

European Network on NMR Relaxometry

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Imaging of acute stroke by FFC-MRI: the PUFFINS study

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Introduction: Our research team is developing Fast Field Cycling (FFC) MRI ¹, an emerging technology that uses variable magnetic fields to detect molecular motion below the cellular scale². It provides contrast in a variety of *ex-vivo* diseased tissues^{3,4} that reflect alterations in cellular water dynamics⁵, protein concentration and protein binding⁶, and are invisible to any other non-invasive image modalities. Here we present results from the PUFFINS study (Potential Use of Fast Field cycling MRI IN Stroke), which aims to assess whether FFC-MRI can identify recent cerebral infarcts in stroke patients.

Materials and Methods: Following approvals (16/NS/0136/AM01 IRAS197187), 22 individuals admitted with ischemic stroke were scanned 24 to 96 hours after presentation. Duration of the FFC-MRI examination was 45 minutes, including setup, scout and FFC images at five evolution fields from 200 μ T to 200 mT. Inversion recovery images were obtained by spin-echo with a 20 kHz bandwidth, 128 x 128 voxels, in-plane resolution of 1.9 mm and a slice thickness of 8 mm. Data analysis was done in Matlab (Mathworks, Natick, USA) using homemade programs to perform image segmentation based on the raw signal and to generate relevant contrast. The results were compared to CT or 3T images acquired within 24 hours of the FFC-MRI images.

Results: In five patients, the infarct region measured by FFC-MRI exhibited hyper-intense regions at fields below 200 mT that correlated with the CT and DWI images (see example in Figure 1). This contrast increased markedly as the evolution magnetic strength field decreased, reaching a maximum below 2.2 mT. Nine participants did not complete the scan due to claustrophobia and/or unsuitable body habitus, while in two subjects the single-slice scan missed small areas of infarction. A Matlab reconstruction of contrast maps in four patients is shown in Figure 2.

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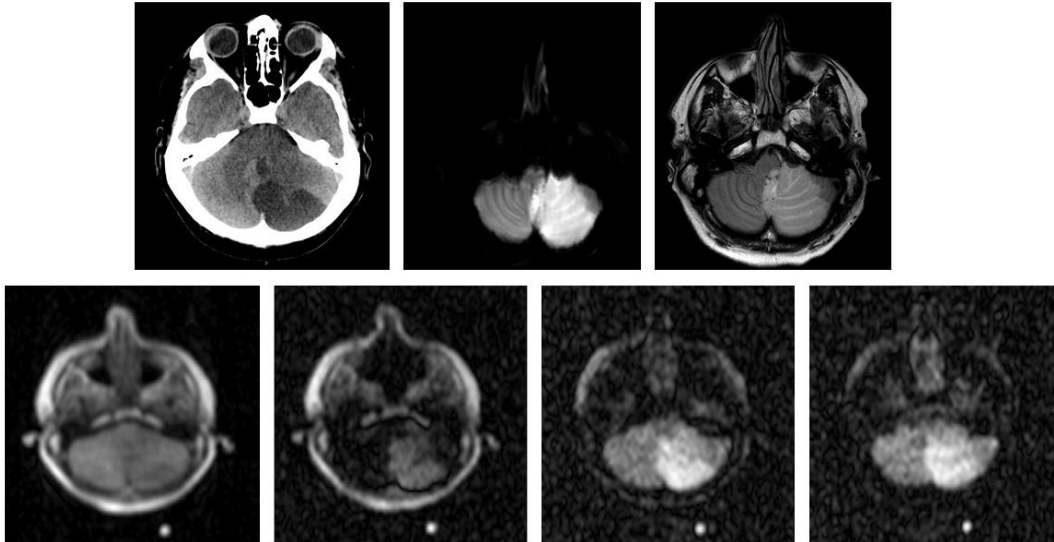


Fig 1. CT, 3T MRI and FFC-MRI images from a 50-year old male admitted with a posterior inferior cerebral artery territory infarct. a) CT at 54 hours after onset, b,c) DWI image and T2 weighted image 7 days after onset, d-g) FFC-MRI inversion recovery images at the level of the lesion at 200mT, 2.2mT, 2mT and 0.2mT respectively, 6 days after onset.

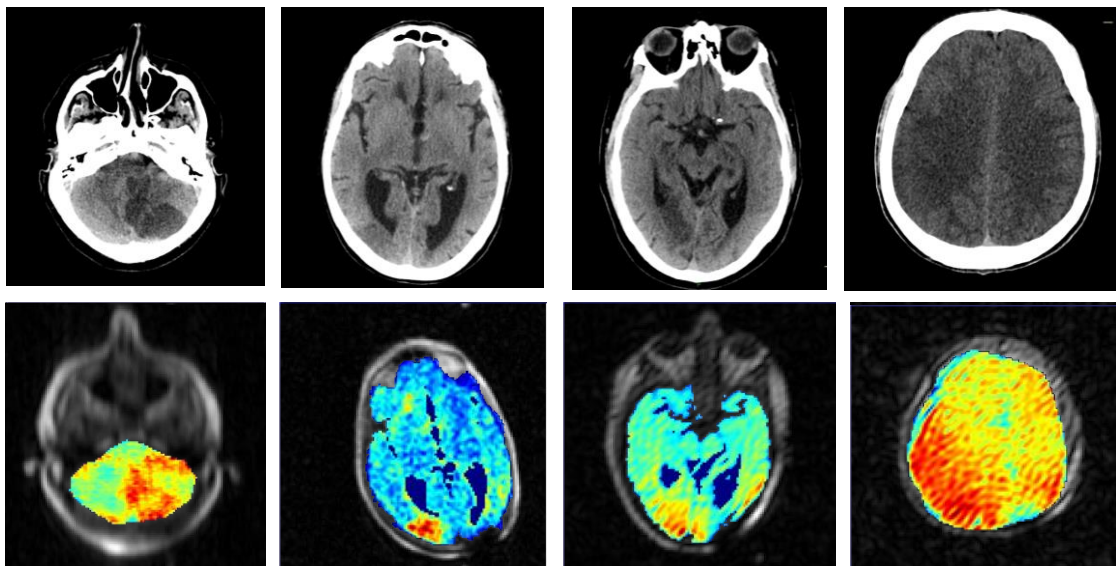


Fig. 2. Comparison of CT (top row) and FFC-MRI images (bottom row) obtained using the magnitude of the raw signal at low magnetic fields in four subjects. a) cerebellar infarct b) right occipital infarct c) right occipital infarct d) right middle cerebral artery territory infarct.

Discussion/Conclusion: This is the first-ever reported *in vivo* data from patients obtained using FFC imaging. It confirms that significant contrast is available below 20 mT in patients with stroke, which discriminates between healthy and ischemic brain regions. These changes may reflect altered water dynamics across cell membranes due to oedema and cell death^{5,6}.

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Further scans as part of the PUFFINS study will explore optimal contrast mapping and changes in the lesion over time. Future work includes developing a more accessible scanner and exploring the role of FFC imaging in hyper-acute stroke, TIA and other diseases of the brain and other organs.

FFC imaging has potential to offer an exciting and safe new modality to complement existing imaging platforms and provide new tissue information in disease.

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