Improved quantification of Choline in breast MRS using Dixon imaging water referencing

Lenka Minarikova[1], Stephan Gruber[1], Wolfgang Bogner[1,2], Katja Pinker-Domenig[3], Siegfried Trattnig[1], Thomas Helbich[3], and Marek Chmelik[1]

[1]MR Center of Excellence, Department of Radiology, Medical University of Vienna, Vienna, Vienna, Austria, [2]Athinoula A. Martinos Center for Biomedical Imaging, Department of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, MA, United States, [3]Division of Molecular and Gender Imaging, Department of Radiology, Medical University of Vienna, Vienna, Vienna, Austria

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.[1] To increase sensitivity and specificity the definition of threshold values [2] 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.

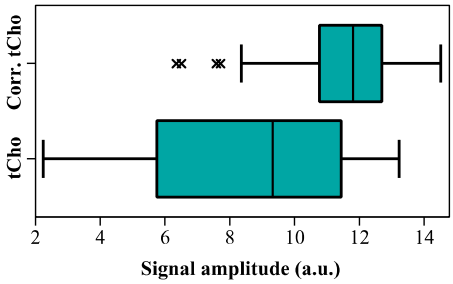
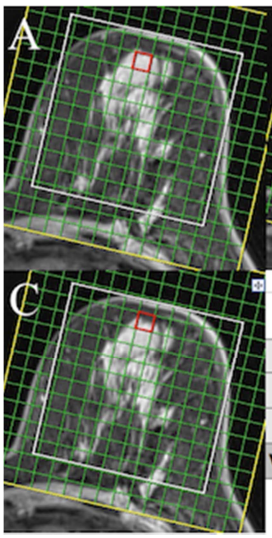


Figure 1: Boxplot of initial choline signal amplitudes (tCho Signal - in UI) from various voxels in phantom measurements compared with corrected amplitudes (Corr. tCho Signal).

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 cm^3 plastic cube filled with 40 mM (10 times the physiological value) phosphocholine chloride calcium salt tetrahydrate ($C_5H_{13}CaCINO_4P$ 4*H_2O) 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 were used for all measurements (TR/TE = 1180/135ms, scan time 11 min 38 sec, FOV 12×12×12 cm^3 and 12×12×12 phase encoding steps, voxel size = 0.25 cm^3, 100% hamming-filter and 2 averages per measurement). Before processing, the data were zero filled to 16×16×16 voxels. tCho signal was quantified with AMARES algorithm using jMRUI software (http://www.mrui.uab.es/mrui/). Furthermore, 3D Dixon MRI with 1 mm isotropic resolution was measured. PRESS box volume was extracted from images and segmented to water maps. Afterwards, maps were reduced to MRSI resolution with corresponding point-spread function (PSF) by applying a mask with elliptical weighted k-space (12×12×12 steps, with 2 averages), hamming filter and zero-filling to 16×16×16 (similar to Gasparovic [3]). All initial tCho signal amplitudes were divided with calculated water-PSF factor. From each MRSI, 16 voxels were selected for comparison (8 from the edge and 8 from center of the MRSI matrix) from both initial and corrected matrices. The same protocol (CSI, voxel size = 1 cm^3 and Dixon imaging) was used *in vivo*. Institutional review board approval was obtained, and the subject gave written informed consent. Patient with high tCho signal was measured and the CSI matrix was subsequently shifted in one direction. One voxel with changing water/fat content was selected for demonstration. tCho SNR for patient's CSI data and Dixon images processing were performed using MATLAB software (MathWorks).



	Init. SNR	Corr. SNR
A	14.3	18.2
B	12.8	18.9
C	11.4	19.2
Variance	2.05	0.256

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.

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.

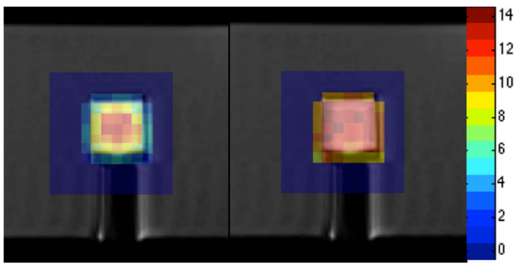


Figure 3: Spectral maps example without (left) and with (right) correction. Note the increased homogeneity of the metabolic map after applying the correction.

References: **1.** Gruber S, Debski BK, Pinker K et al: Three-dimensional Proton MR Spectroscopic Imaging at 3 T for the Differentiation of Benign and Malignant Breast Lesions. Radiology. 2011;261(3):752-61, **2.** Bolan PJ, Meisamy S, Baker EH et al: In vivo quantification of choline compounds in the breast with 1H MR spectroscopy. Magn Reson Med. 2003 Dec;50(6):1134-43, **3.** Gasparovic C, Neeb H, Feis DL et al: Quantitative spectroscopic imaging with in situ measurements of tissue water T1, T2, and density. Magn Reson Med. 2009 Sep;62(3):583-90.