

Magnetization Transfer Saturation per TR (MTsat) better discriminates Normal-Appearing White Matter than Magnetization Transfer Ratio (MTR) in Multiple Sclerosis

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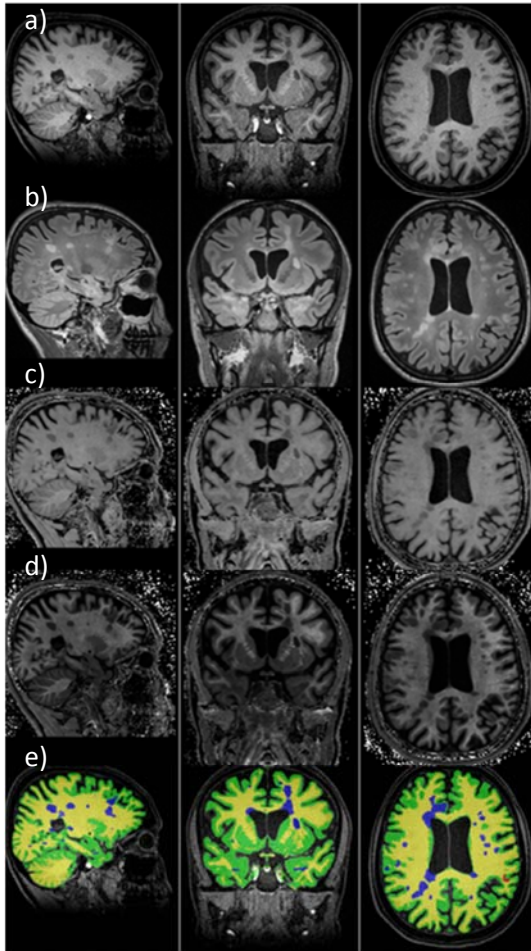


Figure 1. Representative co-registered images in an MS subject. a)MPRAGE b) T2-FLAIR c) MTR d) MT_{sat} e) tissue assignments [NAGM=yellow,NAWM=green, GML=red,WML=blue]

MT_{sat} also had much stronger NAGM/NAWM contrast than MTR due to the T1 dependence of MTR. Acquisition and analysis of MT_{sat} data is less time consuming than for fully quantitative MT, and hence more readily translated into large scale clinical studies.

References – 1.Helms G, MRM 2008;60:1396-1407. 2.Dreha-Kulaczewski SF, JMRI 2012;36:1329-1338. 3.Helms G, NeuroImage 2009;47:194-198. 4. Jack CR, JMRI 2008;27:685-691. 5. Mugler JP, Proc ISMRM 2003:970. 6. Helms G, JMRI 2009;29:198-204. 7. Smith. MIA 2001;5:143-156. 8. Helms G, et al MRM 2008;59:667-672.

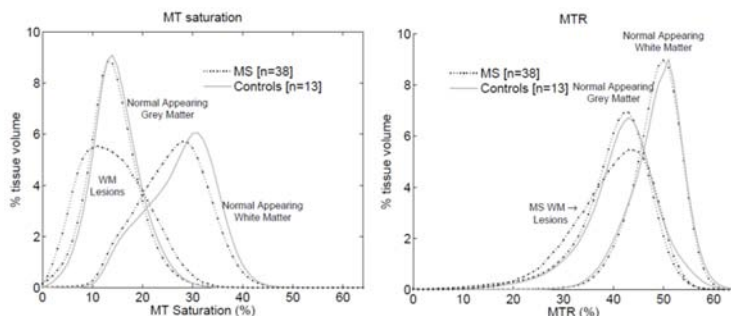


Figure 2. MTR and MT_{sat} histograms. MT_{sat} much more strongly differentiates NAGM and NAWM, but also NAWM between controls and MS subjects. Both MT contrasts highlight WMLs.

Purpose – MT saturation per TR (MT_{sat})¹ has been proposed as a more quantified measure of MT than the MT ratio (MTR). It has been used to study demyelinating diseases² and improve subcortical segmentation³. Here, MT_{sat} was used to interrogate the normal-appearing white matter (NAWM) in a rapidly-evolving multiple sclerosis (MS) cohort.

Methods – 38 MS subjects and 13 age-matched controls were imaged in a 12-ch head coil on a Siemens 3T Verio. All images were acquired as 1mm isotropic 3D volumes: Pre-/post-contrast T1w MPRAGE (ADNI-GO⁴); T2w FLAIR (3D SPACE⁵); MT images used 3 3D FLASH volumes, each in a 256x240x192mm FOV, PI=2, 630Hz/pixel BW with 6 TEs from 1.95 to 11.7ms, summed for SNR⁶. Two volumes of pseudo-proton density weighting (PDw) had a TR=27ms and FA=5° in 7m: 20s. One PDw volume used a 2.2Khz off-resonance 540° 12.24ms duration Gaussian RF pulse to add MT weighting (MTw). The third volume was T1 weighted (T1w) with TR=15ms and FA=18° in 4m: 05s. All volumes were co-registered using FLIRT⁷ to the MPRAGE volume. White and grey matter lesions (WML/GML) were outlined on the MPRAGE and T2-FLAIR by a trained observer. Sienax (with lesions masked) classified tissue on the T1w into NAWM and NAGM. MTR maps were calculated using the MTw and PDw acquisitions by $MTR = 100 \cdot (S_{PDw} - S_{MTw}) / S_{PDw}$. The apparent T₁ relaxation and proton density were first calculated^{1,8}. MT_{sat} in percent units could then be calculated as:

$$MT_{SAT} = 100 \cdot (\tilde{PD} \cdot \alpha_{MTw} \cdot \frac{TR_{MTw}}{\tilde{T}_1}) / S_{MTw} - \frac{TR_{MTw}}{\tilde{T}_1} \cdot \frac{\alpha_{MTw}^2}{2}$$

were created for MTR and MT_{sat} for each region.

Results – As expected, both MTR and MT_{sat} strongly differentiated T1- and T2-visible WMLs from NAWM in both controls and MS subjects (p<0.0001 in all four comparisons). MT_{sat} gave much stronger contrast between NAGM and NAWM than MTR, as can be seen in Figures 1 and 2. Furthermore, the NAWM MTR in the MS subjects was not significantly different from the NAWM in controls, but was significantly different in the MT_{sat} maps.

Discussion – MTR did not differentiate NAWM in controls and MS subjects, a result confirmed or contradicted in previous studies, depending on segmentation and MT methodology in the respective studies. However, using the same setup and ROIs as the MTR, MT_{sat} strongly differed in NAWM between groups. MT_{sat} maps in NAWM had a heterogeneous appearance in MS subjects both proximal and distant to visible lesions, but NAWM was homogeneous in controls, suggesting that pathological abnormalities may exist in non-overtly-lesional tissue. Verification of this observation in an independent study is required.

		NAWM	NAGM	WML	GML
MTR	MS	48.17±1.25	40.01±1.21	39.56±2.31	38.68±4.38
	Control	48.30±0.87	41.27±0.74		
	p=	0.35	0.00012		
MTsat	MS	26.13±1.83	14.51±0.96	14.31±1.94	14.47±3.39
	Control	27.77±1.21	15.15±0.57		
	p=	0.00094	0.022		

Table 1. MTR and MT_{sat} means (±SD) in percent units. MTR does not differentiate NAWM between controls and MS subjects, though MT_{sat} does strongly.