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

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Purpose:
Fast Field-Cycling MRI¹ (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 ‘‘T1 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 T1 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 x 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, T1-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:
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 T2 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).