Improved Choline Resolution And Detection In Breast Lesions Using TE-Averaging

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Introduction

Proton MRS can be used to distinguish benign and malignant lesions, and to follow chemotherapy, using the presence of choline at 3.2ppm.[1] However, the relatively low concentration of choline compared to lipid in the breast, along with lipid sidebands that may arise from gradient-induced B_o modulations, make choline difficult to detect. Most studies of choline detection in breast lesions so far have been performed with a straightforward PRESS acquisition, using either a long TE[1] or inversion recovery (STIR)[2,3] to reduce the lipid signal. These studies generally employed a minimum choline SNR of 2-4 for characterising lesions as malignant. This is a very low value which indicates a choline signal that is barely visible above the noise, and hence possible uncertainty about its presence. Moreover, our early attempts at observing choline using these methods have been totally unsuccessful. Therefore we report here an investigation of 3 techniques aimed at increasing the visibility of choline: a selective excitation sequence (PROSE) that does not excite the 1.3ppm lipid and only 5% of water protons; a TE-averaging sequence (PRESSJR) which acquires a series of spectra, the summation of which would eliminate sidebands; and STIR in addition to TE-averaging (PRESSJR STIR), to null the lipid signal.

Methods

Examinations were performed on 18 patients with invasive ductal carcinoma enrolled in a study monitoring lesion response to 6 cycles of neoadjuvant chemotherapy, using a 1.5T scanner (GE Signa Infinity) and a bilateral breast coil (Machnet). Patients were scanned before treatment, 1-5 days after their 1st cycle, and 2-3 weeks after their 2nd and last cycles. Single voxel ^{1}H MR spectra were acquired from the lesion of each patient (voxel size 1.0-5.2cm^3) after a clinical examination that included contrast administration. 3 PROBE-P based sequences were used: (A) PROSE (12 patients), using a TE of 88ms and 256 averages; (B) PRESSJR (7 patients), with an initial TE of 35ms, 64 steps of 2.5ms, and 4 water-suppressed acquisitions per TE; and (C) PRESSJR STIR (10 patients), using a TI of 118ms.[4] The TR for all 3 sequences was 1.5s. Spectral processing included 2.5Hz Gaussian line broadening, zero-filling to 4K points, Fourier transformation, phasing and baseline correction. The SNR and linewidth of the choline peak, where visible, was calculated, as well as the ratio of choline to unsuppressed water amplitude (Cho/Water).

Results and Discussion

Sequence	PROSE	PRESSJR	PRESSJR STIR
Hits (pre-treatment)	58.3%	71.4%	10.0%
Hits (all lesions)	32.5%	54.5%	7.4%
Choline SNR	11.6 ± 12.1 (13)	15.0 ± 12.0 (12)	5.5 ± 1.8 (2)
Choline linewidth/Hz	6.1 ± 2.4 (13)	3.3 ± 2.5 (12)	5.5 ± 4.3 (2)

Table 1: A comparison of percentage of lesions with visible choline (Hits), and average choline SNR and linewidths (±SD) between the 3 sequences.

The percentage of spectra where choline was visible for each of the 3 sequences used is given in Table 1, together with the respective average choline SNR and linewidths. Figure 1 shows typical spectra acquired with PROSE and PRESSJR, and Figure 2, the plots of Cho/Water against voxel size for the 3 sequences. The latter shows that although the amount of choline detected in a lesion is not dependent on voxel size, there appears to be a minimum voxel size of 2cm^3 below which choline is not visible whatever the sequence used. This figure also shows that almost all the lesions where PRESSJR STIR was performed had no visible choline, whatever the voxel size. Unfortunately the inversion pulse, whilst effectively removing lipid, appears to result in loss of the already small choline signal, due to acquisition of signal before it has fully recovered. We found that the PRESSJR sequence appears to be better than PROSE, in terms of spectral quality and success in choline detection. Although the choline SNR is about the same for both sequences, the choline signal with PROSE is about twice as broad as that with PRESSJR (Table 1). Furthermore, the PROSE spectra are generally noisier and have artefacts in the baseline (Figure 1). These could be sidebands arising from B_o oscillations due to the long SSRF pulsewidths, a problem not encountered with PRESSJR. As a result the baseline correction in PROSE spectra is unreliable, making measurements of the choline signal very difficult. The positive choline identification rate (Table 1) further confirms that PRESSJR is a better sequence than PROSE for detecting choline (71% as opposed to 58% of pre-treatment lesions). In addition to its superior spectral quality, the fact that the PRESSJR sequence acquires spectra over a range of TEs, means that it can also be used to obtain 2D spectra and T2 values for any signals of interest eg. choline. Hence PRESSJR is also a more flexible sequence with a potentially wider range of applications to breast spectroscopy.

Conclusion

Of the 3 sequences tested, PRESSJR produced superior spectra for observing and measuring the choline signal in malignant breast lesions.

References

[1]Katz-Brull *et al* (2002) J. Natl. Cancer Inst. **94** 1197-1203. [2]Kim *et al* (2003) Breast **12** 179-182. [3]Jacobs *et al* (2004) J. Magn. Reson. Imaging **19** 68-75. [4]Tan *et al* (2003) Proc. ISMRM **12** 837.

This work was supported from funds raised by Yorkshire Cancer Research.

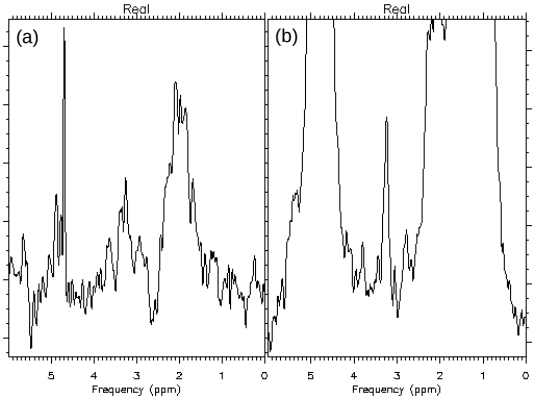

Figure 1: Typical spectra from the same lesion acquired with (a) PROSE and (b) PRESSJR. Spectra were scaled identically.

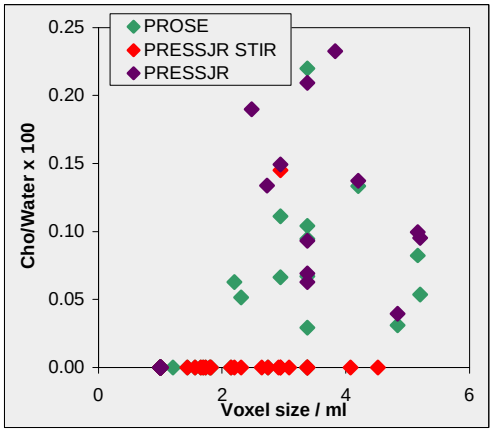

Figure 2: Plot of Cho/Water against voxel size.