Magnims

Magnetic Resonance Imaging in Multiple Sclerosis

VUmc

VU University
MS Center
Amsterdam

Measuring GM damage in MS: the technicalities

Hugo Vrenken

ESMRMB-MAGNIMS Teaching Course
"GM damage in MS as glanced by MRI:
measurement, interpretation and clinical application"
Edinburgh, October 1st, 2015

Disclosures for Hugo Vrenken:
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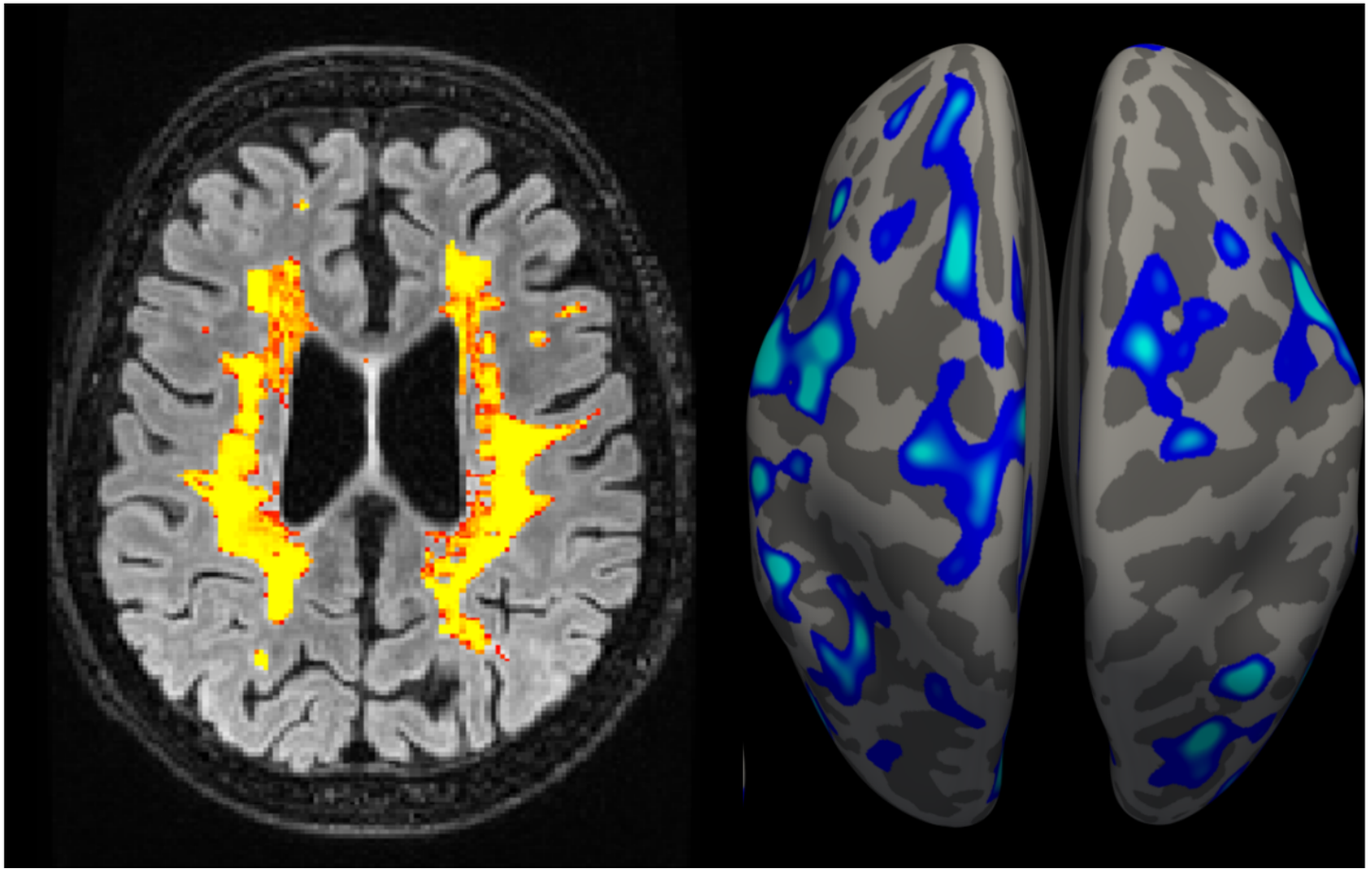
All funds paid directly to his institution.

Outline

- Measuring GM atrophy in MS
- Visualizing focal lesions in MS GM
- Probing diffuse damage in MS GM

MEASURING GM ATROPHY IN MS

Multiple sclerosis



What is Multiple Sclerosis?

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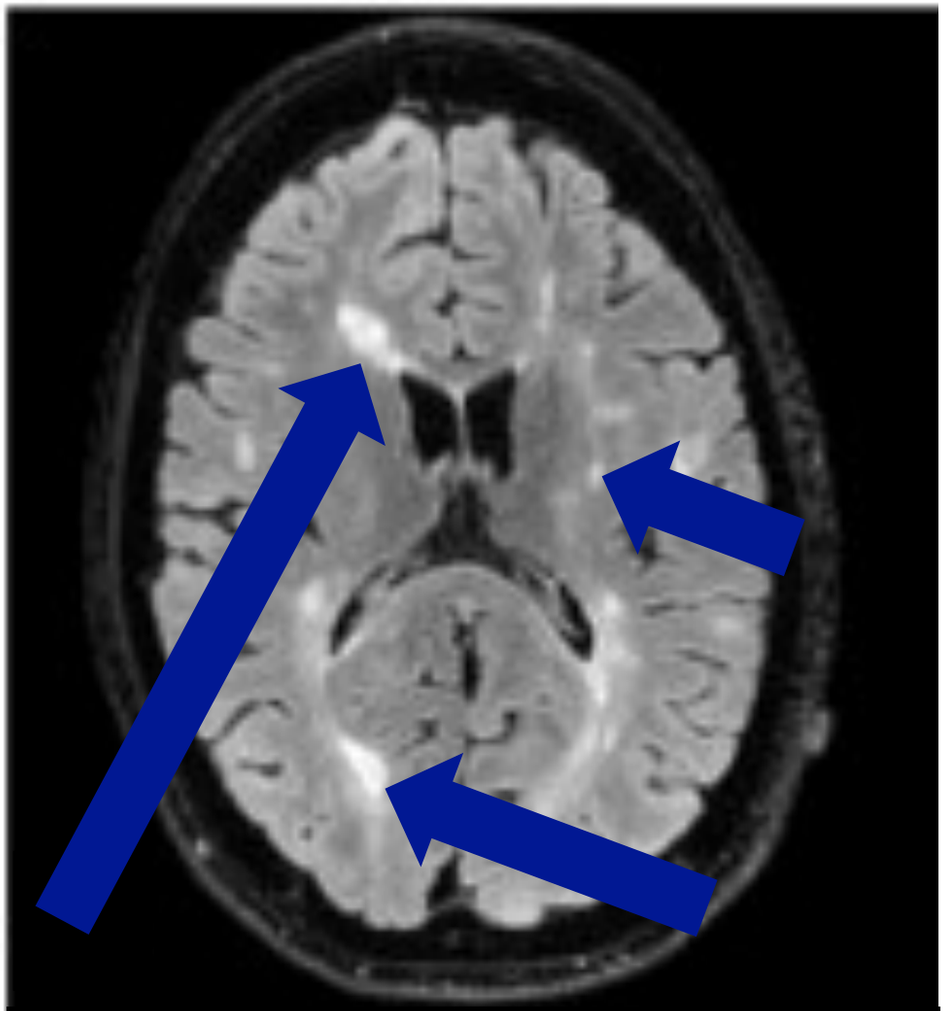

Focal lesions in the white matter

What is Multiple Sclerosis?

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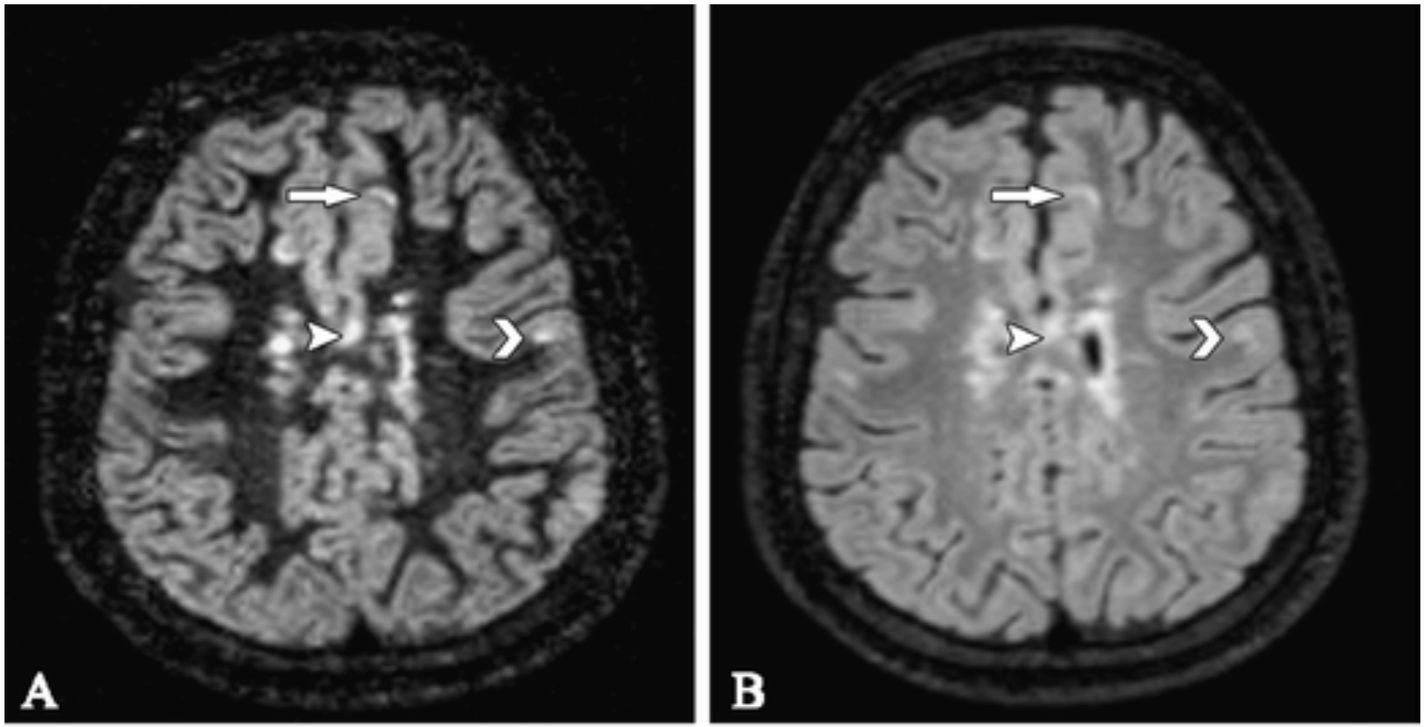
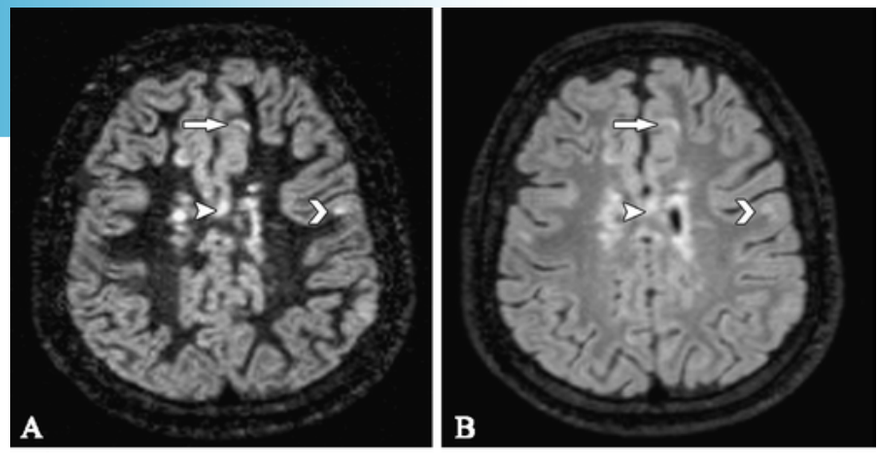
- Not only a white matter disease
- Grey matter is also affected … how?

Moraal *et al.*, Eur Radiol 2008

- Lesions



What is Multiple Sclerosis?

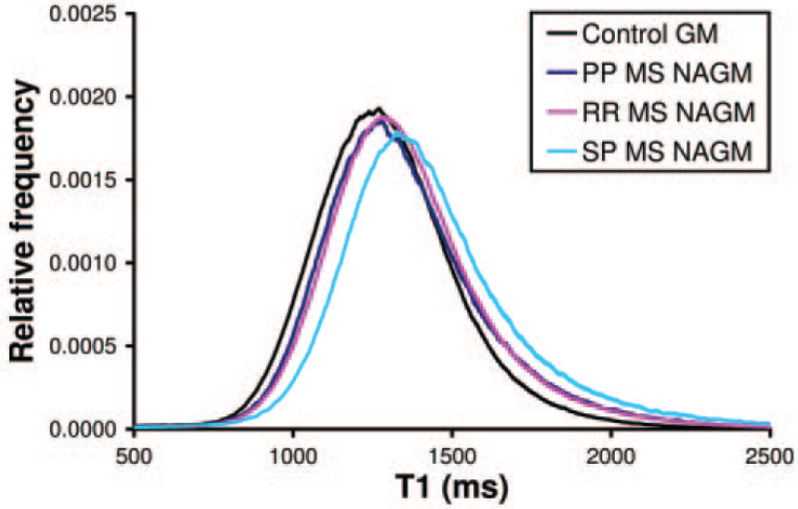


Moraal *et al.*, Eur Radiol 2008

- Not only a white matter disease
- Grey matter is also affected … how?

