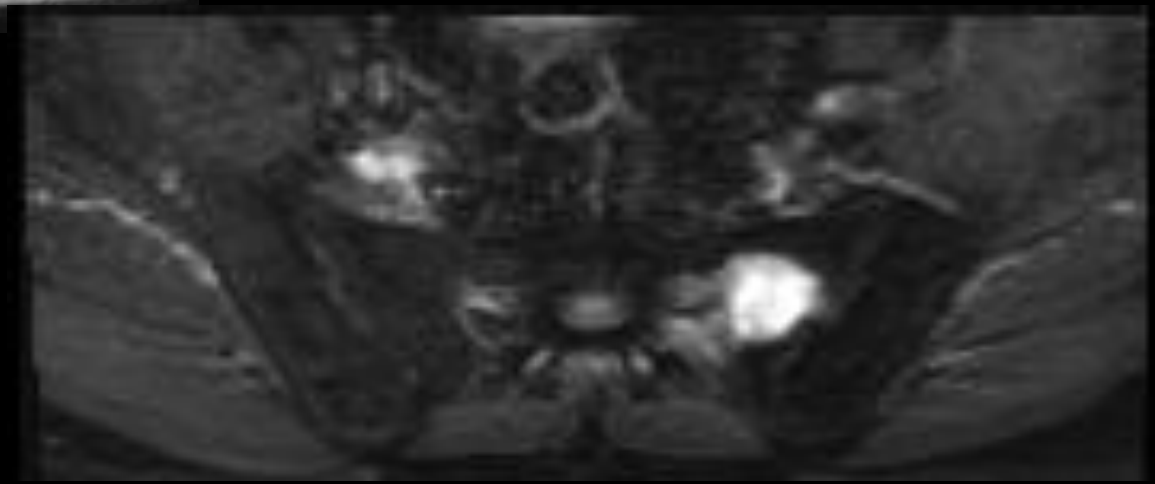
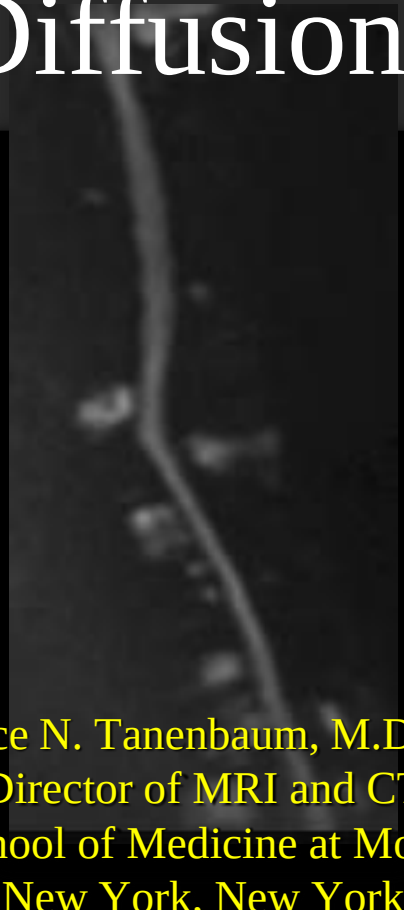











Spine Diffusion Imaging



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