Lipid Suppression using Selective Inversion Recovery for 3D Spectroscopic Imaging at 3T

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Introduction

The most common approach for reducing lipid signals in ^{1}H brain chemical shift imaging (CSI) is the use of volume preselection via the PRESS technique. [1] This technique produces high quality metabolite spectra within a restricted brain volume. To achieve whole brain coverage, non-selective inversion recovery (IR) techniques are generally applied. [2] [3] At 1.5T, metabolite signal loss from IR is on the order of 30-40%. However, at higher fields, e.g. 3T, non-selective IR will cause unacceptable metabolite signal loss due to reduced T1 differences between metabolites and lipids. Fortunately, the increase in spectral separation between lipids and metabolites allows a frequency selective inversion. This paper discusses the design, implementation and results of an IR CSI pulse sequence that performs selective inversion for lipid suppression.

Method

The chemical shift between lipids and the closest metabolite (NAA) is 0.7 ppm. At 3T, these two spins are separated by 89 Hz. The design goals of the inversion pulse were a transition band less than 89 Hz, an inversion band wide enough to cover all of the lipid signals and a short enough pulse width to neglect relaxation effects during excitation. In the design, we chose a minimum phase RF pulse for a sharp transition band with 500 Hz inversion bandwidth and 20ms pulse width. The RF pulse synthesis was done using the Shinnar-Le Roux algorithm [4], in which the transition bandwidth trades off with ripple amplitudes in the pass and stop bands. The ripple amplitudes were chosen such that the transition bandwidth was less than 89Hz. To test the effects of the selective IR, a 3T CSI imaging sequence was implemented with the following characteristics: spectral-spatial spin echo pulse for metabolite excitation and water suppression, TR/TI/TE=2000/170/144 ms, spiral readout gradients, single slice, 2.5 cc voxels and 2 minute acquisition time. [5]

Results

The minimum phase RF pulse and its inversion profile are shown in Figure 1. The ripple amplitudes in the pass and stop bands are 1% and the transition bandwidth of the profile is 50 Hz, measured from 10% to 90% of inversion. Figure 2 shows spectra from two voxels with and without lipid inversion obtained from an in vivo study. The two representative voxels are chosen such that one is in the subcutaneous fat and the other is within the brain. The spectrum from the voxel in the subcutaneous fat clearly shows that the lipid signal is suppressed with the inversion on, and the measured suppression factor is on the order of 10. The spectra from the voxel in the brain show that the spectral artifacts due to lipid signal leakage is significantly reduced, and metabolite spectra are not disturbed by the inversion pulse.

Conclusion

We have designed and implemented a 3T frequency selective IR spiral CSI pulse sequence. The effectiveness of the selective inversion recovery is demonstrated on an in vivo scan showing a lipid suppression factor on the order of 10 while maintaining excellent quality metabolite spectra.

Acknowledgements

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Reference

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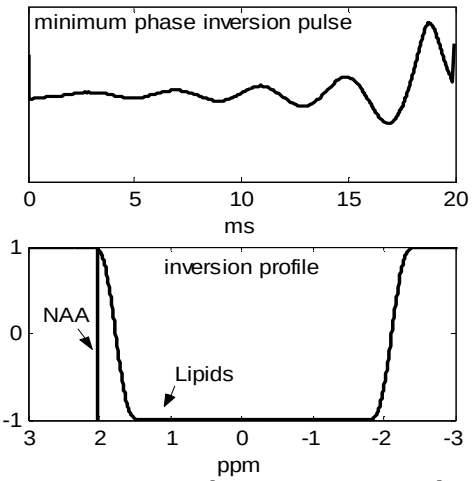

Fig 1. Minimum phase RF inversion pulse and its inversion profile

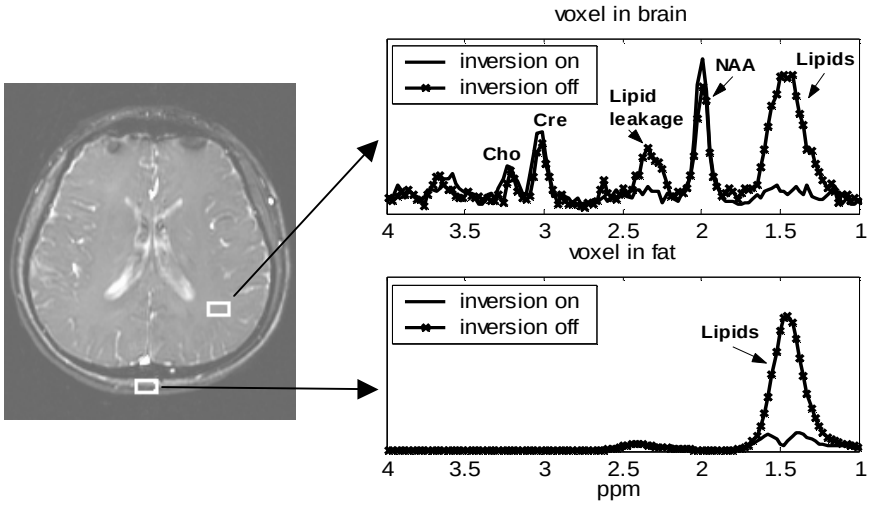

Fig 2. In vivo spectra of representative fat and brain voxels. Spiral CSI TR/TI/TE=2000/170/144ms, 2.5cc voxels, 2 minute acquisition