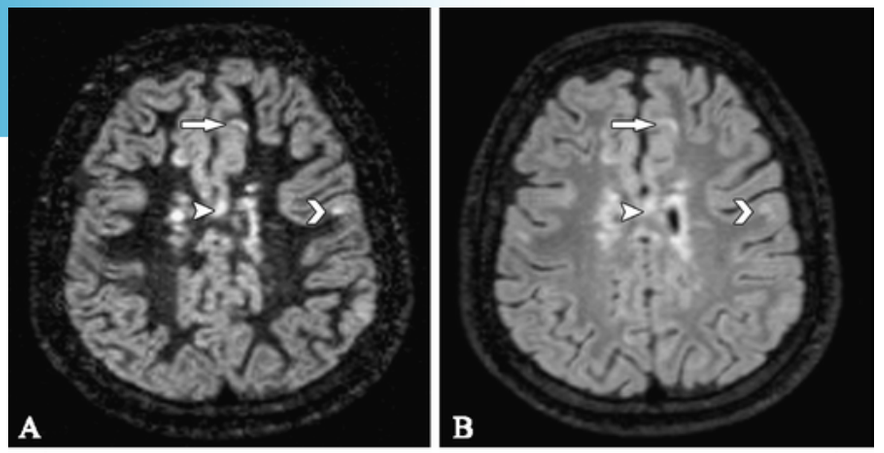
- Lesions

- Diffuse tissue damage



Vrenken *et al.* Radiology 2006

What is Multiple Sclerosis?



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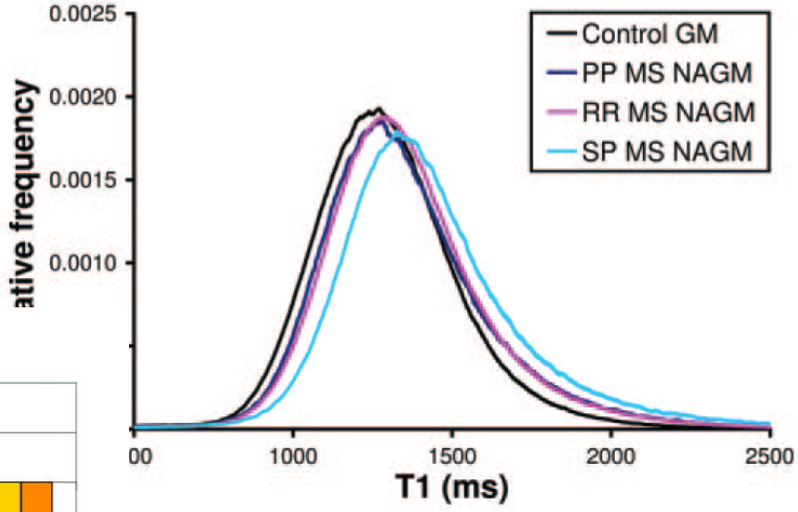
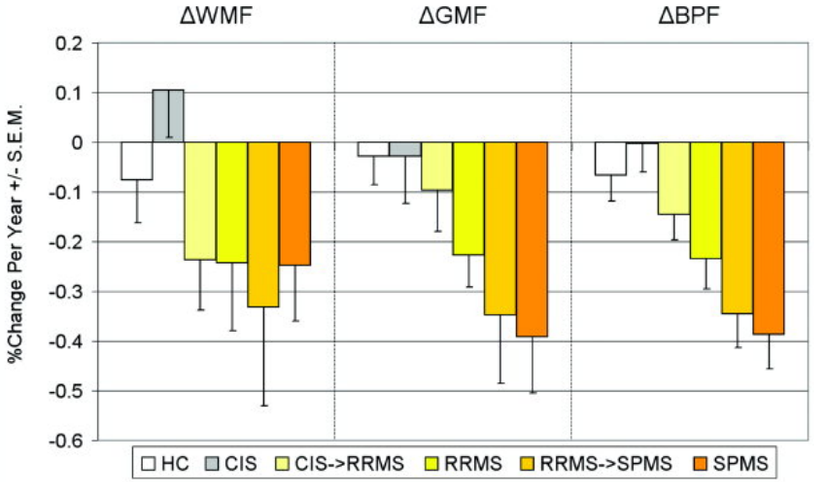
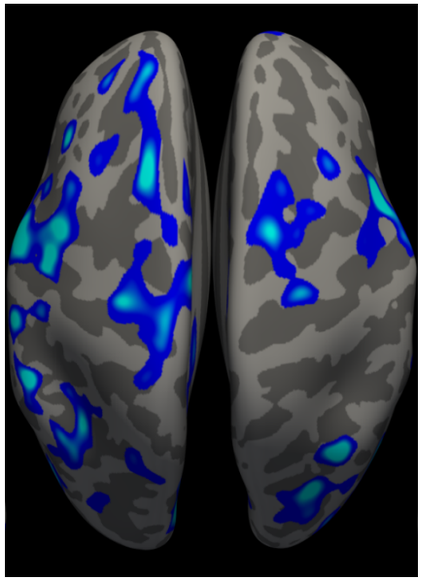


Vrenken *et al.* Radiology 2006

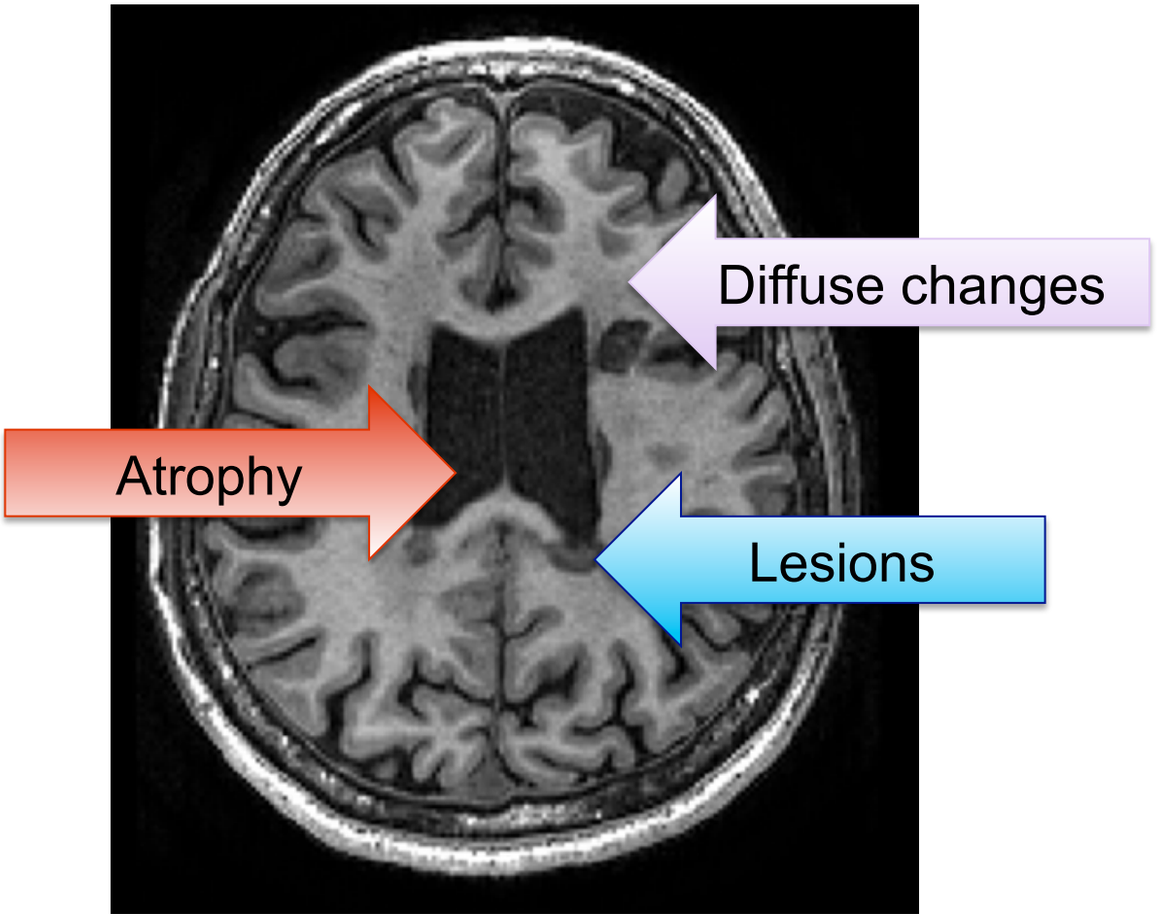


Fisher, Ann Neurol 2008



- Atrophy
- Atrophy = neurodegeneration?

Can we really measure GM atrophy in MS in vivo?

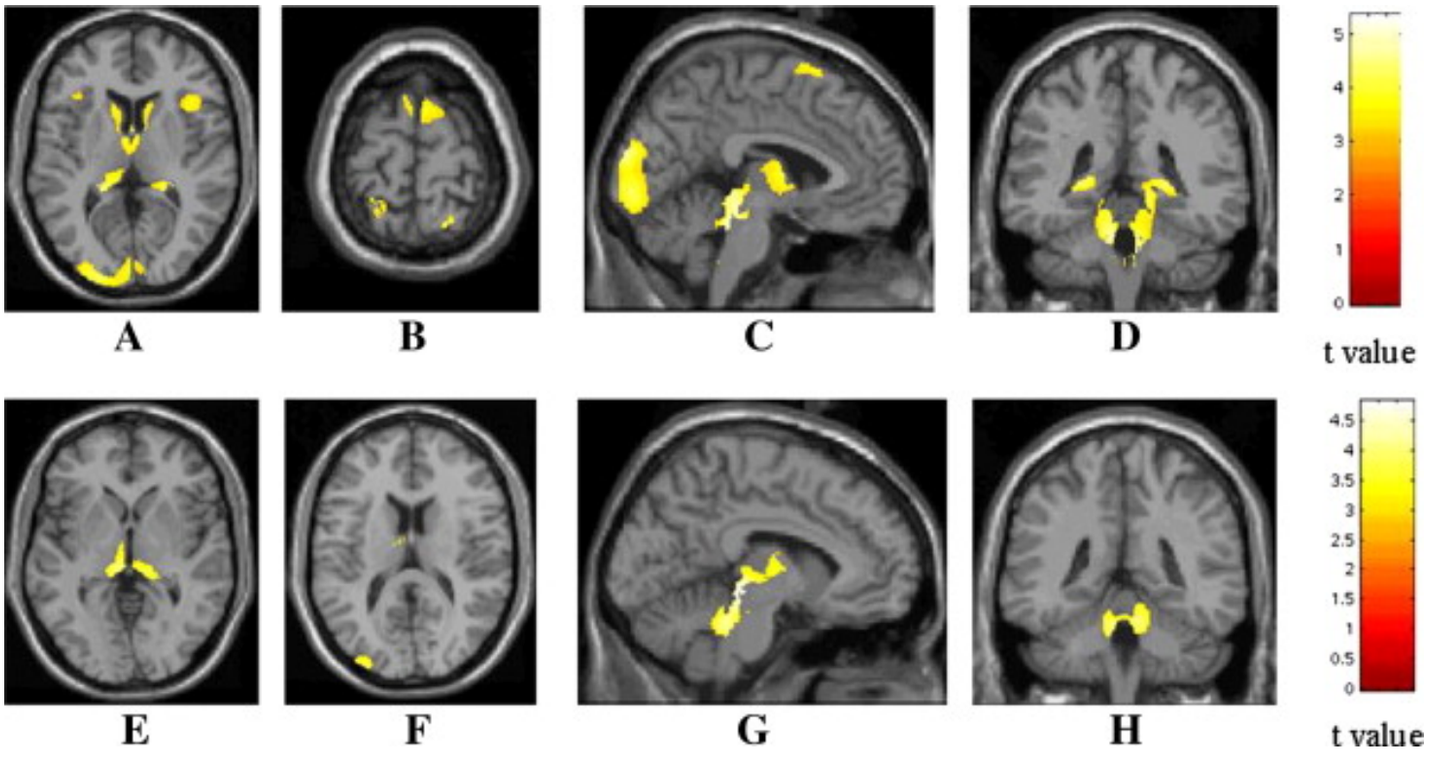


Popescu *et al.*, Neuroimage: Clinical 2014

Can we really measure GM atrophy in MS in vivo?

SPMS vs RRMS

SPMS vs PPMS



Ceccarelli *et al.*, Neuroimage 2008

Can we really measure GM atrophy in MS in vivo?

