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Fast field-cycling MRI identifies ischaemic stroke at ultra-low magnetic field strength

J. Ross[1], L. Broche[1], M. J. MacLeod[2], D. Lurie[1]

[1]*University of Aberdeen, Aberdeen Biomedical Imaging Centre, Aberdeen, UK,*
[2]*Aberdeen Royal Infirmary, Acute Stroke Unit, Aberdeen, UK*

Purpose:
Fast Field-Cycling MRI[1] (FFC-MRI) is a novel MRI technique in which the external magnetic field is switched rapidly between levels during the imaging experiment. In this way, FFC-MRI gains access to information which is invisible to conventional MRI scanners, especially the variation of T1 with magnetic field, known as ''T_1 dispersion''. By performing signal measurements at a relatively high magnetic field, FFC-MRI allows relaxation times below below 1 mT to be probed without the excessive loss of SNR usually incurred at ultra low field. The T_1 values corresponding to these ultra-low magnetic fields are associated with slow molecular motion with long correlation times, which may have diagnostic value in a wide range of pathologies. In this work we aimed to assess whether we can identify recent cerebral infarcts at ultra-low field strength, when compared with conventional imaging.

Methods:
After informed consent, a group of patients (n = 22) with ischemic stroke were scanned using FFC-MRI within 24–96 h of presentation. Initial diagnosis was performed using CT and/or 3T MRI.
The FFC-MRI scans were performed a home-built field-cycling scanner (Fig. 1) comprised of a resistive magnet with a maximum field strength of 0.2 T. Sets of images from five different evolution fields ranging from 200 mT to 0.2 mT were obtained using a spin-echo readout. The FFC-MRI imaging parameters were: Matrix size 128 9 128, FOV = 280 mm, THK = 10 mm, TE = 24 ms. Total scan duration, including setup time, was approximately 45 min.

Results:
In patients with sub-acute ischaemic stroke, T_1-weighted FFC-MRI images exhibited hyper-intense regions, with contrast increasing markedly as the evolution magnetic strength field decreased, to a maximum at the lowest field used (0.2 mT). The infarct region measured by FFC-MRI correlated well with the abnormality in CT and/or DWI images (Examples in Figs. 2, 3).

Discussion/Conclusion:
This is the first-ever clinical application of this new modality, proving that FFC-MRI can generate diagnostic quality images of ischaemic stroke at ultra-low magnetic fields (e.g. 0.2 mT), with significantly enhanced endogenous T1-contrast compared to conventional MRI. These findings have implications for future development of a new and safe imaging modality not only for stroke but many other clinical conditions.

References:
Lurie, D. J. et al. Fast field-cycling magnetic resonance imaging.
Comptes Rendus Phys. 11, 136–148 (2010).

Figure 1: The FFC-MRI system

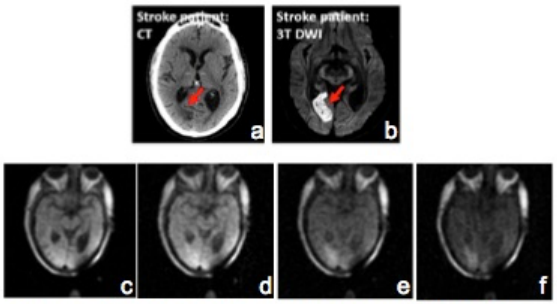

Figure 2: CT, 3T DWI MRI and FFC-MRI images from a 67 year old male admitted with a right occipital infarct. a) CT at 24 hours after onset, b) 3T DWI images at 78 hours after onset. c-f) FFC-MRI images at the level of the lesion at 200 mT, 20 mT, 2mT and 0.2 mT respectively (75 hours after onset).

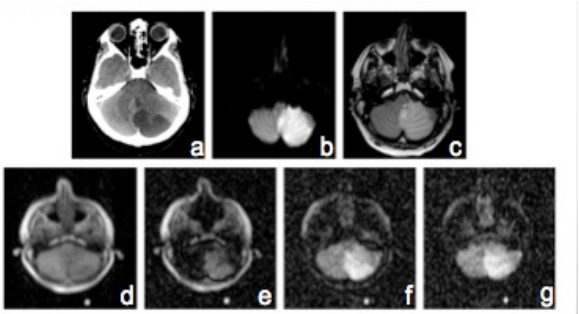

Figure 3: CT, 3T DWI MRI and FFC-MRI images from a 50 year old male admitted with a posterior inferior cerebral artery territory infarct. a) CT at 24 hours after onset, b) 3T DWI images at 96 hours after onset, c) 3T T_2 weighted image at 96 hours after onset. d-g) FFC-MRI images at the level of the lesion at 200 mT, 20 mT, 2mT and 0.2 mT respectively (90 hours after onset).