A comparison of FLAIR* and T2*-weighted imaging in detecting white matter lesions and central veins in patients with MS and ischaemic lesions at 3T.

Amal Samaraweera[1], Margareta Clarke[2], Olivier Mougin[3], Rob Dineen[4], Ian Driver[3], Paul S Morgan[5], and Nikos Evangelou[1]

[1]Division of Clinical Neuroscience, University of Nottingham, Nottingham, United Kingdom, [2]Clinical Neurology, Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom, [3]Sir Peter Mansfield MR Centre, University of Nottingham, Nottingham, United Kingdom, [4]Department of Neuroradiology, Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom, [5]Nottingham University Hospitals NHS Trust, Nottingham, United Kingdom

TARGET AUDIENCE: Neurologists or Radiologists involved in the diagnosis and management of patients with Multiple Sclerosis (MS).

PURPOSE: Detecting cerebral white matter (WM) central veins (CV) appears to be very common in MS. [1–3] In one study using 7T MR it has been used as an imaging biomarker for patients in times of diagnostic uncertainty.[4] If to be used in clinical scanners, it is essential to achieve accurate and reproducible lesion and vein identification. T2*-weighted imaging has been shown to delineate CV in MS using 7 and 3T MRI [5,6] however the visibility of lesions is sometimes poor. More recently an image postprocessing technique that combines FLAIR and T2* (FLAIR*) has been shown to delineate lesions and veins more accurately than standard T2*-weighted protocols.[7] However the accuracy of this technique has not been fully tested without intravenous contrast and in patients with small vessel ischaemia (the commonest MS MRI mimic) at 3T. The aim of this study was to assess the accuracy in detecting WM lesions and WM CV in patients with MS and ischaemic lesions using FLAIR* compared to T2* with high EPI and SWI using 3T MRI brain imaging.

METHODS: Eighteen patients (10 MS and 8 ischaemic) were scanned on a 3T Achieva (Philips Healthcare, Best, The Netherlands) and all had the following sequences: 3D FLAIR, 3D T2*-weighted GRE and 3D T2*-weighted protocol with high EPI. Production of the FLAIR* requires two different images. FLAIR images were acquired with the following parameters: pixel size of 1x1x1mm3, matrix size of 256x256x180, acquisition time of 6min10s, TI=1650ms, TR=4800ms, TEeff=290ms, NSA=2. SWI was acquired with a 3D GRE sequence with following parameters: pixel size of 0.5x0.5x1.05mm3, matrix size of 384x384x96mm, acquisition time of 8min23s, TR=150ms, TE=25ms, EPI factor of 3, FA=14. Phase mask was obtained as mentioned in Haacke et al.[8] Registration of the FLAIR images onto the SWI images was obtained using flirt from FSL. Multiplication of FLAIR by SWI produced the FLAIR* images (Fig. 1)

The detection of WM lesions on FLAIR and FLAIR* was compared by two raters, including an experienced neurologist. Lesion and vein identification were then compared between FLAIR* and T2* on a subset of patients after randomisation. Finally the diagnosis of MS or ischaemia was determined after reviewing a sample of lesions as described by Mistry et al.[9]

RESULTS: Out of a total of 1,172 WM lesions seen on FLAIR, 240 WM lesions were reviewed and found present on FLAIR*. Similarly, 120 lesions seen on T2* were assessed for their visibility on FLAIR* and no lesion was missed by FLAIR*. The inter-rater reproducibility in the detection of veins on FLAIR* was assessed in 100 lesions (both MS and ischaemic) and was found to be good. Cohen's $\kappa = .734$, $p < .0005$. (Both observers agreed on the presence or absence of a CV in 91/100 lesions).

CV detection was high in MS lesions. 51 out of 60 lesions (85%) had CV seen both on FLAIR* and T2*. In ischaemic lesions, similar to the literature [1,10] only a minority had CV (13%, 8 out of 60 lesions). Based on identifying only 6 lesions with CV, 87.5% of MS patients could be correctly diagnosed on FLAIR* and T2*. All ischaemic patients were diagnosed correctly based on less than 6 lesions with CV.