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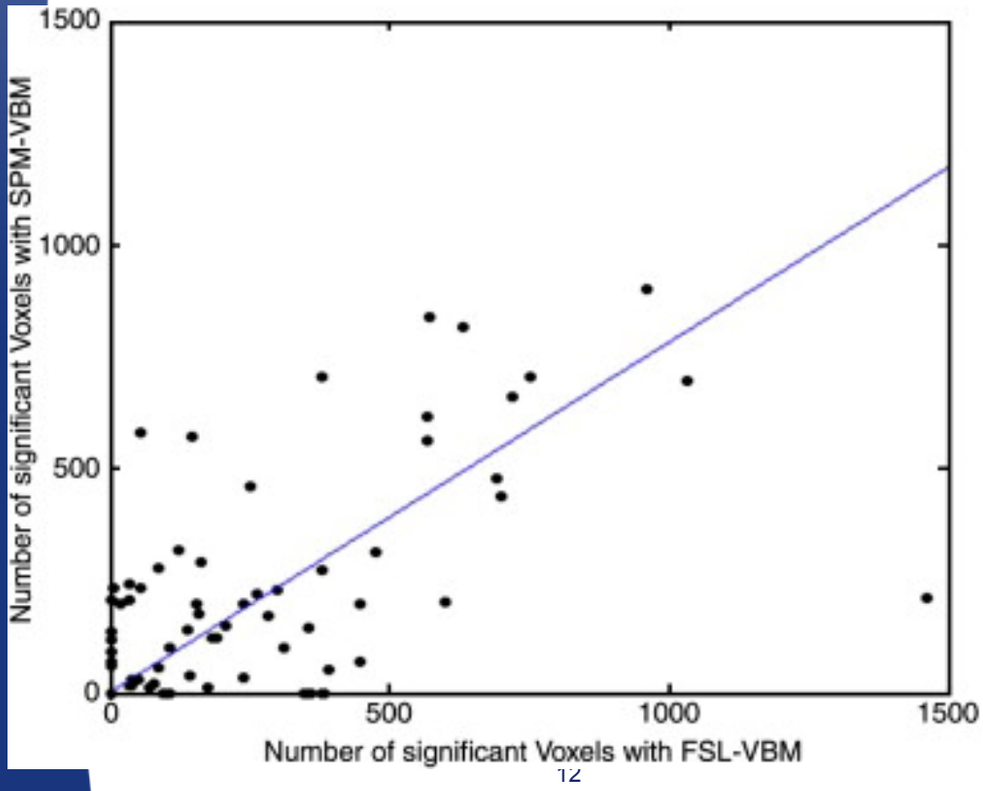
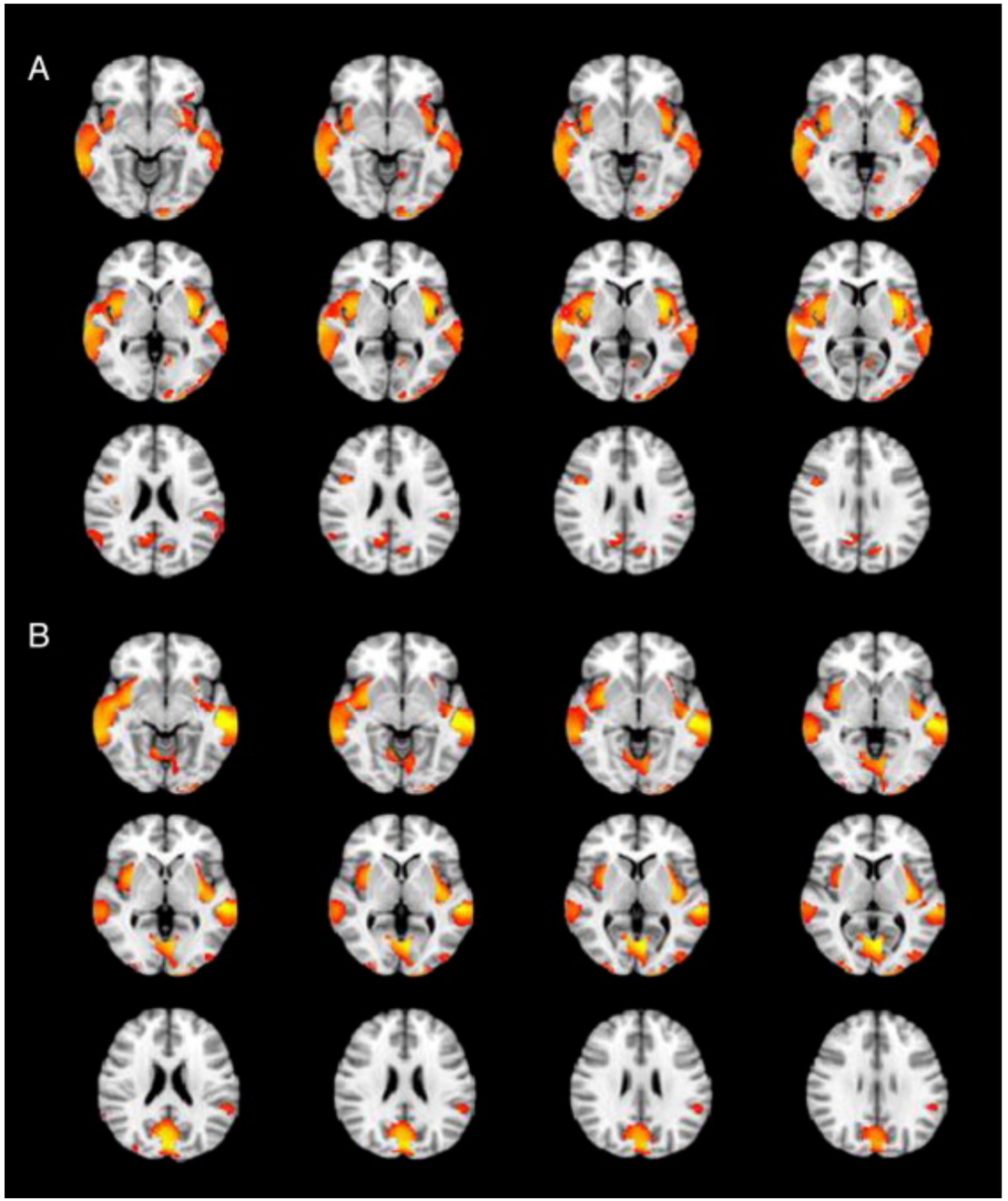
- Similar methods can give different answers!

Battaglini *et al.*, J Neurol Sci 2009





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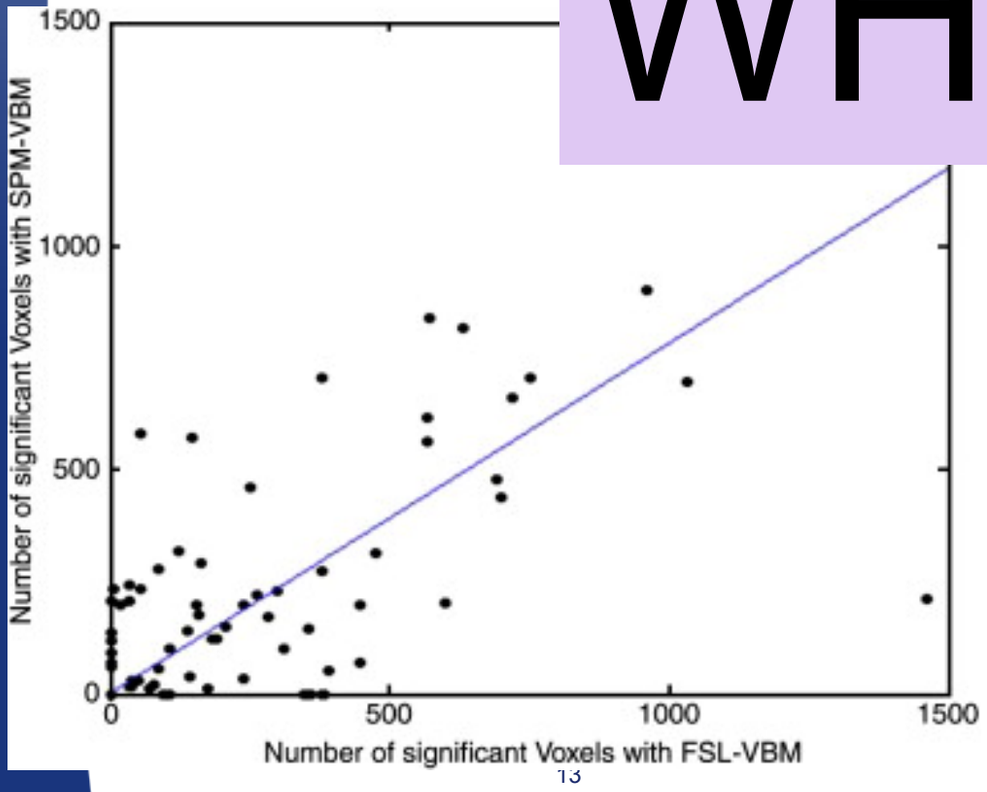
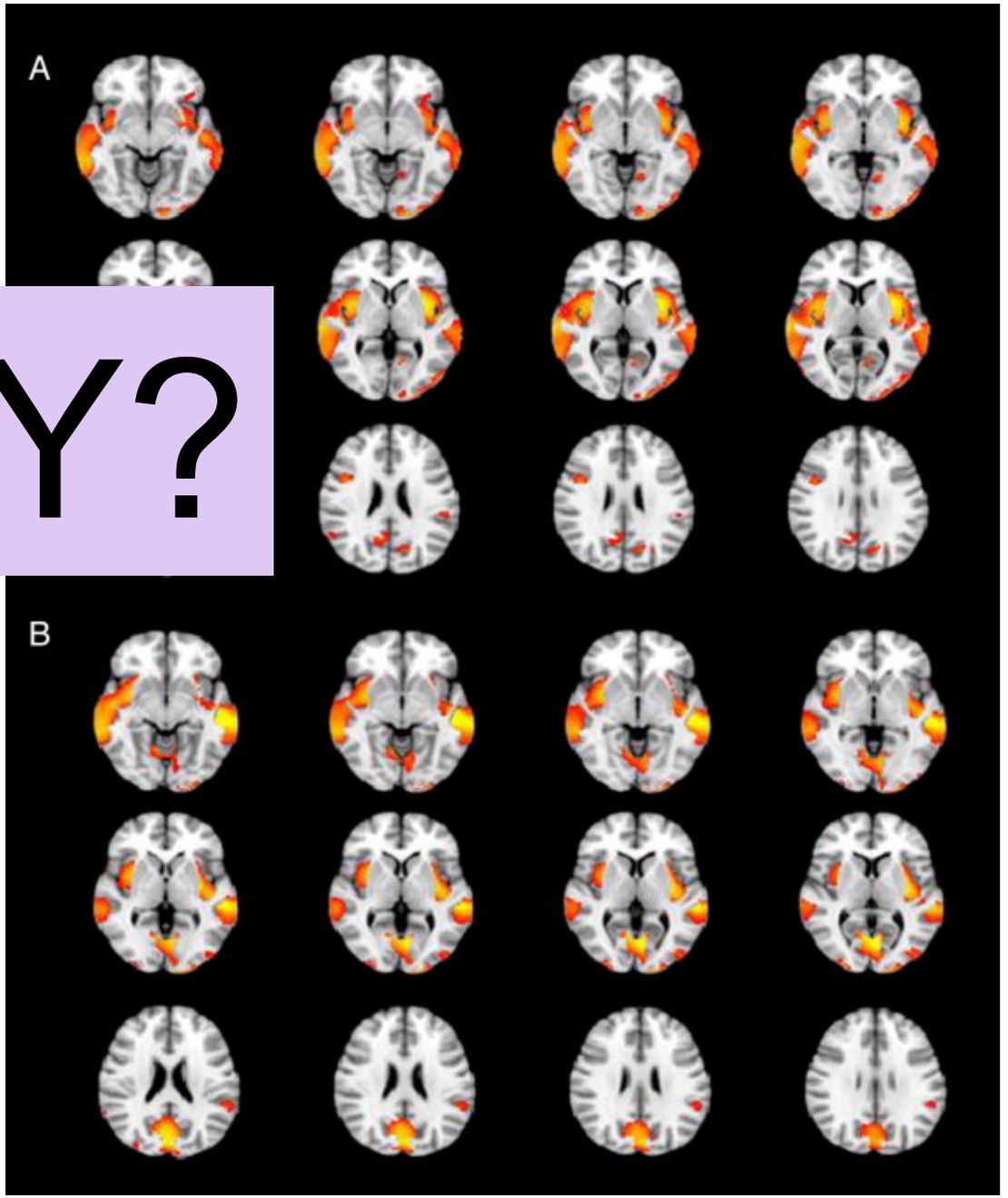
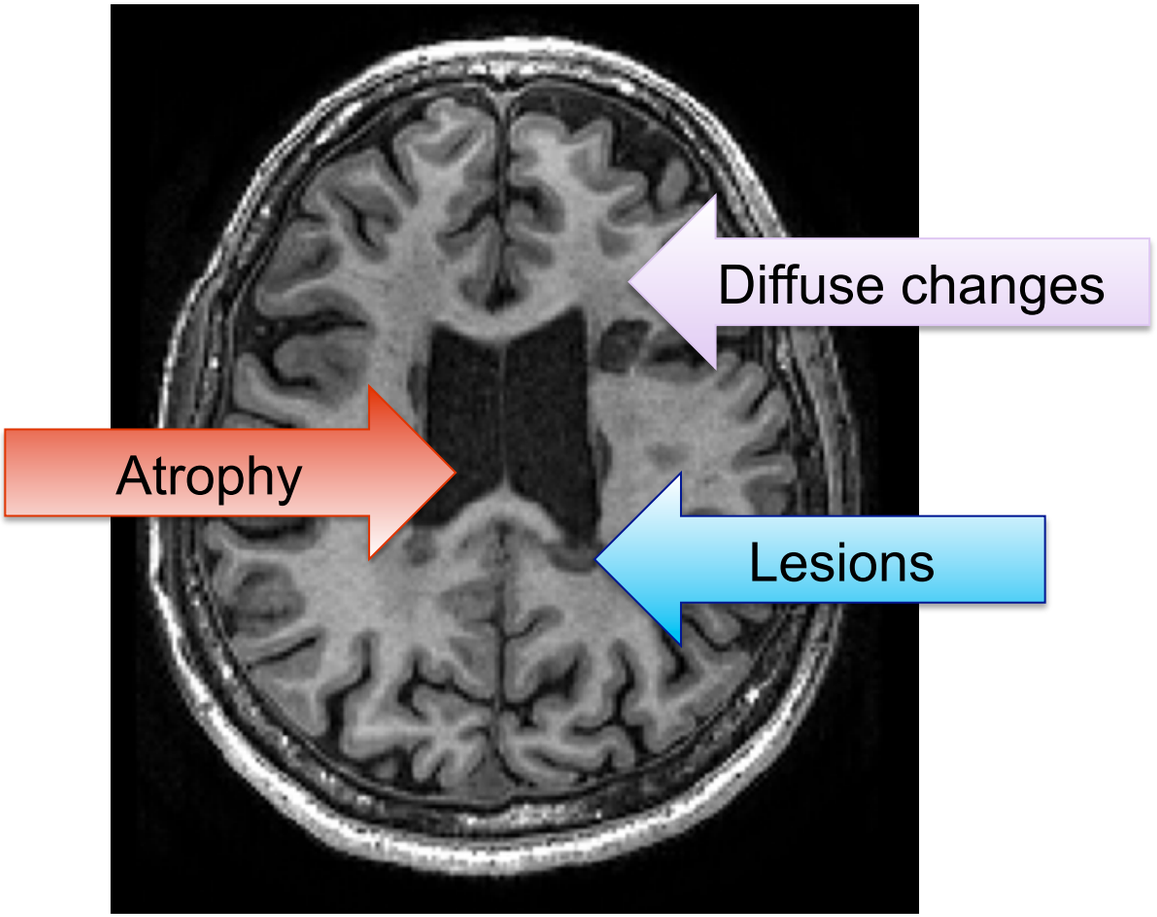
Battaglini *et al.*, J N

