## FIELD-CYCLING MAGNETIC RESONANCE IMAGING – A CURIOSITY OR THE NEXT BIG THING?

<u>David J. Lurie</u>, Lionel M. Broche, Gareth R. Davies, Nicholas R. Payne, P. James Ross and Vasileios Zampetoulas

Aberdeen Biomedical Imaging Centre, University of Aberdeen, AB25 2ZD, Scotland, UK

The use of Fast Field-Cycling Magnetic Resonance Imaging (FFC-MRI) is a relatively new variant of MRI, aimed at increasing its medical diagnostic potential [1].

FFC-MRI was first demonstrated in conjunction with Proton-Electron Double-Resonance Imaging (PEDRI) to image the distribution of free radicals in biological samples using the Overhauser Effect (combined NMR and Electron Spin Resonance (ESR). Field-cycling allows the ESR irradiation to be applied at low field (hence relatively low frequency, and low non-resonant absorption), while NMR signal detection and imaging is carried out at higher field, to preserve SNR [2].

NMR relaxometry is usually accomplished using FFC, by switching the magnetic field rapidly between levels during the pulse sequence. In this way, a single instrument can be used to measure  $T_1$  over a wide range of magnetic field strengths. FFC-MRI aims to obtain spatially-resolved  $T_1$ -dispersion data, by collecting images at a range of evolution field strengths [1,3,4]. We have demonstrated methods for implementing relaxometry on localised regions defined on a pilot image [5]. We have also shown that FFC relaxometry can detect the formation of cross-linked fibrin protein from fibrinogen *in vitro*, in a model of the blood clotting process, via the measurement of  $^{14}$ N- $^{1}$ H cross-relaxation phenomena [6], and we have shown that FFC-MRI can detect changes in human cartilage induced by osteoarthritis [7]. Recent work has focussed on speeding up the collection of FFC-MRI images by incorporating rapid MRI scanning methods and improved pulse sequences and algorithms [8,9].

In our lab we have built a range of FFC-MRI equipment, including two whole-body human sized scanners, operating at detection fields of 0.06 T [10] and 0.2 T. The 0.06 T scanner uses a double magnet, with field-cycling being accomplished by switching on and off a resistive magnet inside the bore of a permanent magnet; this has the benefit of inherently high field stability during the detection period. We have also demonstrated technology for localised field switching within a clinical MRI system [11].

This presentation will cover the main techniques used in FFC-MRI and will summarise current and potential bio-medical applications of the methods.

- [1] Lurie D.J., Aime S., et al., Comptes Rendus Physique 11, 136-148 (2010).\*
- [2] Lurie D.J., Hutchison J.M.S., et al., J. Magn. Reson. 84, 431-437 (1989).\*
- [3] Carlson J.W., Goldhaber D.M., et al., Radiology **184**, 635-639 (1992).
- [4] Lurie D.J., 1st Symposium on Field-Cycling NMR Relaxometry, Berlin, p5, (1998).\*
- [5] Pine K.J., Davies G.R. and Lurie D.J., Magn.Reson.Med. 63, 1698–1702 (2010).\*
- [6] Broche L.M., Ismail S.R., et al., Magn.Reson.Med. 67, 1453-1457 (2012).\*
- [7] Broche L.M., Ashcroft G.P and Lurie D.J., Magn.Reson.Med. 68, 358-362 (2012).\*
- [8] Ross, P.J., Broche, L.M., and Lurie, D.J., Magn. Reson. Med. 73, 1120-1124 (2015).\*
- [9] Broche, L.M., Ross, P.J., Pine, K.J. and Lurie, D.J., J. Magn. Reson., 238, 44-51 (2014).\*
- [10] Lurie D.J., Foster M.A., et al., Phys.Med.Biol. 43, 1877-1886 (1998).\*
- [11] Pine K.J., Goldie F. and Lurie D.J., Magn. Reson. Med. 72, 1492-1497 (2014).\*
  - \*These references are available at http://www.ffc-mri.org/publications