Can 7T White Matter Attenuated Turbo Field Echo Replace FLAIR for White Matter Lesion Load Assessment in MS?

Andrew J Kalnin[1], Katharrine Bluestein[1], David Pitt[2], Grant K Yang[1], Michael V Knopp[1], and Petra Schmalbrock[1]
[1]*Radiology, The Ohio State University, Columbus, Ohio, United States,* [2]*Neurology, The Ohio State University, Columbus, Ohio, United States*

Introduction: T2-FLAIR white matter lesion load is typically viewed as a marker of disease burden in MS but has limited value for predicting disease progression. Thus there is significant interest in finding more specific imaging markers, and 7T MRI is especially promising in this context. T2-FLAIR fast spin echo is feasible at 7T [1], but requires high SAR. The objective of this study was to evaluate an inversion recovery turbo-field echo sequence that uses TI selected such white matter signal is attenuated (termed *WH*ite matter *AT*tenuated or *WHAT*) [2]. This sequence has high contrast between white matter lesion (WML) and normal appearing white matter (NAWM), is fast and has lower SAR requirements, but unlike FLAIR, WHAT reflects only T1 but not T2 tissue differences. WML detection with 7T-WHAT and 3T-FLAIR were compared.

Methods: Four MS patients (mean age 34.3y) were studied at 3T and 7T. 7T-WHAT images covering the brain were acquired in less than 5 minutes using shot interval TS/ inversion time TI=4450/500ms, 0.5x0.5x2.0mm voxels and adiabatic hyperbolic secant inversion pulses. Conventional 3T MRI included 2D-FLAIR (TR/TI/TE=11000/2800/125ms, 0.75x0.77x4.0mm, 1mm slice gap), pre/post T1-SE (TR/TE 500/10ms) and T1-3D-MP-RAGE (TS/TI=3000/980ms, 0.9x1.15x2.0mm). 3T FLAIR images were registered to the 7T-WHAT using FSL which included 2.5-fold interpolation of the 3T FLAIR images in the slice direction. Images were then viewed side by side by two observers each with more than 20y experience (R1: Neuroradiologist, R2: MRI researcher) and lesions were counted in representative slices.

Results: Figure 1 shows representative image examples. Overall, the lesions having the highest signal are more distinct on FLAIR. Conversely on WHAT, contrast between lesions and both gray matter and CSF is lower. This slightly hinders detection of WM lesions especially near the cortex, deep gray matter and ventricles. Most notably, lesions that appeared contiguous on 3T-FLAIR were differentiated at 7T-WHAT and lesions often appeared smaller in WHAT. This may be in part due to the higher slice resolution in WHAT. It also reflects diffuse T2 changes seen on FLAIR, but not on WHAT, which reflects only tissue T1 differences. Thus WHAT may be more indicative of tissue damage, while FLAIR may better reflect reversible tissue change. Overall, the WHAT sequence detected an average of 76% of all 200 lesions seen on FLAIR.

Conclusion: It is well known that only a portion of the T2-FLAIR lesions are seen on conventional T1-weighted images. It has been shown that the presence of persistent T1 "black holes" correlates with clinical outcomes and atrophy [3], that about 20% of Gd enhancing lesions eventually will become "black holes" [4,5] whereas remyelination may reverse lesion hypointensity [4]. Pathology studies further confirm that T1 black holes reflect structural tissue damage [6]. Consequently, T1 hypointensity is considered a marker for more advanced, persisted tissue damage in MS. Sinnecker et al recently demonstrated that T1-weighted MP-RAGE at 7T detects more lesions than T2 weighted imaging at 1.5T or 7T [7]. Our study confirms that an inversion recovery turbo-field echo sequence can detect a large fraction of lesions seen with FLAIR, and WHAT may also better differentiate important characteristics of lesions such as their T1 relaxation.

References: [1] de Graaf, ISMRM 2010, 2067; [2] Bluestein, ISMRM 2011, 2158; [3] Sailer Eur J Neurol 2001; [4] Bagnato, Brain 2003; [5] vanWaeshberghe AJNR 1998; [6] Walderveen, Neurology 1995; [7] Sinnecker, ISMRM 2011, 2165;

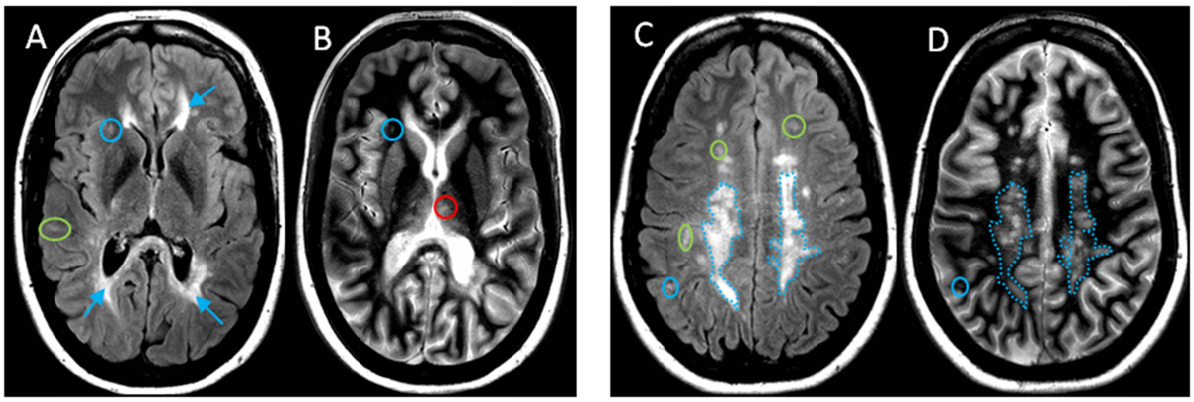

Figure 1: 3T FLAIR (A,C) versus 7T-WHAT (B,D): WHAT better separates individual lesions from large confluent lesions on FLAIR (dashed outline, arrows). Two example lesions marked blue are seen with both sequences, but more conspicuous on FLAIR. Lesions marked green are only seen on FLAIR, Lesions seen only on WHAT are marked red.