WHY?





Many simultaneous changes in MS



Popescu *et al.*, Neuroimage: Clinical 2014

Can we really measure GM atrophy in MS in vivo?

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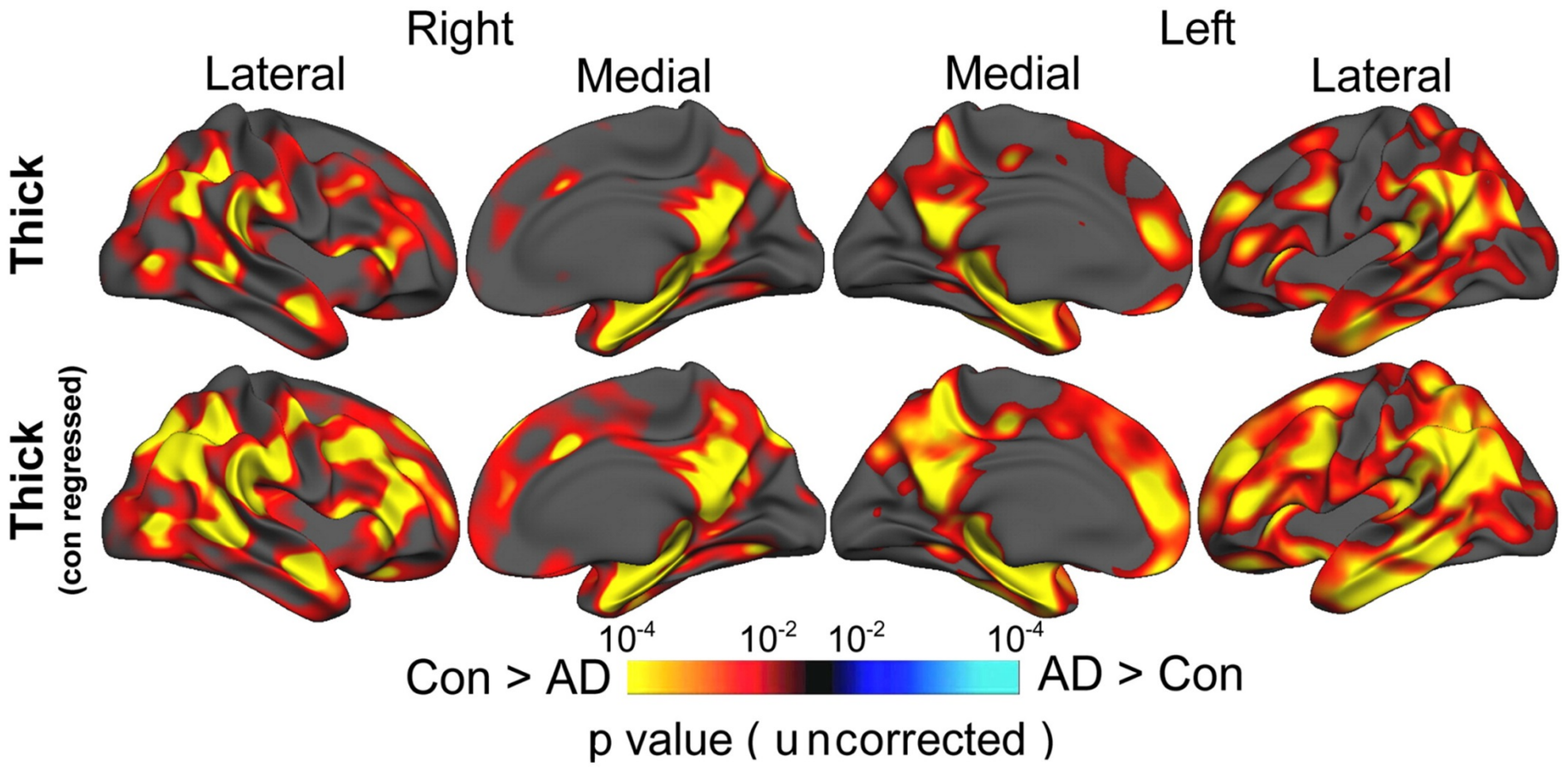
- Diffuse changes
- Atrophy
- Lesions

- Influence of local tissue contrast



Westlye Neuroimage 2009

Can we really measure GM atrophy in MS in vivo?

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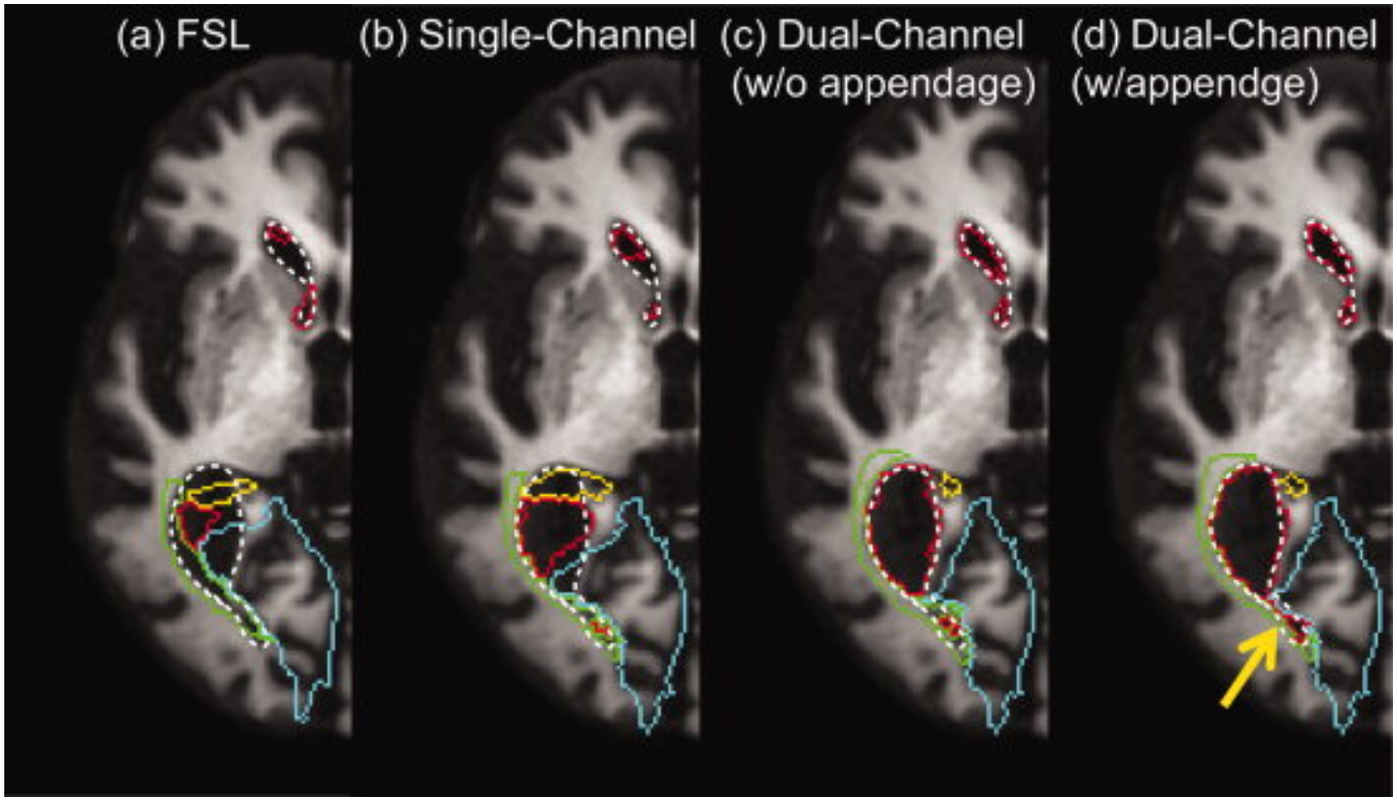
- Diffuse changes
- Atrophy
- Lesions

- Influence of atrophy on measurement of … atrophy



Djamanakova JMRI 2013

Can we really measure GM atrophy in MS in vivo?

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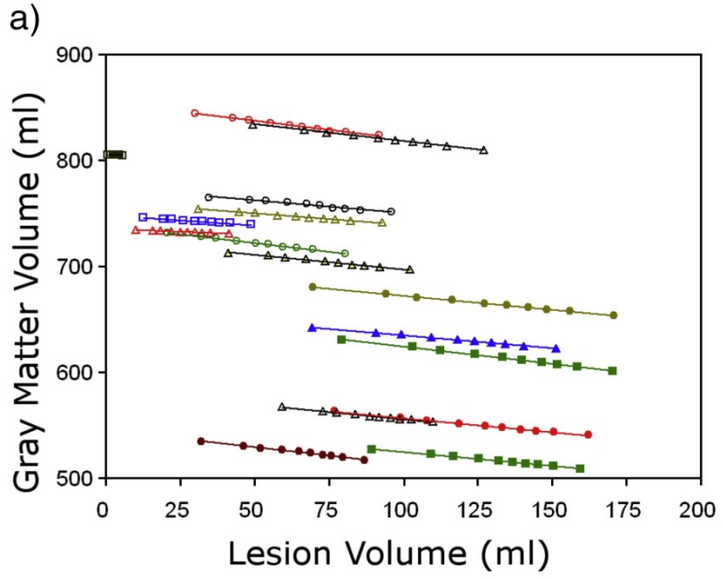
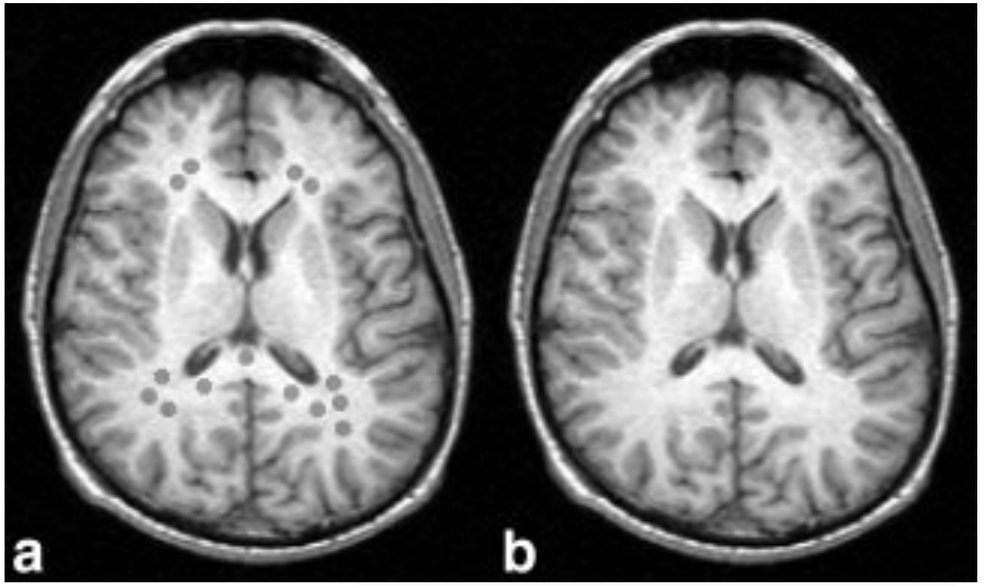
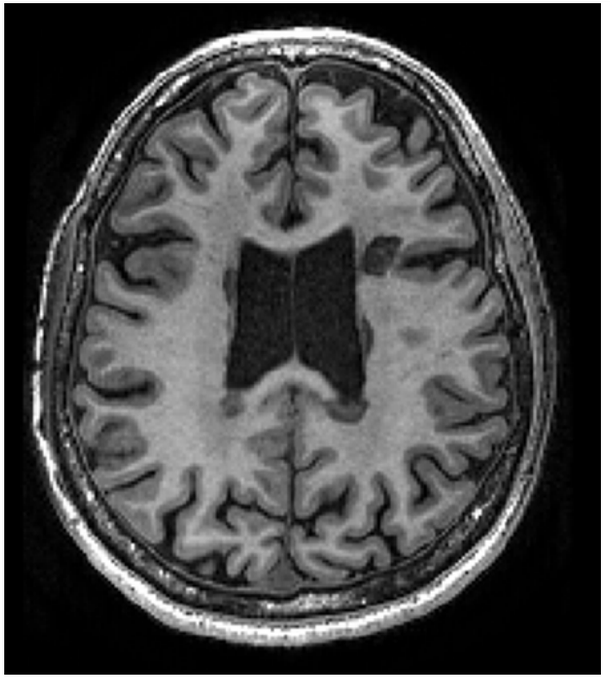
- Diffuse changes
- Atrophy
- Lesions

