Cylindrical-FSE for rapid, quantitative T2 mapping in Alzheimer's mice

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Introduction

One of the main pathological hallmarks of Alzheimer's disease (AD) is the accumulation of amyloid β protein (Aβ) into extracellular toxic plaques. Although there is debate as to the role that Aβ plays in the pathology of AD, it represents an important molecular target in treating AD as agents that can prevent its accumulation, or stimulate its clearance, are being developed as potential new therapies. The ability to non-invasively detect the presence and progression/regression of Aβ plaques in vivo with MRI would be extremely useful for this area of research and a number of groups are working in this effort [1-3]. Because of the documented effect of Aβ on T2 relaxation times in the brain, we have developed a cylindrical-FSE MRI method that allows rapid, quantitative measurement of T2 relaxation with high spatial resolution in 3D. Initial results from imaging of fixed brains of an Alzheimer's mouse model are presented.

Methods

The 3D cylindrical-FSE sequence collects Fourier data along radial lines in two dimensions and at equally spaced phase encoding steps in the slice select direction as shown in Fig. 1. Within an FSE echo train, multiple radial lines of data are acquired at different TE times at a particular k_{ss} location. The order in which radial lines are collected can be controlled to suppress artifacts from motion, T2 decay and off-resonance signals. Images can be reconstructed from cylindrical-FSE datasets by first Fourier transforming the data in the k_{ss} direction, followed by filtered backprojection reconstruction of the hybrid data at each slice select location. Because of the inherent oversampling of the center of Fourier space at each k_{ss} location, and the fact that radial lines with different TE times pass through the origin, multiple images can be reconstructed from a single cylindrical-FSE dataset that have different effective T2 weighting [4]. From these images, quantitative T2 maps can be generated as previously described [4]. Therefore, from a single cylindrical-FSE dataset, quantitative volumetric T2 maps can be generated. Furthermore, the volume excitation maximizes the signal to noise and minimizes the RF pulse imperfections that can generate unwanted stimulated echoes within the FSE train.

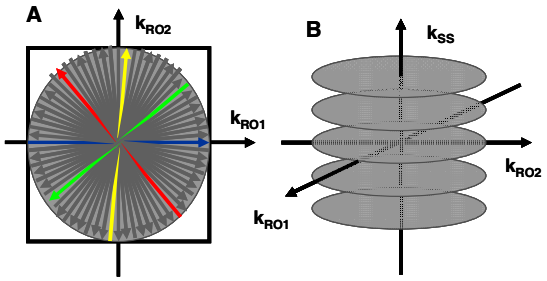

Fig. 1 Cylindrical-FSE trajectories. Colored lines in panel A show the approximate orientation of an ETL = 4 echo train. The radial lines within each echo train coarsely sample Fourier space and maintain a high frequency variation in TE_{eff} with view angle [5]. Equally space sets of radial lines are acquired by phase encoding in the slice select direction, as shown in panel B.

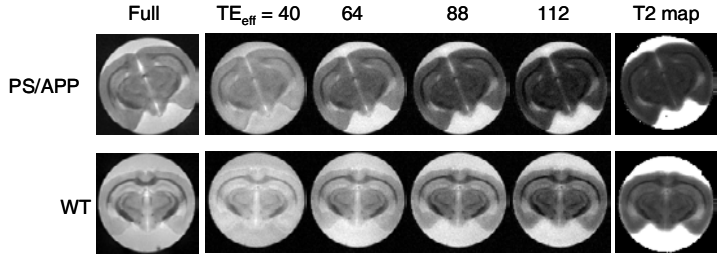

Fig. 2 Cylindrical-FSE images of fixed double transgenic (PS/APP) and wildtype (WT) mouse brains. The Full images were reconstructed using all radial lines collected and has a TE_{eff} = 76 ms. Representative images at four different TE_{eff} are shown and were generated using partial radial datasets as previously described [4]. T2 maps were generated by fitting image intensity versus TE_{eff} to a single exponential decay.

Cylindrical-FSE datasets were collected on fixed brains of double transgenic PS/APP and wildtype mice. The mouse brains were obtained from 18 month old mice, an age at which the PS/APP mice have significant Aβ plaque burden. Data were collected at 4.7 T on a Bruker Biospec instrument with gradients capable of 200 mT/m using a 20 mm ID Litz coil (Doty Scientific) using the following parameters: TR = 2000 ms, matrix size = 256 x 1024 x 16 (radial points x radial lines x slices), FOV = 25.6 x 25.6 x 8 mm^3, ETL = 16, echo spacing = 8 ms. The total experiment times = 34 minutes.

Results and Discussion

Example cylindrical-FSE images of the fixed mouse brains are shown in Fig.2. The images and maps shown in Fig. 2 demonstrate the ability to produce high-resolution T2-weighted images and quantitative T2 maps from individual cylindrical-FSE datasets. The T2 measured from a region of interest in the hippocampus in the PS/APP mouse brain was 54 ± 4 ms while the T2 in the same region of the WT mouse was 86 ± 7 ms. While this difference might be expected by the presence of Aβ plaque, these results come from fixed tissue and will need to be verified by additional in vivo studies and by histological determination of Aβ load. In any case, the ability to rapidly and quantitatively measure T2 maps in three dimensions could have a significant impact on the ability to monitor the presence of amyloid plaque and evaluate therapy in AD.

References

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