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Fast field-cycling magnetic resonance imaging: a new imaging modality

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Purpose: Fast Field-Cycling (FFC) MRI has been demonstrated as a novel imaging modality. In FFC, the magnetic field is switched rapidly between levels during a scan, allowing the dependence of T1 on magnetic field strength to be exploited for the first time as a contrast mechanism.

Methods and Materials: In FFC-MRI the magnetic field strength is switched between two levels. High field polarises the spins. Then the field is switched to a lower value ("evolution") at which T1 is to be measured, for a duration ~T1. The field returns to the high value for the application of gradients and signal detection. A technical challenge is to switch field rapidly (~20 ms) while maintaining field stability and repeatability. Two prototype whole-body human FFC scanners have been built in our laboratory, using different technologies. One uses a hybrid magnet, with a permanent magnet (59mT) for polarisation and detection, offset by a coaxial resistive magnet for evolution. Another uses a single, 200mT resistive magnet with a switchable power supply (~2000 A) under control of the console.

Results: Both scanners proved capable of obtaining FFC-MRI images, with data showing T1 dispersion in the range 1mT to 100mT. The hybrid scanner showed better immunity to magnetic field instability, albeit with SNR than the purely resistive scanner. Data was obtained from a range of phantoms, tissues and volunteers, exhibiting novel contrast through FFC.

Conclusion: FFC-MRI is a novel imaging technique which can exploit T1-dispersion as a contrast mechanism. Early results show promise as a new clinical imaging modality.