DISCUSSION: Qualitatively, FLAIR* is superior in distinguishing periventricular WM lesions from CSF compared to standard T2*-weighted imaging therefore preventing incorrect segmentation of CSF. It is also better in differentiating juxtacortical WM lesions from grey matter. Perivascular spaces are hyperintense on standard T2* images. These are less prominent on FLAIR* therefore reducing the chance of mistaking these for lesions. Dirty appearing WM is less prominent on FLAIR* so making lesion segmentation easier. These features make the images easier to use clinically. FLAIR* was able to detect WM lesions and their veins in MS, in agreement to Sati et al[7] but without the need of contrast agent. For the first time, we also report the use of FLAIR* in ischaemic lesions at 3T and reassuringly only a minority of lesions show a CV, suggesting that it can be used for diagnostic purposes once exact criteria are established.

CONCLUSION: T2* previously and in this cohort has been found useful in the detection of central veins in MS. If FLAIR* can be produced easily in a clinical setting (it requires an extra post acquisition step) it has greater advantages than T2* at 3T. Even without intravenous contrast it is useful for identifying WM lesions and central veins in patients with MS and does not overestimate veins in ischaemic lesions. Prospective studies are needed to see if this can be used as an imaging biomarker.

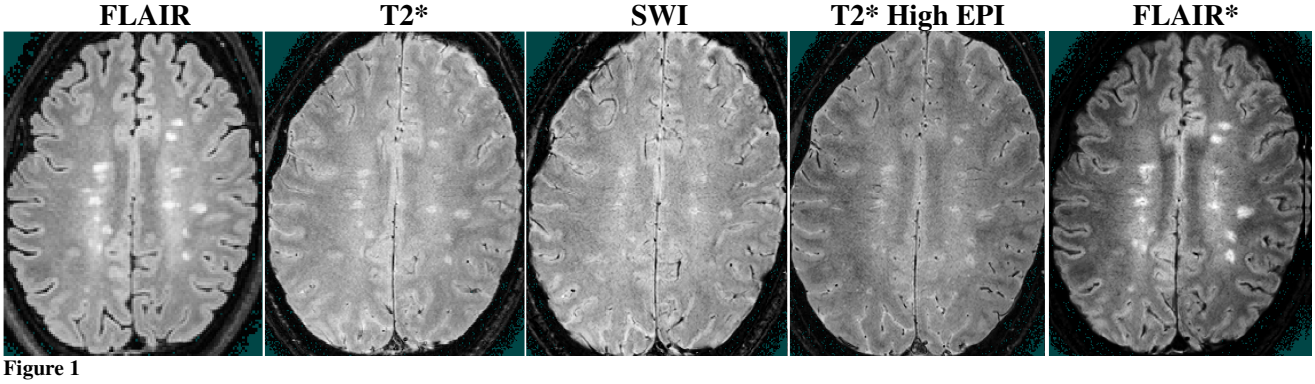

Figure 1

REFERENCES

1. Tallantyre EC et al. Ultra-high-field imaging distinguishes MS lesions from asymptomatic white matter lesions. Neurology. 2011
2. Kister I et al. Ultrahigh-Field MR (7 T) Imaging of Brain Lesions in Neuromyelitis Optica. Mult Scler Int. 2013
3. Wuerfel J et al. Lesion morphology at 7 Tesla MRI differentiates Susac syndrome from multiple sclerosis. Mult Scler J. 2012
4. Mistry N et al. Central veins in brain lesions visualized with high-field magnetic resonance imaging: A pathologically specific diagnostic biomarker for inflammatory demyelination in the brain. JAMA Neurol. 2013
5. Tallantyre EC et al. Demonstrating the Perivascular Distribution of Ms Lesions in Vivo with 7-Tesla MRI. Neurology. 2008
6. Tallantyre EC et al. A Comparison of 3T and 7T in the Detection of Small Parenchymal Veins within MS Lesions. Investig Radiol. 2009
7. Sati P et al. A Combined MR Contrast Technique for Visualizing White Matter Lesions and Parenchymal Veins. Radiology. 2012
8. Haacke EM et al. Susceptibility weighted imaging (SWI). Magn Reson Med. 2004
9. Mistry et al. 3 Tesla T2* brain MRI distinguishes multiple sclerosis from incidental white matter lesions. Poster presented at ECTRIMS 2013, Copenhagen
10. Kau T et al. The 'central vein sign': is there a place for susceptibility weighted imaging in possible multiple sclerosis? Eur Radiol. 2013