An improved 1H magnetic resonance spectroscopic imaging technique for the human breast

J. Hu[1], Y. Xuan[2], Z. Latif[2], R. L. Soulen[2]

[1]Wayne State Univeristy, Detroit, MI, United States, [2]Wayne State Univeristy, Detroit, MI

Introduction: Compared with MRI, it has been well documented that 1H MRS can improve the differentiation of malignant from benign breast tumors. However, the technical challenge presented by a combination of relatively poor achievable B_0 homogeneity and the requirement of "extra" lipid suppression (compared to the brain), has limited progress in the application of MRSI to the breast. With one exception (1), most 1H MRS of the human breast up to now has been performed using single-voxel techniques, due in part to these difficulties. Using an inversion-recovery method to suppress strong lipid signal, and conventional k-space sampling, investigators in John Hopkins University have been able to acquire 1H MRSI of the human breast (1). Despite this significant progress, an inversion-recovery suppression technique will suppress desired Cho signal in addition to the undesired large lipid signals. Another relevant issue in ^{1}H MRSI of the human breast is that the acquisition time is typically much longer than that for a single-voxel technique. In this report, we present an improved 1H MRSI technique for the human breast using an elliptical weighted k-space sampling scheme combined with a Hamming filter to improve sampling efficiency and two independent CHESS to suppress undesired water and lipid signals

.

Method: The pulse sequence consists of four parts: water suppression, lipid suppression, the outer volume pre-saturation (OVP), and a PRESS MRSI with a weighted k-space sampling scheme. Water suppression and lipid suppression are achieved by two independent optimized CHESS pulses. The OVP is determined by applying slice-excitation pulses to select the area outside the volume of interest (VOI), and can be turned on or off as needed. To improve sampling efficiency and reduce the relatively long acquisition associated with conventional MRSI, a weighted k-space sampling scheme is used to acquire the MRSI data set (2). The weighted k-space samples only the points located on or within the k-space ellipse. This reduces the measurement time by approximately 25% while the spatial resolution remains largely the same. When the number of averages (NA) is greater than 1, the central points of k-space are measured NA times and points on the boundary of the ellipse at least once. For intermediate points, the sampling frequency is determined by their radial distance from the center of k-space. This incorporates the Hamming filter during the measurement, resulting in an improved SNR per measurement time of approximately 20% on a phantom test (2).

Results: To date, nine studies from six patients with DCE-MRI demonstrated breast lesions have been performed with this 1H MRSI approach on Siemens whole-body 1.5T. All but one were technically successful; one study failed due to poor shimming. Figure 1B shows a ^{1}H spectrum from a gadolinium-enhanced area in the right breast of a patient undergoing neoadjuvant chemotherapy for locally advanced cancer. The spectrum is extracted from both water and lipid suppressed ^{1}H MRSI of the small box #1 in Fig 1A. The spectrum, as well as spectra in nearby voxels (boxes 2-7 in Fig 1A, not shown), demonstrates a distinct Cho peak (SNR > 10), suggesting malignancy. Figure 1C shows a color-coded Cho image generated from the MRSI overlaid on the corresponding MRI. Note that the Gd-enhanced areas in the superior portion of the region of interest (top row in Fig. 1A) yield no Cho signals, suggesting absence of viable tumor in these areas. The 16x16 2D spectra were acquired in only 11:40 minutes with a TE of 270 ms and 8 averages using the weighted k-space sampling scheme. Biopsy prior to cryotherapy confirmed persistent active tumor at the area with Cho signals. Repeat 2D 1H MRSI study acquired 5 days after cryotherapy showed no Cho signal, suggesting successful tumor ablation.

Discussion: Increased difficulty in lipid suppression, compared with a single-voxel technique, is a major problem in 1H MRSI of the human breast. The lipid signals in the breast can be so intense that even the α-methylene (labeled as α-lip in Fig 1B) of lipid (C**H2**-CH=CH) is often more than 20 times stronger than the desired Cho signal, as illustrated in Figs 1. Our results demonstrate that the proposed independent optimized CHESS pulse for lipid suppression can suppress undesired lipid signal sufficiently for *in vivo* 1H MRSI of the human breast. Moreover, *in vivo* ^{1}H MRSI of the human breast can be acquired within clinically acceptable time. In summary, we have presented a scheme for *in vivo* ^{1}H MRSI of the human breast that is robust and can be easily integrated with MRI on a standard clinical scanner.

This work was supported by The Suan G. Komen Breast Cancer Foundation.

Reference: (1) Jacobs MA, etc, JMRI , 19, 68(2004); (2) Maudsley A, etc, MRM, 31, 645(1994).