- Measured grey matter volumes vary with white matter lesion volume!



"Solution": lesion-filling





Sdika Hum Brain Mapp 2009; Nakamura Neuroimage 2009; Chard JMRI 2010; Battaglini Hum Brain Mapp 2012

Effects of WM lesions: not just at lesion location

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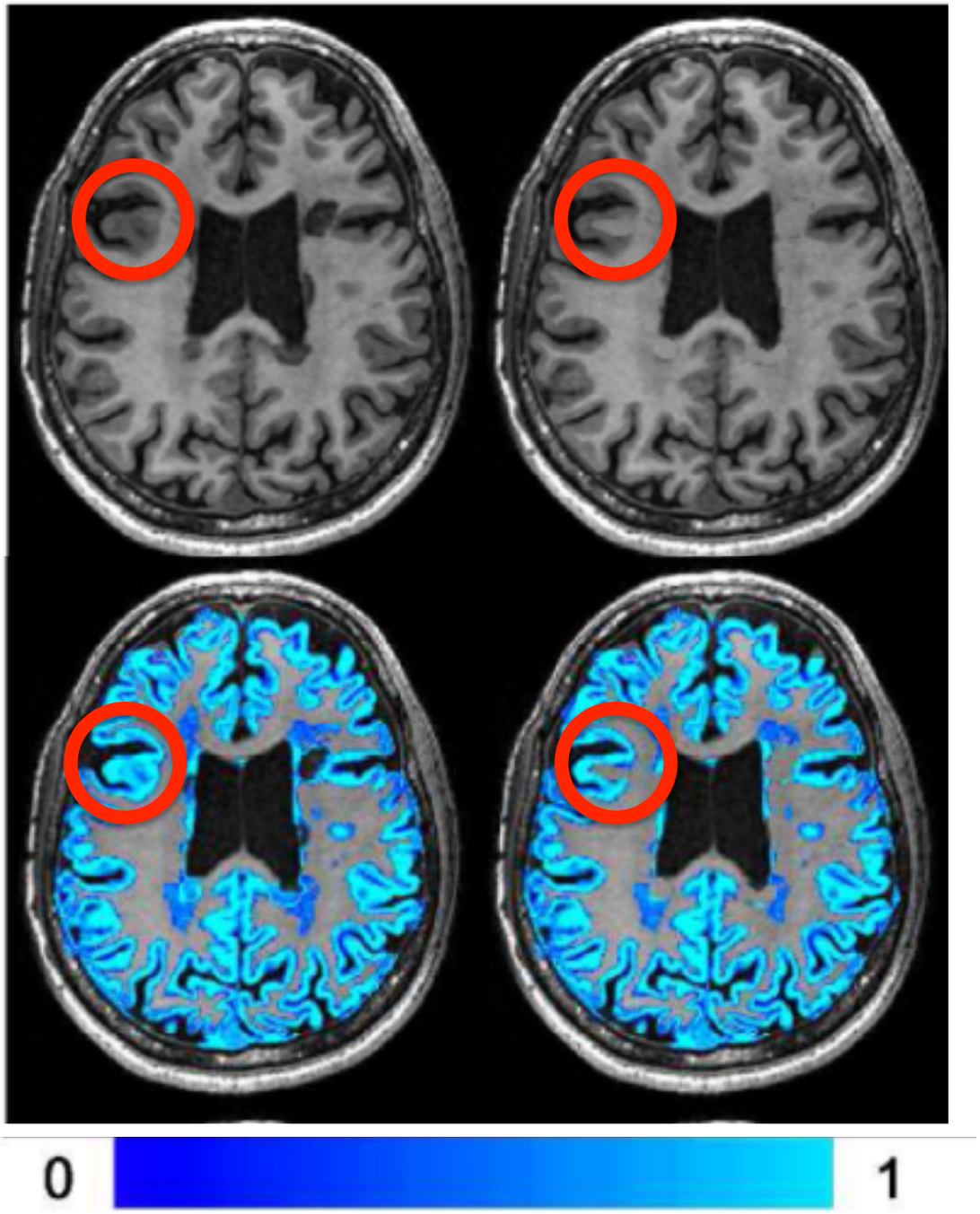
- GM volume estimation disturbed throughout brain



Popescu *et al.*, Neuroimage: Clinical 2014

WM lesions: global effects on GM volume

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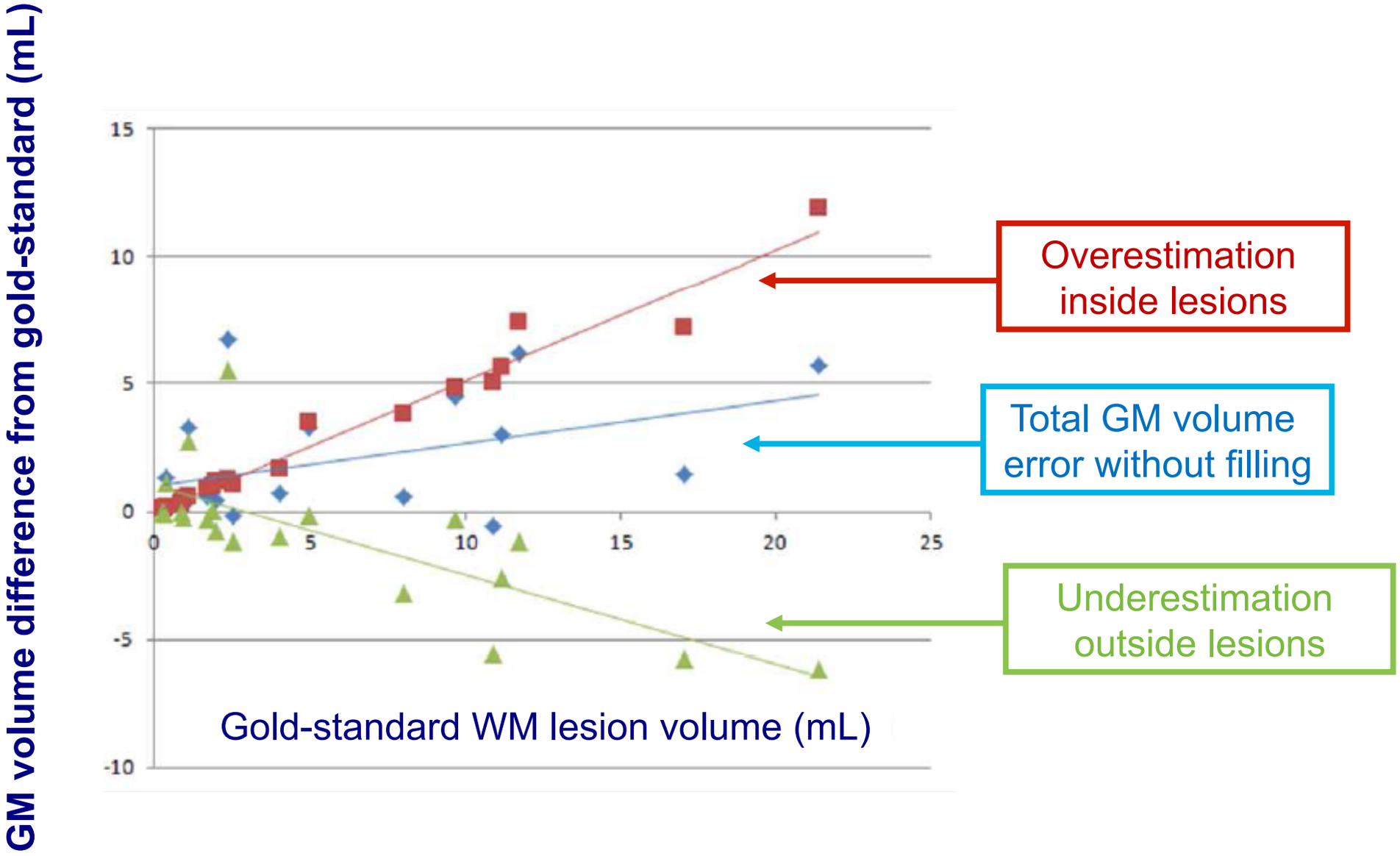

- FSL-FAST
- 20 patients, 2 centers

Popescu *et al.*, Neuroimage: Clinical 2014

Does lesion-filling solve the problem?

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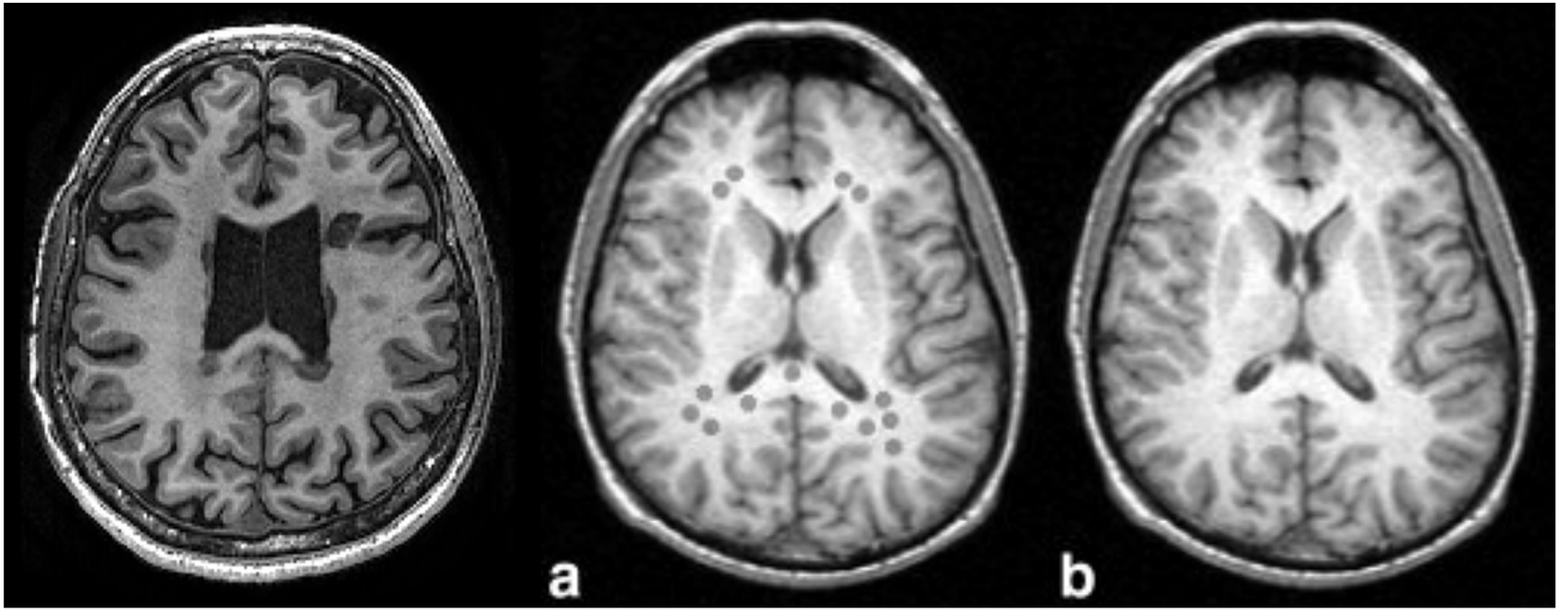
- Lesions have to be precisely outlined
- 3D T1-weighted images are of high resolution

