Ultrashort Echo Time (UTE) Contrast in Multiple Sclerosis

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Target audience: Multiple sclerosis researchers, neurologists and neuroradiologists

Purpose: Multiple sclerosis (MS) is a chronic and often disabling disease that affects 2-2.5 million people worldwide in which myelin in the central nervous system is damaged. Non-invasive monitoring of demyelinated lesions is critical for clinical management of MS. Recent ex vivo and in vivo MR studies have demonstrated the existence of ultrashort-T2 components in myelin (10 μs < T2* < 1 ms), presumed to be associated with methylene ^{1}H in the myelin membranes [1-3]. Imaging this component could potentially provide valuable new information for the assessment of MS lesions and monitoring their treatment response. In this project we applied an ultrashort echo time (UTE) MRI pulse sequence with off-resonance RF contrast pulses for enhanced myelin contrast in MS patients.

Methods: Four relapsing-remitting MS patients were scanned on a GE 7T system using a 32-channel head coil with a 3D UTE pulse sequence. The sequence used 10º slab-selective excitation and 3D radial readout with anisotropic FOV [4] to acquire a 4 cm axial slab with 0.8 mm isotropic resolution in ~5 minutes. A second UTE scan was acquired with an adiabatic 360º off-resonance saturation preparation pulse every 32 readouts, applied at -1.8 kHz, and was subtracted from the original UTE image to create a UTE off-resonance saturation contrast image (UTE-OSC) [5]. Other sequence parameters were: TE = 226 μs, TR = 2.4 ms, 1 ms readout duration. Other contrast mechanisms were also explored, including subtraction of a TE = 2 ms image, and an adiabatic IR prep UTE (TI = 600ms, 1.1 mm resolution, 4º hard pulse excitation, TE = 76 μs, TR = 1.8ms). They were compared to an IR SPGR sequence with TE = 2.3 ms, TR = 6.2 ms, 1 mm isotropic resolution, 8º flip angle.

Results:

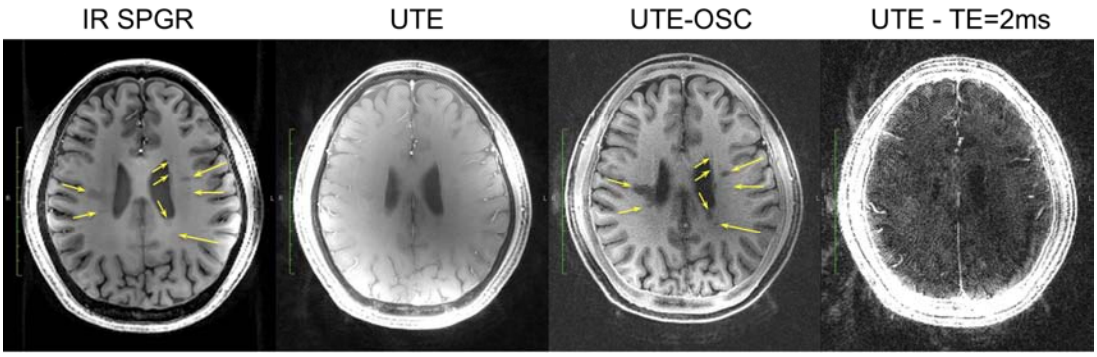

Figure 1: Comparison of various contrast mechanisms in a MS patient with several large lesions. Suspected lesions (yellow arrows) are clearly delineated by the absence of signal in the UTE-OSC images, at least comparably to the IR SPGR. They have less contrast in UTE alone, and no contrast in the UTE - TE=2ms difference image.

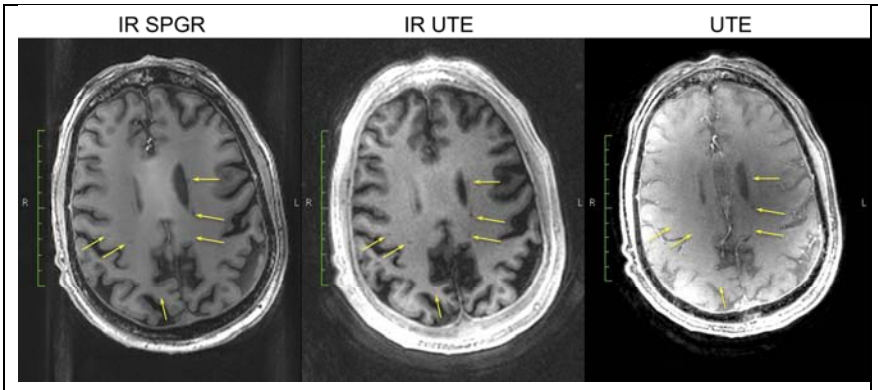

Figure 2: Comparison of IR SPGR and IR UTE showing very similar contrast of suspected lesions. Compared to UTE alone, IR improved the gray/white and lesion contrast substantially.

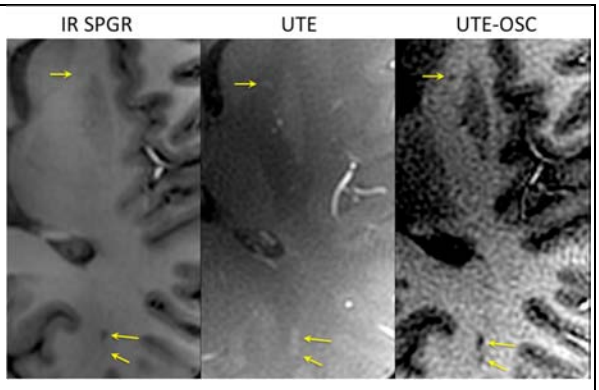

Figure 3: Depiction of small suspicious lesions was enabled by the 0.8 mm isotropic UTE/UTE-OSC resolution. A suspected lesion in the internal capsule was most clearly visible in the UTE images.

Discussion & Conclusion: The UTE-OSC images provided the clearest depiction of suspected demyelinated lesions. The 0.8mm isotropic resolution enabled detection of small lesions, some of which were difficult to observe in the conventional IR SPGR. We expect UTE-OSC to specifically sensitive to positive contrast of myelin, with a constructive combination of ultrashort-T2 components and magnetization transfer contrast. With UTE alone these suspected lesions had variable contrast, likely due to flip angle differences creating variable T1-weighting. UTE with IR depicted the MS lesions, similarly to an IR SPGR acquisition. A dual-echo subtraction primarily depicted the skull and meninges, but had no contrast in the cortex. These initial results indicate that UTE with IR or OSC could provide valuable new information for the assessment and monitoring of MS lesions.

References: [1] Horch et al. *MRM* 2011;66:24-31. [2] Wilhelm et al. *PNAS* 2012;109:9605-10. [3] Du et al. *Neuroimage* 2013; Available online. [4] Larson et al. *IEEE-TMI* 2008;27:47-57. [5] Du et al. *MRM* 2009;62:527-31.