EUROMAR - European Conference on Magnetic Resonance
5th-8th July 2021

FAST FIELD-CYCLING MAGNETIC RESONANCE IMAGING

DAVID J. LURIE[1], LIONEL M. BROCHE[1], GARETH R. DAVIES[1], MARY JOAN MACLEOD[1], P. JAMES ROSS[1], ROBERT STORMONT[1,2]

[1]University of Aberdeen, Foresterhill, Aberdeen, United Kingdom
[2]GE Healthcare, Waukesha, WI, USA

Most contrast in conventional MRI arises from differences in T_1 between normal and diseased tissues. Studies on small tissue samples have shown that extra information could be obtained from T_1-dispersion measurements (plots of T_1 versus magnetic field), but this information is invisible to standard MRI scanners, which operate only at fixed magnetic field (*e.g.* 1.5 T). We have developed Fast Field-Cycling (FFC) MRI to exploit T_1-dispersion as a novel biomarker [1].

FFC relaxometry is conventionally used to measure T_1-dispersion, by switching the magnetic field rapidly between levels [2] (polarisation at high field, followed by evolution (relaxation) at low field, and finally detection at high field. FFC-MRI obtains spatially-resolved T_1-dispersion data, by collecting MR images at a range of evolution magnetic fields [3].

We have built two whole-body human sized FFC scanners, operating at detection fields of 0.06 T [4] and 0.2 T [5]. The 0.06 T device 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. The 0.2 T FFC-MRI system uses a single resistive magnet, bringing the advantage of increased flexibility in pulse sequence programming, at the expense of lower field stability during the detection period, necessitating more complex instrumentation.

We have demonstrated that FFC relaxometry can detect the formation of cross-linked fibrin protein from fibrinogen in vitro [6]. We have also shown that FFC can detect changes in human cartilage induced by osteoarthritis [7] and differences between normal tissue and tumour [8]. We have performed *in vivo* FFC-MRI studies on patients with acute ischaemic stroke; FFC-MRI images exhibited increased intensity in stroke-affected regions, with maximum contrast typically at the lowest evolution field used (0.2 mT) [9]. All human studies were conducted following approval of the relevant Research Ethics Committees and with the informed consent of patients.

Other work has focused on improving pulse sequences and data analysis, as well as speeding up the collection of FFC-MRI images [10,11]. Work to improve the hardware and software is ongoing, including the implementation of improved RF coils and receiver coil arrays [12].

FFC-MRI has significant potential for the generation and use of novel biomarkers arising from ultra-low field MRI contrast and from low- and ultra-low field T_1-dispersion phenomena.

INTRODUCTION
SPONSORS
PROGRAM
PROGRAM — BY DAY
TOPICS
PRIZE LECTURES
PLENARY LECTURES
TUTORIAL LECTURE
INVITED AND PROMOTED LECTURES
POSTERS
ADVERTISERS
AUTHOR INDEX

References: [1] D.J. Lurie et al., *C. R. Physique* **2010**, 11, 136-148. [2] R. Kimmich, E. Anoardo, *Prog. Nucl. Magn. Reson. Spectrosc.* **2004**, 44, 257-320. [3] D.J. Lurie, P.J. Ross, L.M. Broche, in: *New Developments in NMR No. 18, Kimmich R., ed., Roy. Soc. Chem., UK*, **2018**, pp 358-384. [4] D.J. Lurie et al., *Phys. Med. Biol.* **1998**, 43, 1877-1886. [5] L.M. Broche et al., Sci. Rep. **2019**, 9:10402. [6] L.M. Broche et al., *Magn. Reson. Med.* **2012**, 67, 1453-1457. [7] L.M. Broche, G.P. Ashcroft, D.J. Lurie, *Magn. Reson. Med.* **2012**, 68, 358-362. [8] E. Masiewicz et al., *Sci. Rep.* **2020**, 10:14207. [9] L.M. Broche et al., *11th Conference on FFC NMR Relaxometry, Pisa, Italy*, **2019**, p6. [10] P.J. Ross, L.M. Broche, D.J. Lurie, *Magn. Reson. Med.* **2015**, 73, 1120-1124. [11] L.M. Broche, P.J. Ross, K.J. Pine, D.J. Lurie, *J. Magn. Reson.* **2014**, 238, 44-51. [12] G.R. Davies et al., *ISMRM 27th Annual Meeting, Montreal, Canada*, **2019**, p1570.

Acknowledgements: This project received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 668119 (project "IDentIFY").