Improved quantification of Choline in breast MRS using Dixon imaging water referencing
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INTRODUCTION: In several studies it was shown that MR-spectroscopy (MRS) is an important investigational tool in breast cancer with high sensitivity and specificity. To distinguish between benign and malignant breast lesions absolute or signal-to-noise (SNR) based quantification of total choline (tCho) is used. To increase sensitivity and specificity the definition of threshold values are necessary. 3D-MR-spectroscopic imaging (MRSI, chemical shift imaging - CSI) enhances spectroscopy alone by covering a larger fraction of breast. However, each measured voxel has usually a specific proportion of glandular and adipose tissue, which – depending on the water to fat ratio in the quantified voxel – will modulate the SNR of the tCho signal. Therefore, we propose semi-quantitative tCho signal estimation with additional correction to water content for each voxel, using information extracted from Dixon imaging to correct SNR of tCho signal.

MATERIAL AND METHODS: Experiments were performed with a 3 T MR imaging system (TIM Trio; Siemens Healthcare, Erlangen, Germany) using a dedicated, bilateral breast coil (In Vivo, Orlando, Fla). A phantom used for in vitro tests at one side of the breast coil consisted of cylindrical 1 Liter plastic container filled with vegetable oil. An 8 cm3 plastic cube filled with 40 mM (10 times the physiological value) phosphocholine chloride calcium salt tetrahydrate (C8H17CaCINO4P 4H2O) in 0.9% saline was placed in the middle of the cylinder. PRESS box volume for 3D MR spectroscopic imaging was placed at the beginning, covering an area slightly bigger than the cube with tCho solution. Water resonance linewidth was shimmed to ~35 Hz. Seven 3D MRSI measurements with PRESS pre-localization were performed, each with different position relatively to the cube with tCho solution. Weak water suppression; spectral fat and spatial outer volume suppression. A box of weak suppression was placed at the beginning, covering an area slightly bigger than the cube with tCho solution. Weak water suppression; spectral fat and spatial outer volume suppression. A box of weak suppression was placed at the beginning, covering an area slightly bigger than the cube with tCho solution. Weak water suppression; spectral fat and spatial outer volume suppression. A box of weak suppression was placed.

RESULTS: Average variance of initial tCho signal amplitude from selected voxels was 16.1 ± 2.30 and from corrected amplitudes 5.72 ± 1.49. Variances of initial and corrected tCho signal amplitude differ by a factor of 2.93 ± 0.72 in average for individual CSIs. Comparison of boxplots of amplitudes without and with water-PSF correction is depicted in Fig. 1. For the same voxel in vivo, which was shifted for gaining different amount of water content (shown in Fig. 2), variance differs by factor of 7.98 in initial SNR vs. corrected SNR.

CONCLUSION: Assuming that, tCho concentration was equal throughout the volume of the cube in phantom, we can conclude that our water-referencing correction improves tCho signal amplitudes homogeneity (Fig. 3). Therefore, corrected signal value reflects more real tCho concentration. Furthermore, spatial CSI matrix shift can considerably influence tCho SNR in patient’s data. Our method is able to compensate for deviations in matrix positioning, which can noticeably help in repeated measurements (e. g. therapy monitoring).

In this study we have shown that information deriving from Dixon images can be used as a partial water reference for tCho SNR in 3D MR spectroscopy imaging.


Figure 1: Boxplot of initial choline signal amplitudes (tCho Signal - in UI) from various voxels in phantom measurements compared with corrected amplitudes (Corr. tCho Signal).

Figure 2: Different position of evaluated voxel (red square) in initial (A) and shifted (B, C) CSI matrixes. Table describes SNR values of tCho signal without and with correction (corr.) and variances throughout the various positioning.

Figure 3: Spectral maps example without (left) and with (right) correction. Note the increased homogeneity of the metabolic map after applying the correction.