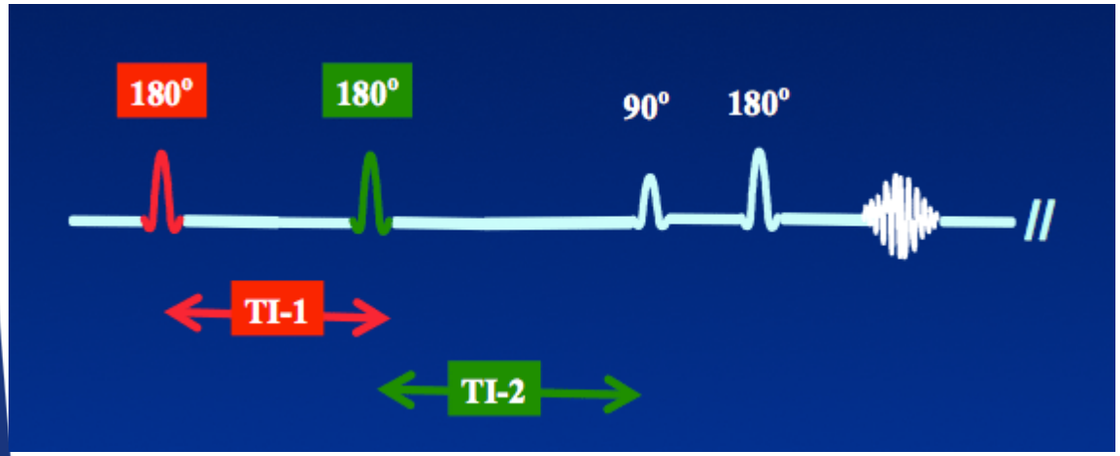
- Precise lesion outlines have to be available in 3DT1 space to apply lesion-filling



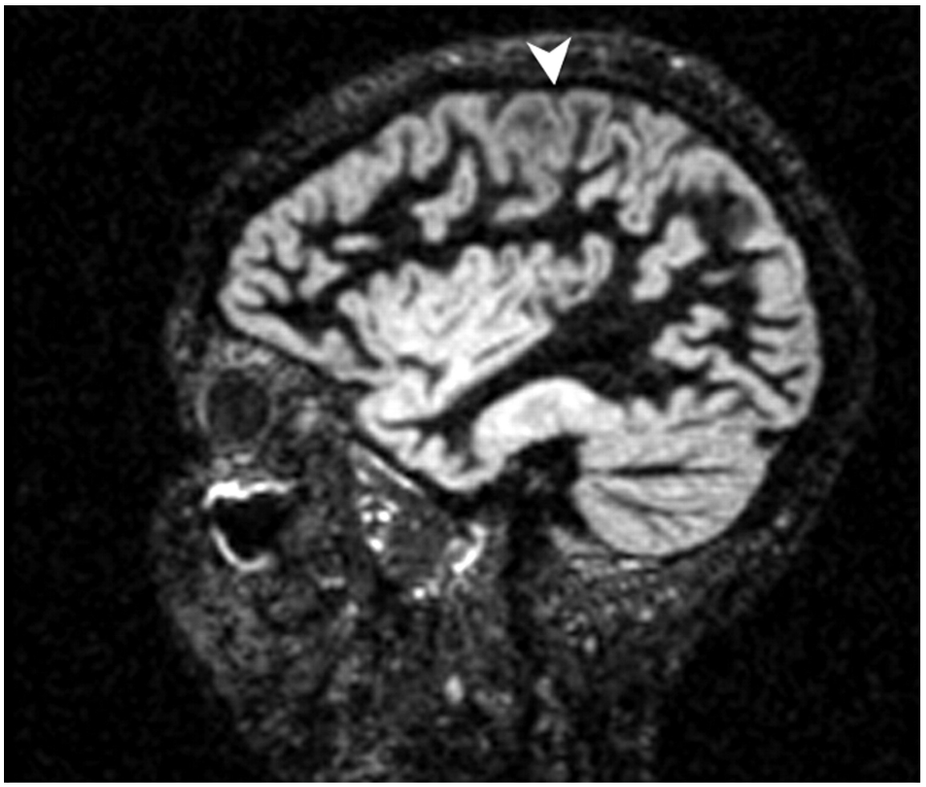
VISUALIZING FOCAL GM LESIONS

Double inversion recovery (DIR)

- Two inversion pulses
- Optimizing TI_1 and TI_2 to null signal from both WM and CSF
- Retain only GM in controls
- … + lesions in MS



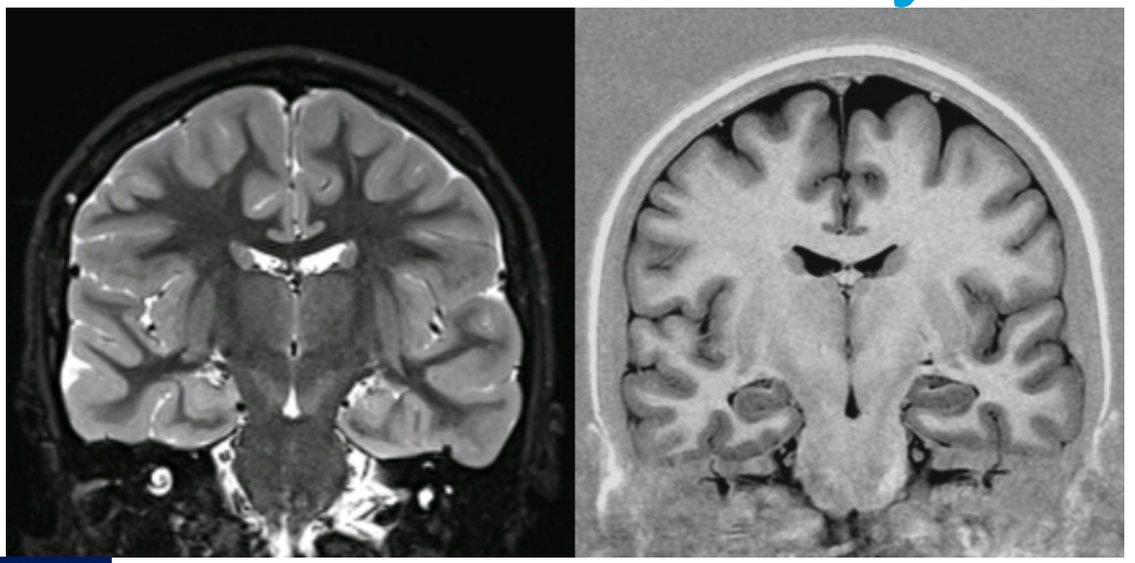
mri-q.com

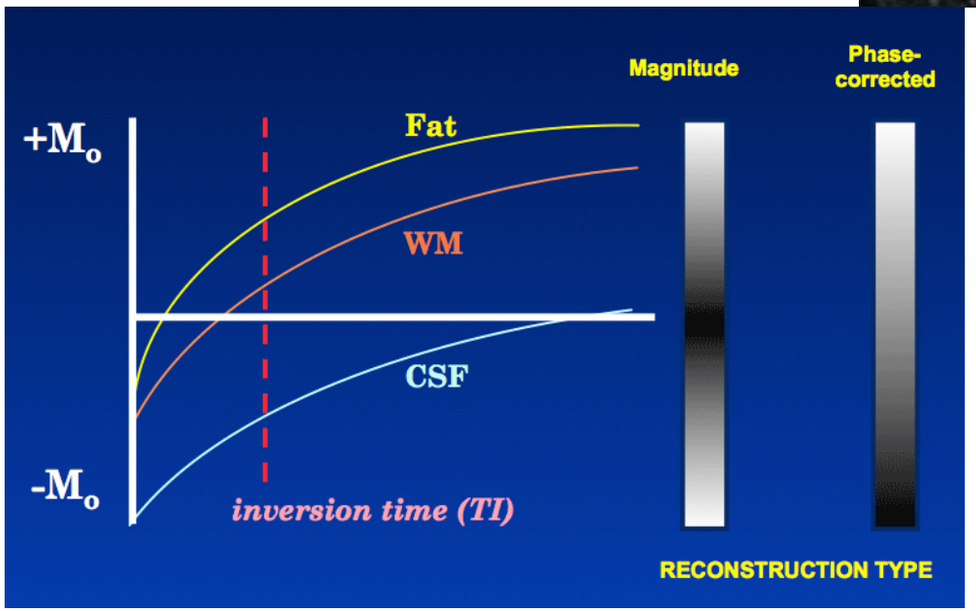


Pouwels et al. Radiology 2006

Phase-sensitive inversion recovery (PSIR)

- Single inversion pulse
- Phase-sensitive reconstruction





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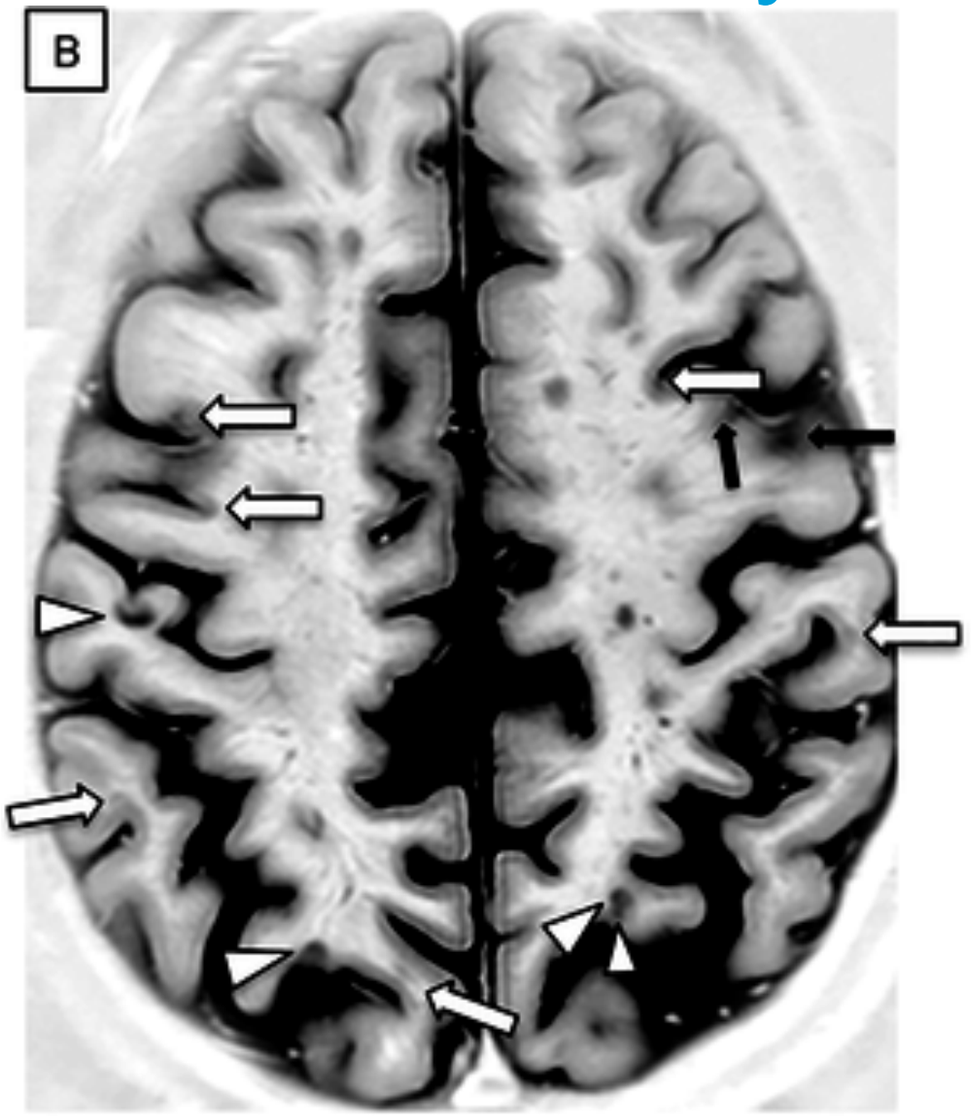
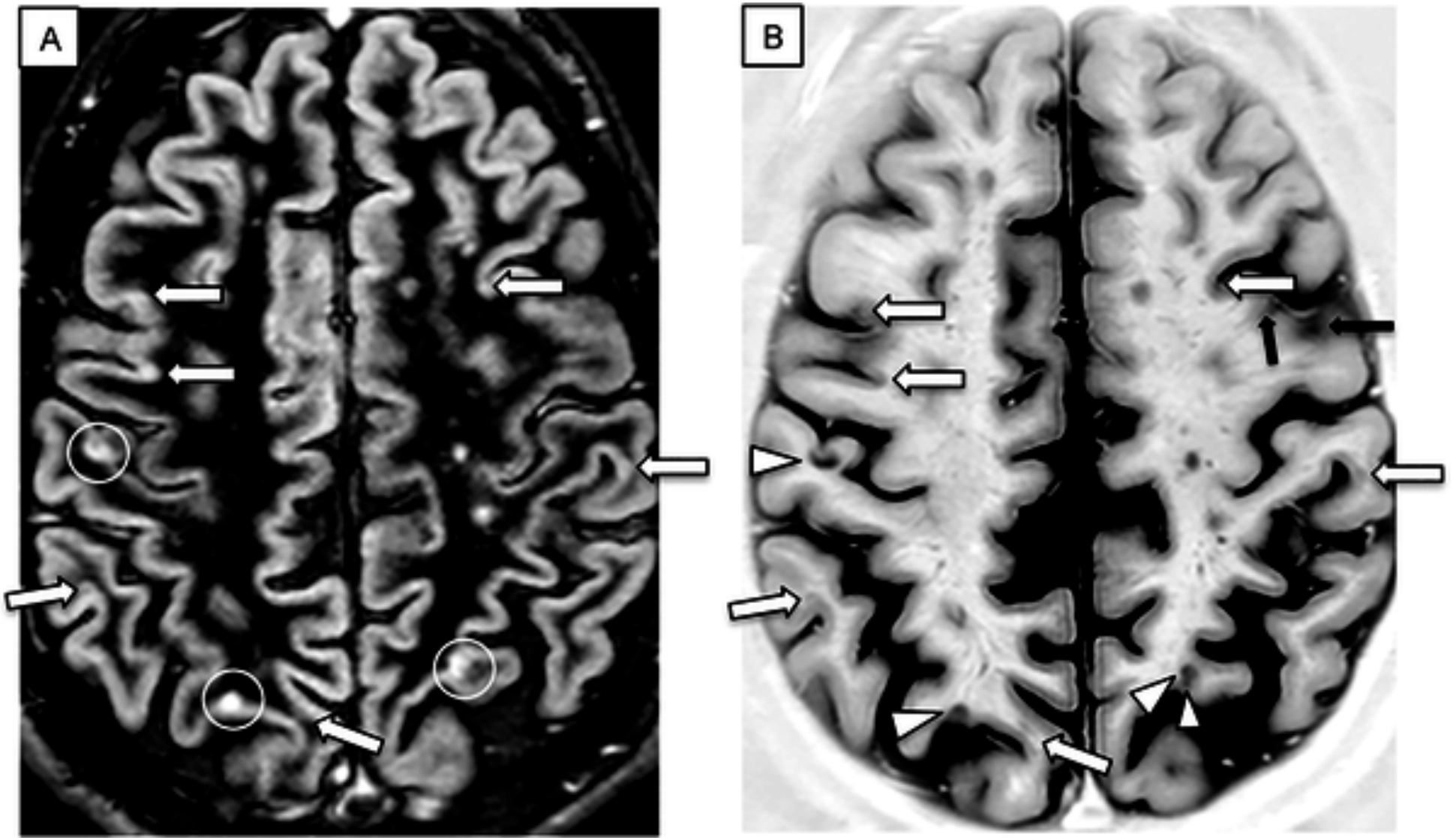


