

Rapid Fast Field-Cycling Imaging using the Keyhole Technique

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Purpose

Fast Field-Cycling MRI (FFC-MRI)¹ is an emerging technique that adds a new dimension to conventional MRI by making it possible to rapidly vary B_0 during a pulse sequence. By doing this it is possible to observe how the NMR relaxation rates of biological tissues vary with magnetic field strength - information which can be employed as a useful contrast mechanism. In this work we have made use of the keyhole MRI technique² in order to speed up FFC-MRI.

Methods

Imaging was carried out on a home-built, whole-body, field-cycling imager with a 59 mT detection field³. Images were constructed by combining an initially-acquired full resolution k-space with a set of low resolution k-space matrices acquired at each evolution field, requiring a scan time of 25% compared to conventional imaging. The technique was used to derive R_1 dispersion curves from a phantom consisting of cross-linked bovine serum albumin (BSA) across a field range of 32 mT to 59 mT (proton Larmor frequencies of 1.4 MHz to 2.5 MHz). Brain images were also collected from a volunteer (Fig 2A) in order to validate that the method generated artefact free images *in vivo*. Images were collected for evolution fields of 49 mT and 59 mT (2.1 MHz and 2.5 MHz) and from these images R_1 maps were derived.

Results and Discussion

R_1 dispersion curves derived from BSA using the technique show excellent agreement with results obtained using a conventional scan. (Fig.1). The R_1 maps (Fig. 2B and 2C) generated from brain images show an increase in R_1 at 49 mT, which was used to generate a ΔR_1 map (Fig. 2D) which shows a higher increase in R_1 in predominately white matter regions.

Conclusions

This work has demonstrated that the keyhole technique can readily be applied to FFC-MRI and used to obtain a 4-fold or greater speed up in scan times while still retaining the same contrast as standard FFC-MRI methods. The rich ΔR_1 contrast present in brain images indicates that FFC-MRI has potential application in the characterization of neurodegenerative conditions where subtle changes in R_1 , which may not be visible on conventional T_1 -weighted imaging, could be used as an early marker of disease. The reduction in scan time achieved by use of the keyhole technique will significantly improve the applicability of FFC-MRI in volunteer and clinical studies, which we are currently working towards.

References

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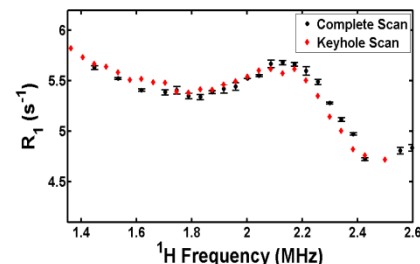


Figure 1: Dispersion curves for a phantom of cross-linked BSA obtained using the keyhole method (red diamonds) show good agreement with results obtained using a conventional field-cycling spin-echo sequence (black circles).

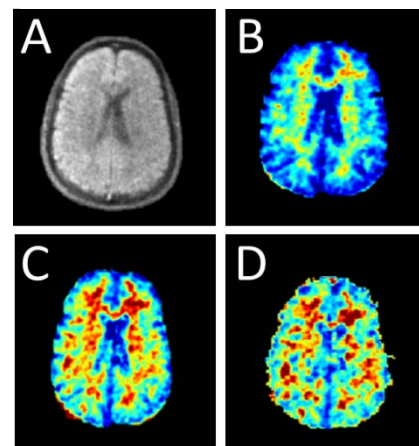


Figure 2: A: Brain image collected from a volunteer at 59 mT
 B: Keyhole R_1 map collected at 59 mT
 C: Keyhole R_1 map collected at 49 mT
 D: ΔR_1 map generated from the subtraction of B from C.
 Image parameters: matrix size = 128x128, FOV = 280 mm, THK = 15 mm, NEX = 6, TE = 30 ms, TR = 1500 ms, evolution time = 200 ms, field-cycling ramp time = 30 ms.