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Fast Field-Cycling MRI: a new diagnostic modality?

David Lurie, Lionel Broche, Gareth Davies, James Ross
School of Medicine, Medical Sciences & Nutrition, University of Aberdeen, Aberdeen, United Kingdom

Most contrast in conventional MRI arises from differences in T1 relaxation time. Studies on small tissue samples have shown that extra information could be obtained from T1-dispersion (plots of T1 versus magnetic field strength), but this information is invisible in conventional MRI since scanners operate at fixed magnetic field (e.g. 1.5 T). We are developing Fast Field-Cycling Magnetic Resonance Imaging (FFC-MRI) to exploit T1-dispersion as a new biomarker, with the aim of increasing diagnostic potential.

FFC measures T1-dispersion by switching the magnetic field rapidly between levels during the pulse sequence, with relaxation occurring at the "evolution" field (usually a low value) and always returning to the same "detection" magnetic field (a higher value) for NMR signal measurement. FFC-MRI obtains spatially-resolved T1-dispersion data, by collecting images at a range of evolution magnetic fields.

We have built two whole-body human sized scanners, operating at detection fields of 0.06 T [3] and 0.2 T. 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 which has 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 are investigating a range of applications of FFC relaxometry and FFC-MRI. Our work has demonstrated that FFC relaxometry can detect the formation of cross-linked fibrin protein from fibrinogen *in vitro*, through the measurement of ^{14}N-^{1}H cross-relaxation phenomena, known as "quadrupolar dips". We have also shown that FFC-MRI can detect changes in human cartilage induced by osteoarthritis. Recent work has focused on speeding up FFC-MRI by incorporating rapid MRI scanning methods.