Favaretto et al. Plos One 2015

DIR and PSIR



Favaretto et al. Plos One 2015

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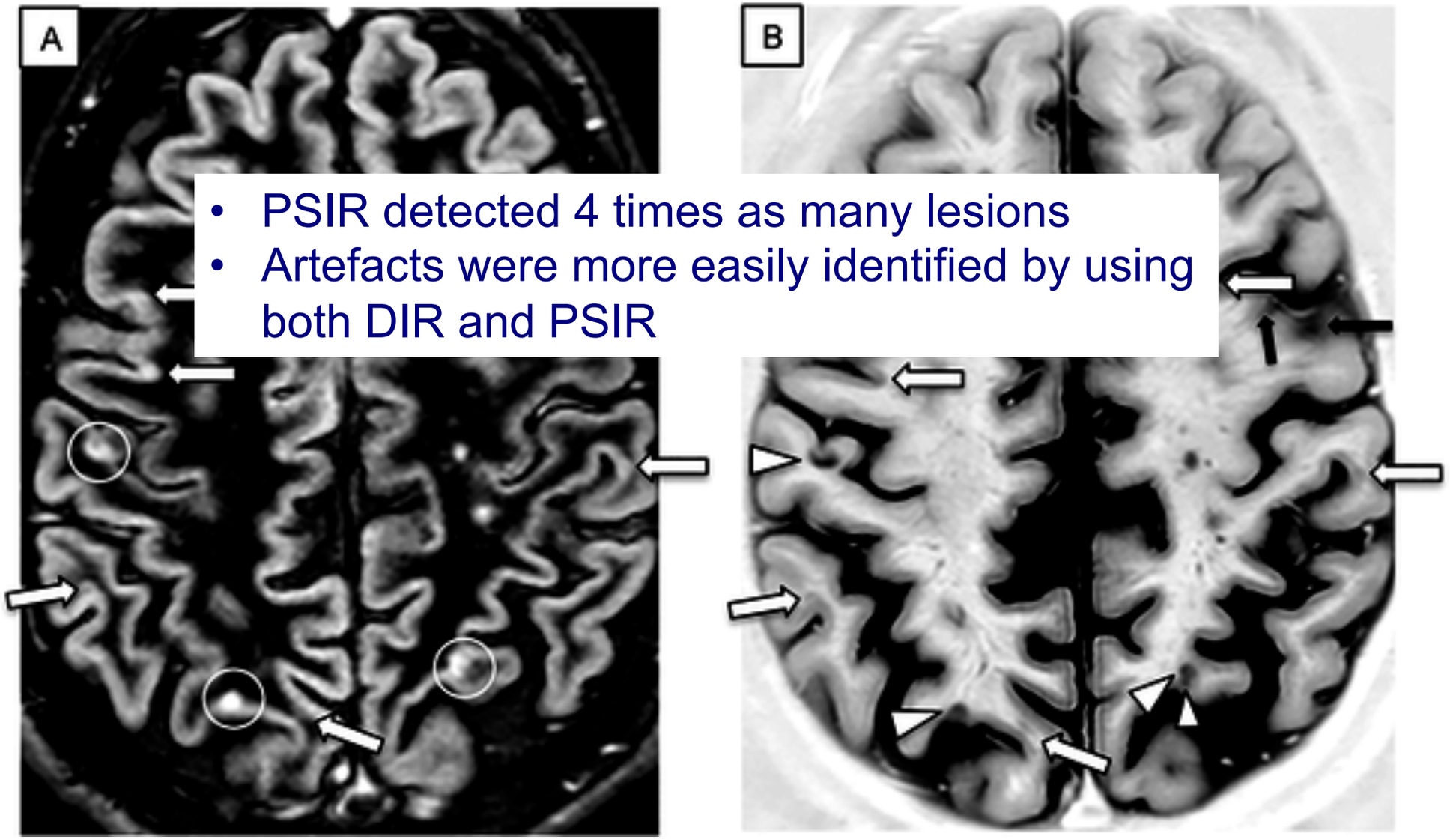
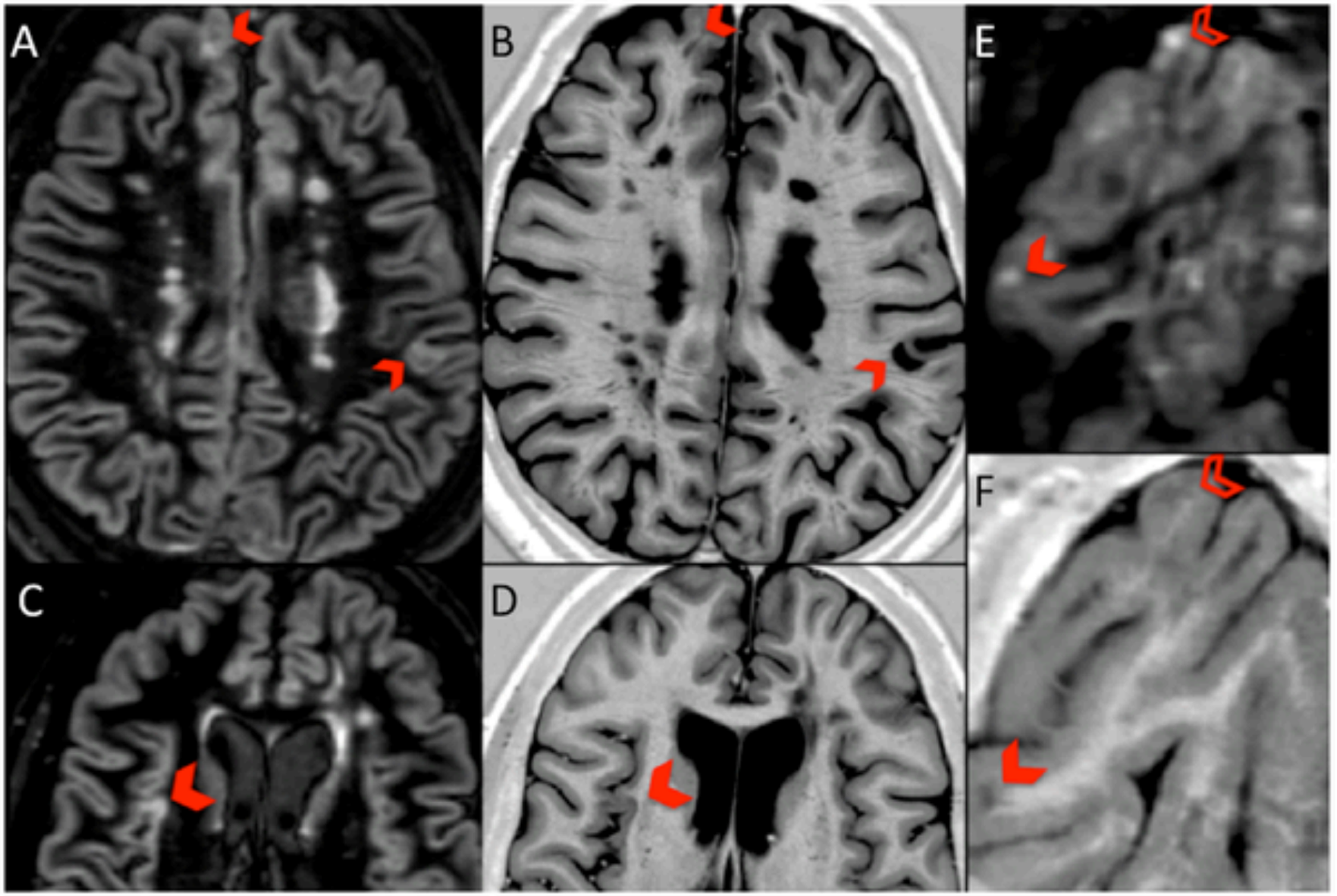


- PSIR detected 4 times as many lesions
- Artefacts were more easily identified by using both DIR and PSIR

Favaretto et al. Plos One 2015

Is PSIR better than DIR for determining lesion locations?



Sethi et al. Plos One 2013

DIR and PSIR and MPRAGE

Multiple Sclerosis and Related Disorders (2014) 3, 253-257

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/msard

Is 3D MPRAGE better than the combination DIR/PSIR for cortical lesion detection at 3 T MRI?

Flavia Nelson[a,*], Aziz Poonawalla[b], Sushmita Datta[b], Jerry Wolinsky[a], Ponnada Narayana[b]

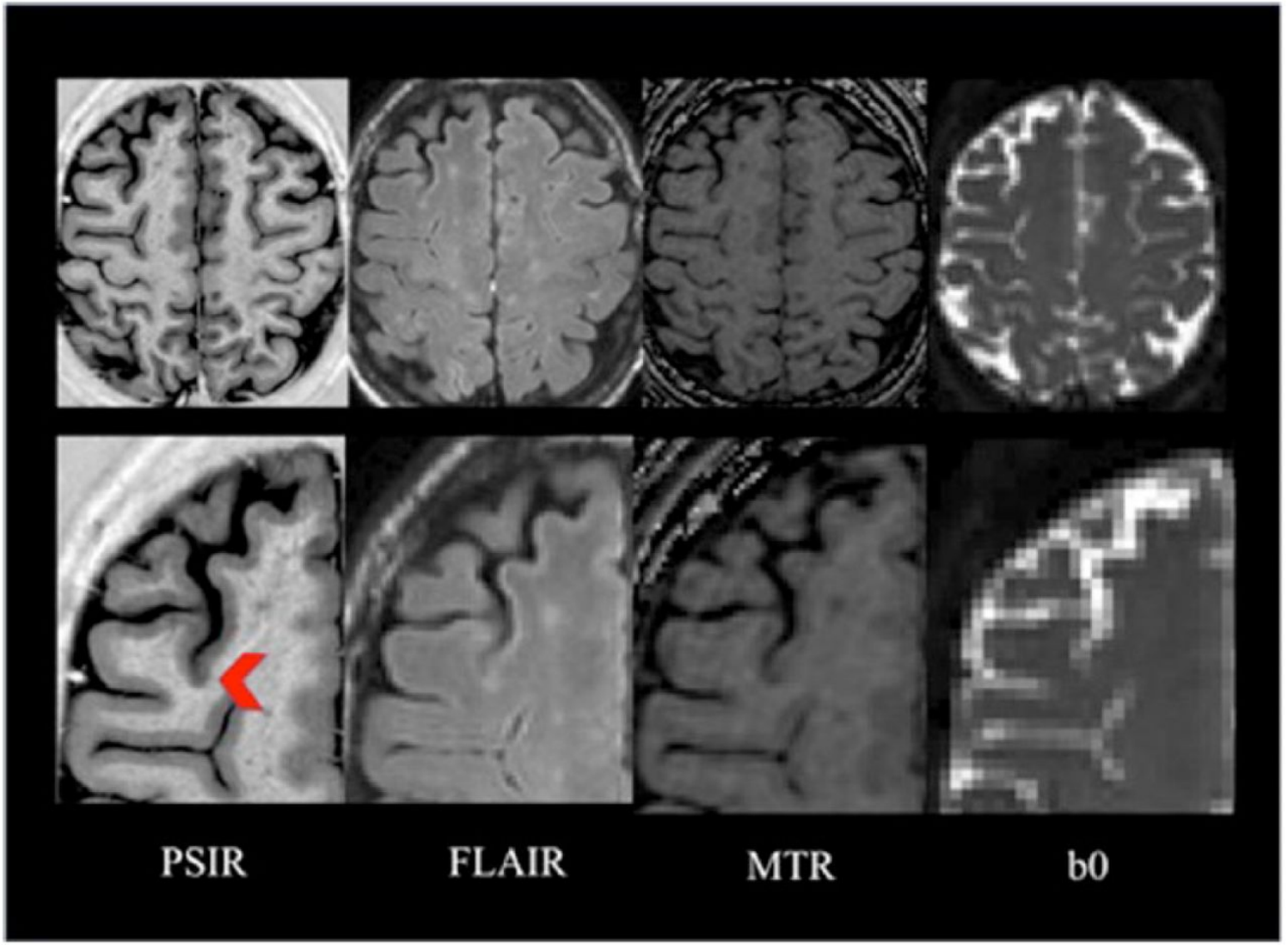
Conclusions: Combination DIR/PSIR at 3 T is superior to 3D MPRAGE for detection of cortical gray matter lesions in MS. The contrast-to-noise ratio of CL appears to be inferior on the MPRAGE images relative to DIR/PSIR

