Frequency Selective Inversion of Lipid Improves Choline Conspicuity in Breast Spectra

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Introduction

The presence of an elevated choline peak in proton spectra appears to be a consistent marker of malignancy in many tissues. In most tissues this is relatively easy to detect. In breast tissue, however, the dominant peaks from lipid may considerably reduce the visibility of choline. Several approaches have been used to combat this problem including T_2-weighting (1,2), double suppression (3,4), and TE-averaging (5). Each has advantages and disadvantages but the method which has gained some acceptance combines the first and last using long echo times (~150ms) to reduce lipid signal and also removing sideband artefacts by TE-averaging. Since the T_2 of choline in breast tumours is around 180ms (6) this will considerably reduce the SNR of the choline peak, which is problematic particularly when it is present at low concentrations. A long TE may thus compromise the diagnostic utility of the technique. In this study we implemented an additional fat-suppression pulse that allows shorter echo times and also used enhanced post-processing.

Methods

Twenty-five consecutive patients referred for breast imaging for screening or pre-chemotherapy assessment of their tumours were included. All were scanned on a 3T HDx (GE Healthcare, Milwaukee, USA) using an 8-element breast phased-array receive coil. Single voxel spectroscopy was performed following clinical imaging which included contrast injection. Two different sequences were used; a) TE-averaged PRESS (product name, BREASE) with standard protocol (TR = 2s, 4 echo times, average TE = 155ms, ΔTE = 5ms, 32 averages/TE) and b) PRESS with fat suppression (TR = 2s, 128 averages). For fat suppression a frequency selective, minimum-phase Shinnar-Le Roux inversion pulse was used with centre frequency at 1.3ppm and 2ppm bandwidth. Each FID was stored separately to facilitate additional processing.

Initial experiments with the PRESS sequence were performed to identify the optimal TI for nulling of the two dominant lipid signals at 1.3 and 0.9ppm. In these experiments a 8cm^3 voxel was placed in normal parenchymal tissue and only 32 averages were acquired and compared to those acquired with BREASE.

There are several other broad lipid peaks in the spectrum of breast tissue arising from coupled proton resonances. One of them at 2.8ppm is outside the bandwidth of the inversion pulse and, if prominent, could adversely impact on the visibility of choline. We determined the T_2 of this resonance using BREASE (average TE = 85ms, 4 echo times ΔTE = 10ms, 32 averages/TE).

Post-processing was performed interactively using the SA/GE package (GE Healthcare, Milwaukee, USA) and included SNR-weighted signal combining, zero-filling (from 4096 to 8192 samples), apodisation (2.5Hz Gaussian), Fourier transformation, frequency alignment using water as reference at 4.7ppm, automatic phase correction and baseline subtraction.

Results

In the spectra of normal parechymal tissue a TI of 200ms or less showed inversion of both peaks in most patients (figure 1) although their amplitudes remained large. A TI of 220ms appears to lie close to the null point of the 1.3ppm peak yet the 0.9ppm peak is still inverted whilst both peaks are significantly reduced in amplitude compared to BREASE at the same echo time.

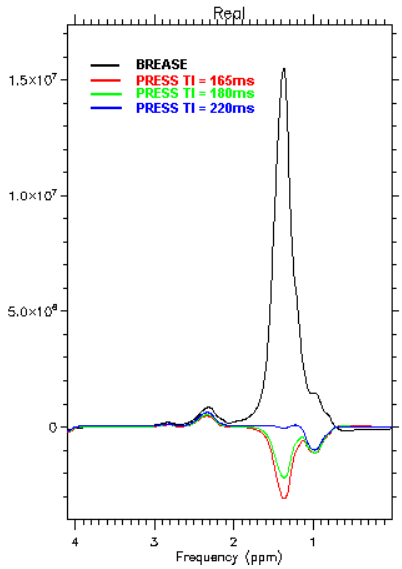

Figure 1

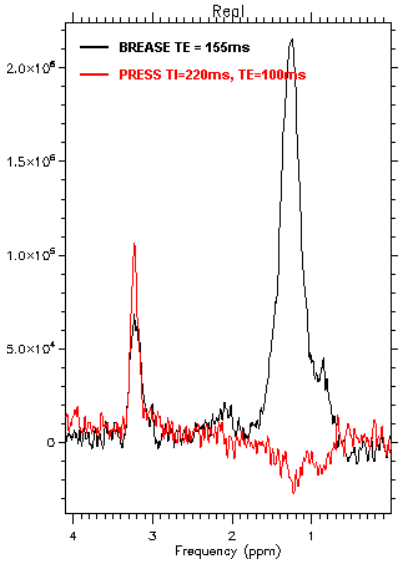

Figure 2

From 4 patients we obtained a T_2 for the 2.8ppm lipid peak of 43 ± 10ms. Subsequent fat suppressed PRESS spectra were acquired with a TE of 100ms giving 90% suppression of this peak whilst potentially improving the choline signal by 35% over the BREASE acquisition. An example is shown in figure 2 where it can also be appreciated that the ability to frequency align the spectrum from each excitation significantly improves the linewidth of the choline peak.

Discussion

Frequency referencing and shorter TE lead to an improved SNR of the choline peak. The implemented fat suppression pulse can be applied to TE-averaged PRESS and allows good suppression of the dominant fat peaks without affecting the choline resonance. This also reduces potential sideband artefacts and baseline effects that may coincide with the choline peak. Further it removes the necessity to totally exclude normal tissue from the voxel which may then be chosen to encompass the whole lesion.

References

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