3D Breast MRSI with Dualband Presaturation and Dualband Dephasing at 3T

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Introduction:

Proton Magnetic Resonance Spectroscopy (MRS) [1] measurements of Choline (tCho) have been shown to be useful for the diagnosis of breast lesions, and evaluating their response to neoadjuvant chemotherapy. The majority of studies performed to date have used single voxel localization techniques. However, increased spatial coverage using either 2D or 3D MRSI is desirable for clinical applications, where lesion location may be uncertain, or if there are multiple lesions to investigate, or if the lesions are heterogeneous. Breast MRSI has many technical challenges, however. One major challenge is that the desired tCho signal at 3.2ppm lies within a narrow spectral region between water and lipid signals. In particular, lipid signals may overwhelm the tCho signal by several orders of magnitudes, particularly if field homogeneity is suboptimal. Recently, we have developed a dualband water and lipid suppression method combining frequency selective suppression with spatially selective Outer Volume Suppression (OVS) for applications in brain spectroscopy. The method reduced residual lipid signals by a factor up to 50. In this study, the dualband suppression method is modified for breast MRSI, and water and lipid suppression was further improved by combining dualband suppression before excitation with dualband dephasing after excitation ('BASING').

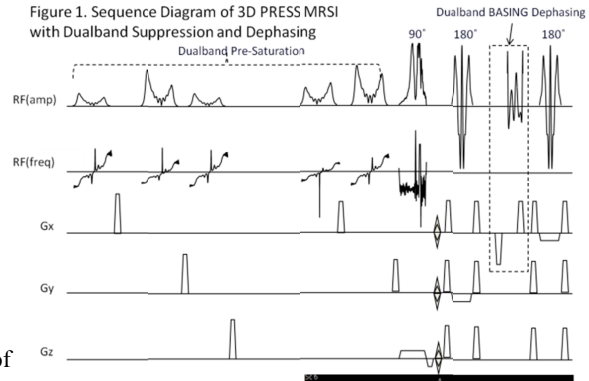

Figure 1. Sequence Diagram of 3D PRESS MRSI with Dualband Suppression and Dephasing

Materials and Methods

Dualband pre-saturation for 3D breast MRSI was adopted from its predecessor originally designed for neuro imaging [2]. The interleaved OVS pulses were removed between the 3rd and 4th dualband pulses. In addition, the water and lipid components of these frequency modulated pulses were combined with a narrower frequency separation. Specifically, the spectral locations of water and lipid suppression edges were defined at 4.1ppm and 2.2ppm, respectively, i.e. at 3T, the passband was reduced to 250Hz, compared to 350Hz for neuro imaging. All other parameters were unchanged. In order to further reduce water and lipid contamination, a dephasing module (BASING) was inserted between the two 180 refocusing pulses of the PRESS sequence. The module consisted of a dualband refocusing and bi-polar gradients (dashed box in Fig.1). The dualband pulse was applied to the water and lipid signals so they would be dephased by the bi-polar gradients, while the unaffected tCho signal would be rephased. Unilateral spatial localization was achieved with PRESS volume excitation with phase encodings in 3 directions (3D PRESS). Excitation was applied in the coronal plane with a thickness of 8 cm in the AP direction. A FOV of 16x16cm was sampled with an MRSI matrix of 32x32x8 in FH, RL and AP directions respectively. SENSE factor was 2 in RL direction. TE and TR were 140ms and 1.5s. Experiments were performed on 5 normal volunteers on a 3T TX Achieva system (Philips Healthcare), equipped with parallel transmit and a 16-channel phased array coil embedded in a detachable breast imaging system (MammoTrak). Field-map based B_0 shimming and patient adaptive B_1 shimming were performed prior to MRSI acquisition. Figure 2 shows a typical layout of MRSI planning in one subject. A 2D-PRESS MRSI sequence was used to determine water and lipid suppression factors *in vivo*. The sequence was repeated 4 times with : (a) Dualband pre-saturation with BASING, (b) dualband pre-saturation only, (c) BASING only, and (d) no suppression. Water and lipid suppression factors were quantified relative to the unsuppressed water and lipid signals respectively.

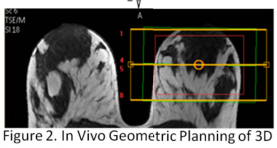

Figure 2. In Vivo Geometric Planning of 3D PRESS MRSI

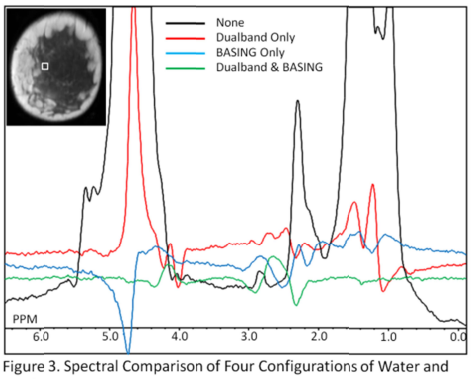

Figure 3. Spectral Comparison of Four Configurations of Water and Lipid Suppressior

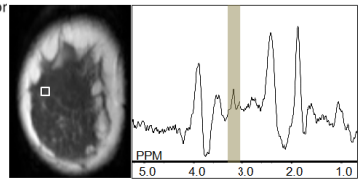

Figure 4. Choline Detection in Healthy Breast Tissues with 3D PRESS MRSI

Results

Figure 3 shows spectra acquired with the four different suppression schemes. The residual water and lipid signals were integrated and normalized to the unsuppressed signals (integrated from the black plot). The measurements were performed at four voxel locations in the slice. One voxel was chosen as the example located at the boundary of glandular tissue and fatty tissue (marked by white box in coronal MRI). The reduction factors for water and lipid signals were: with dualband&BASING, 0.002±0.001 for water and 0.007±0.004 for fat; with dualband only, 0.030±0.006 for water and 0.11±0.04 for fat; with BASING only, 0.020±0.005 for water and 0.07±0.07 for fat. Figure 4 shows a spectrum from a 3D MRSI scan (healthy volunteer) acquired with dualband&BASING. A sharp tCho peak was detected at 3.2ppm

Conclusion

The combination of dualband pre-saturation and BASING reduced residual water and lipid signals to less than 1%, and was superior to either method applied alone. Individually each method reduced the signals to between 2 to 11%. Combined dual-band presaturation with BASING dephasing appears to be optimal for water and lipid suppressed MRS and MRSI of the breast.

Reference: [1] Bolan et al. MRM 50, 1134-1143 (2003) [2] Zhu et al. MRM 63: 1486-1492 (2010) Supported by 5R01CA125258.