PROBING DIFFUSE GM DAMAGE

Different quantitative MR techniques

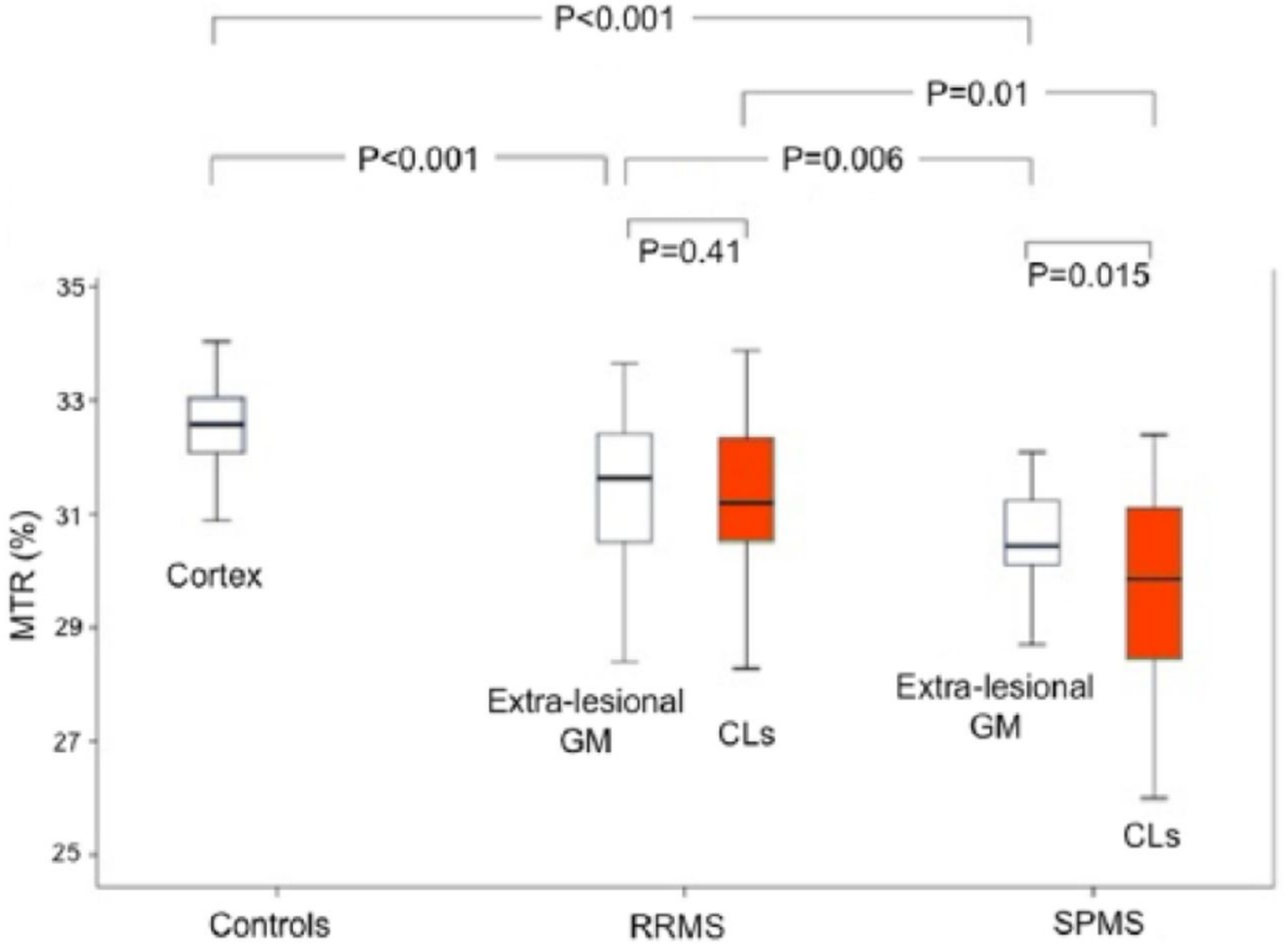
- Diffusion tensor imaging
- Magnetization transfer imaging
- Quantitative susceptibility mapping
- T2* mapping

Magnetization transfer imaging



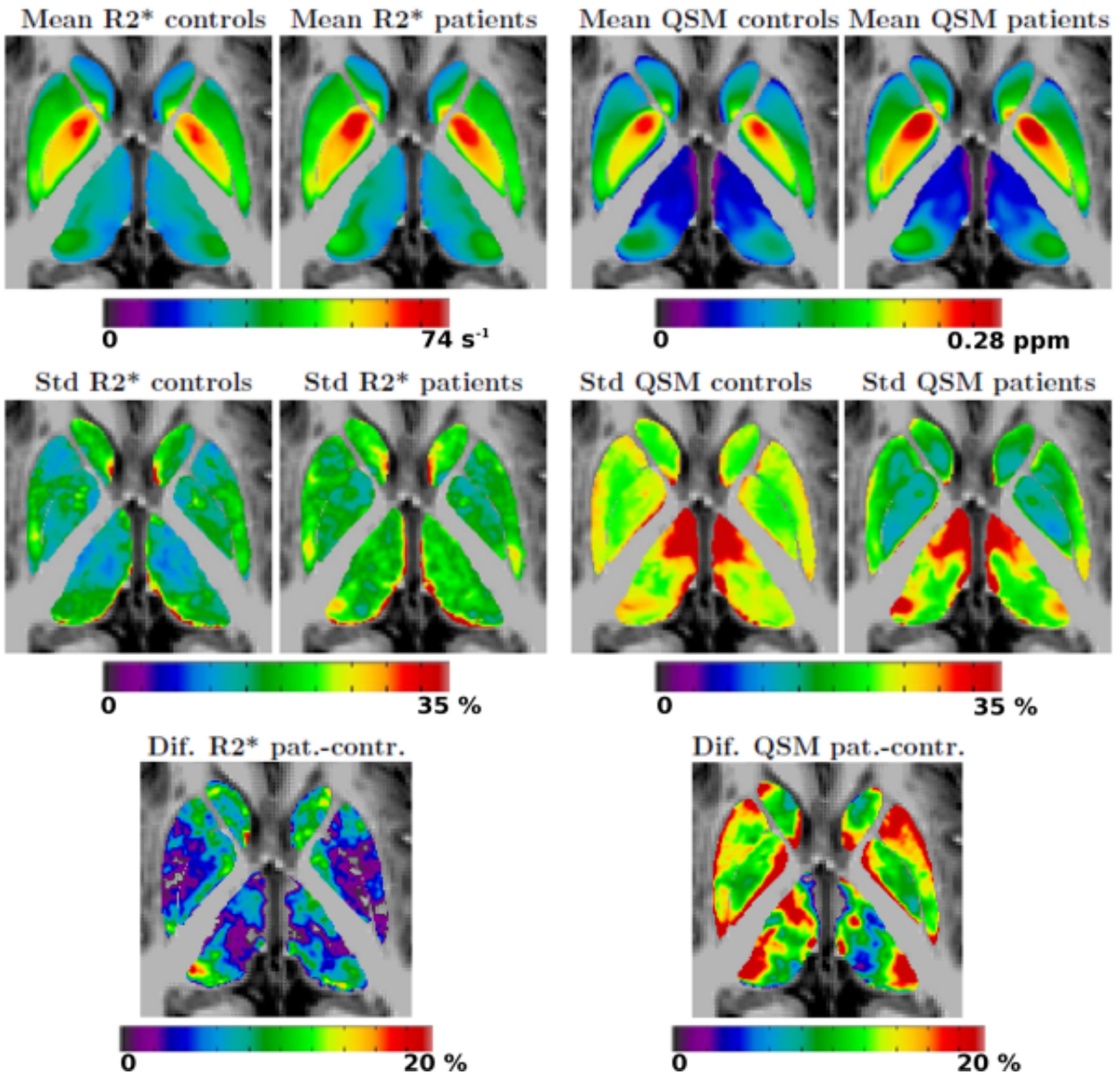
Yaldizli et al. MSJ 2015

Magnetization transfer imaging



Yaldizli et al. MSJ 2015

Quantitative susceptibility mapping



Cobzas et al. JMRI 2015

Acknowledgements

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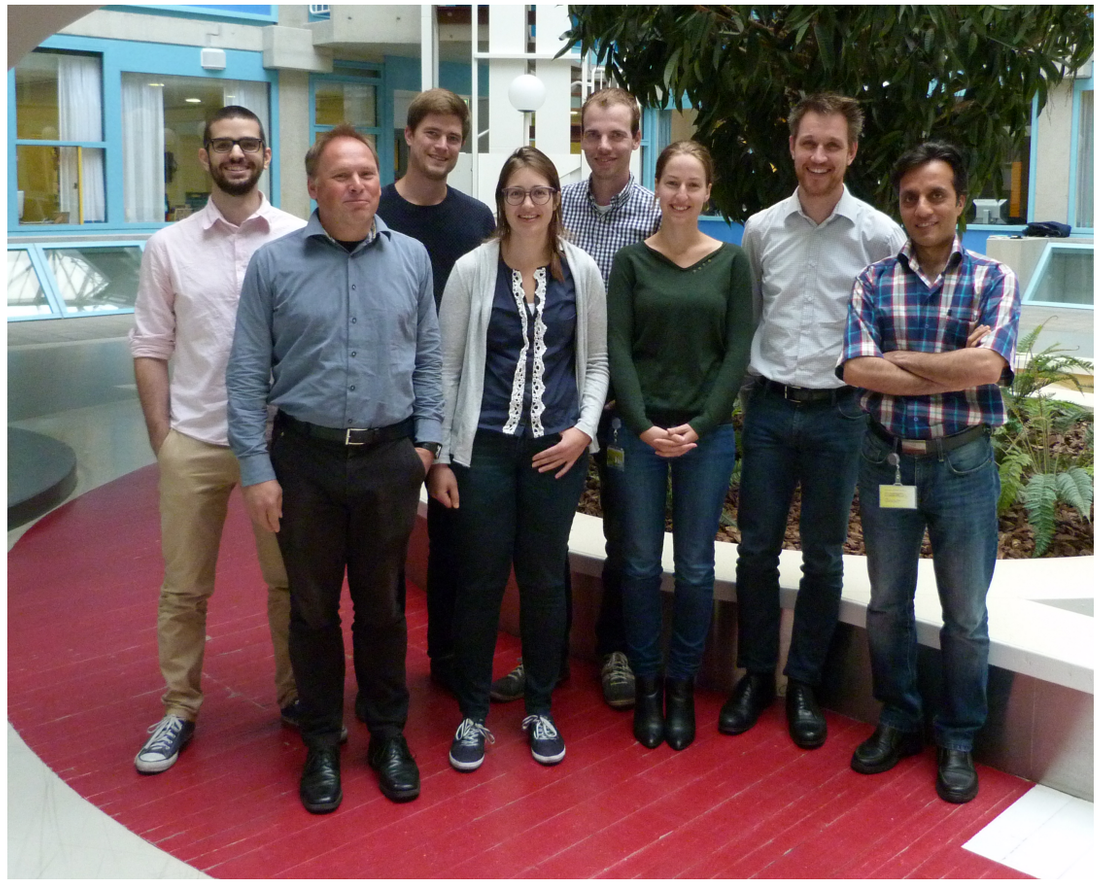

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