Fast Field-Cycling MRI Technology: Prototype Human Scanner and First Clinical Results

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PURPOSE

A prototype human-scale Fast Field-Cycling (FFC) MRI scanner has been built, allowing good quality images at ultra-low field (0.2 mT) with enhanced T1-contrast. It has been used to image the brain in patients with acute ischemic stroke.

METHOD AND MATERIALS

FFC-MRI is a new method, designed to image at ultra-low field while preserving signal-to-noise ratio (SNR) and image quality. The main field (B0) is switched between values during the pulse sequence, with polarization at the scanner's highest field, evolution (relaxation) at low field, followed by gradients, RF pulses and signal detection at high field. Our in-house-built prototype scanner has a water-cooled resistive magnet (Tesla Engineering, UK; bore 0.5 m, length 2 m) providing a maximum field of 0.2 T, with the evolution field controllable between 0.2 mT and 0.2 T; switching time between fields is 20 ms. A home-built head birdcage coil (8.5 MHz) was used. Scanner control is via a commercial console (MR Solutions, UK), running pulse sequences which include control of B0. Magnet current (up to 1950 A) is from a low-noise power supply amplifier (International Electric Company, Finland). Following research ethics committee approval, patients (N=10) with acute ischemic stroke were recruited and gave informed consent. They were scanned by FFC-MRI within 24-96 h after presentation. Duration of the FFC-MRI examination was typically 45 minutes, including setup, scout and FFC images at five evolution fields (0.2 mT to 200 mT). Patients were scanned by CT prior to FFC-MRI and some had 3 T MRI (N=2) including DWI.

RESULTS

The usable range of B0 during the evolution period was validated in phantoms. In scans of patients with acute ischemic stroke, T1-weighted FFC-MRI images exhibited hyper-intense regions, with contrast increasing markedly as the evolution magnetic strength field decreased, with maximum lesion intensity at the lowest field used (0.2 mT). The infarct region seen by FFC-MRI correlated well with the appearance in CT and DWI (where appropriate) images.

CONCLUSION

A whole-body FFC-MRI scanner was built and has been used to image the brain in patients with ischemic stroke, in the first-ever clinical demonstration of this technology.

CLINICAL RELEVANCE/APPLICATION

FFC-MRI is a new modality which can generate diagnostic-quality images at ultra-low magnetic fields (e.g. 0.2 mT), with significantly-enhanced endogenous T1-contrast compared to conventional MRI.