Fast field-cycling MRI: Novel contrast changes through switched magnetic fields

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Purpose

Fast Field-Cycling MRI (FFC-MRI) is a novel MRI technique in which the external magnetic field (B_0) is switched during the imaging experiment, always returning to the same value (B_0^D) for signal detection. By doing this, FFC-MRI grants access to information which is invisible to conventional MRI scanners, including the variation of T_1 with magnetic field. These measurements, known as T_1-dispersion, exhibit great promise as a new form of endogenous image contrast, and may have application in the early diagnosis of a range of diseases. Construction of an MR imaging system capable of rapidly switching magnetic fields, and reaching ultra-low fields (200 µT or lower), requires novel magnets, power supplies and control electronics. Here we will describe progress on a whole-body human sized FFC imaging system and preliminary results from a clinical trial imaging acute stroke using FFC-MRI.

Methods

The magnet (Tesla Engineering Ltd, UK) is of a resistive design with a length of 2 m and an inner bore diameter of 500 mm; it is capable of achieving a maximum field strength (B_0^D) of 0.2 T (8.52 MHz proton Larmor frequency). The system can switch between zero and maximum field in 12 ms, corresponding to a maximum dB/dT of 16.7 T/s. The gradients and RF system are controlled by a commercial MRI console (MR Solutions Ltd, UK) while the main magnet coil, shim coils and earth's-field cancellation coils (necessary for ultra-low field operation) are controlled by a dedicated embedded computer running in-house software written in Labview (National Instruments, US).

Results

The prototype system has been fully commissioned and is now operational. FFC-MRI imaging of patients (with full ethical permissions granted) using the system has now commenced as part of a clinical study on imaging acute stroke. It is hoped that the new information afforded by FFC-MRI will aid in the detection and assessment of stroke.

Conclusions

The novel system design described here will allow us to explore the unique T_1 dispersion contrast made available by FFC-MRI. Future work will concentrate on identifying how this newly accessible region of the T_1 dispersion curve can be exploited for clinical diagnosis.