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Magnetization Transfer in Brain: Comparison to Relaxation and Proton Density

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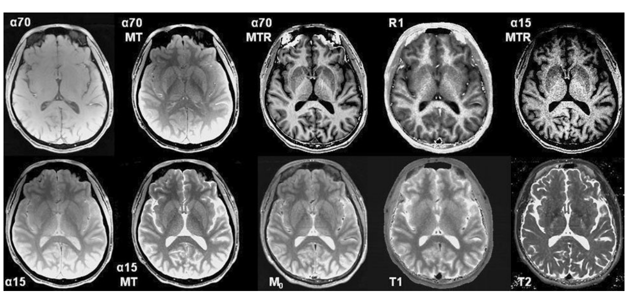
Purpose/Introduction: To obtain various quantitative maps of the human brain and examine which factor determines the magnetization transfer (MT) contrast.

Subjects and Methods: Seven volunteers (age 31 ± 7 y.o.) are recruited. At 3 T (Magnetom Prisma, Siemens Healthcare, Erlangen) transversal MRI (2D FLASH, TR/TE = 863/4.4 ms, α 70° (and 15°), $(0.66\ mm)^2$ resolution, 2.5 mm slice thickness, 21 slices, measuring time = 4 min 35 s) was performed. For off-resonance irradiation, magnetization transfer and fat saturation provided by the manufacturer are used. T1, R1, T2, R2, and M_0 mapping [1-3] were performed with the same spatial resolution. Regions-of-interests are selected in the frontal subcortical white matter, prefrontal cortex, caudate nucleus, putamen, thalamus, globus pallidus, subthalamic nucleus, red nucleus, and substantia nigra. Regional values are compared to each other and to the mean regional water content given in the literature [4].

Results: The **figure** below shows T1-weighted MRI without (α70) and with MT (α70MT), MT ratio map (α70MTR), R1 map (R1), MT ratio map (α15MTR), proton-density-weighted MRI without (α15) and with MT (α15MT), M_0 map (M_0), T1 map (T1), and T2 map (T2). α70MTR, α15MTR, and R1 show a similar contrast in brain as well as α70MT, α15MT, and M_0. Quantitative evaluation confirms this observation. Mean regional MT ratios (α70) and T1 values correlate significantly ($r = -0.98$, $p < 0.0005$) with each other and both correlate ($r = -0.995$ for MT ratios and $r = 0.98$ for T1) significantly ($p < 0.0005$) with regional water content. In particular, the MT ratios correlate significantly ($p < 0.005$) with water content in any individual subject, whereas correlation coefficients between T1 values and water content show substantially greater inter-individual variances. Regional signal intensities in α70MT correlate significantly ($p < 0.005$) with those in M_0 in any subject.



Discussion/Conclusion: The results suggest that (1) there are no substantial inter-individual variations in regional water content in healthy brain, (2) MT ratios are more robust indicators of regional water content than T1 values, (3) compared to MT ratios, T1 values are more sensitive to paramagnetic ion concentrations (which are reported to considerably vary between subjects), and (4) signal intensities in T1-weighted MRI with MT reflect proton density rather than T1 values.

References:

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Anisotropic Conductivity Imaging Using Electrical Properties Tomography at 3T-MRI

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Purpose/Introduction: Recently, the technique for characterizing the electrical property of the biological tissues (Electrical Properties Tomography: EPT) was reported [1]. There have been several reports on applications of EPT to tumors [2], stroke [3], etc. In most reports on EPT, the isotropy of conductivity is assumed. However, the anisotropy in the actual tissue structure, such as muscle and nerve, may induce an orientation dependency in the tissue's electrical conductivity. Therefore, anisotropic conductivity imaging may provide information about biological organ, and may potentially be useful for the clinical application. In this study, we will present our preliminary data on EPT for anisotropic conductivity.

Subjects and Methods: We constructed a phantom using plastic bottle, filled with 1.0% [w/w] NaCl/water solution. The diameter of the bottle was 70 mm, and a pack of straws with 12 mm in diameter was then inserted into the bottle as shown in Fig. 1 [4, 5]. To induce a cross-sectional anisotropy, the straws were squeezed along one direction, as shown Fig. 1c, hence, $\sigma_1 > \sigma_2 > \sigma_3$ are expected. MRI experiment was performed using a transmit/receive head RF coil at a 3T-MRI system (Tim-Trio, Siemens Medical Solution, Erlangen, Germany). The absolute value of B_1^+ was measured using dual-angle gradient-echo [6] with FA: 45^o and 90^o, TR/TE: 5000/3.12 ms, FOV: $160 \times 160\ mm^2$, thickness: 2.5 mm, acquisition matrix: 128×128. The B_1^+ phase was measured by using 3D True-FISP with FA: 47^o, TR/TE: 4.28/2.14 ms, FOV: $160 \times 160 \times 40\ mm^3$, and acquisition matrix: $128 \times 128 \times 16$. The assumption that the B_1^+ phase is the half of the image phase was used. The experiment was repeated with the phantom oriented along three different directions (x, y, and z-axis). The conductivity was calculated by using the absolute value and the phase of B_1^+ [1].

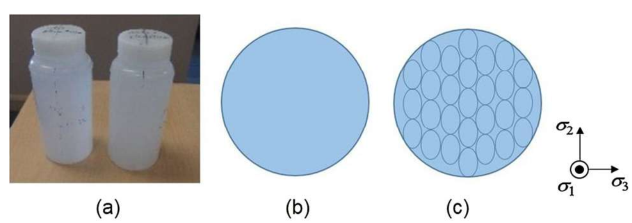

Fig. 1 Bottle phantom for the measurement of conductivity. (a) picture of the bottles, (b) schematics of cross-section of uniform phantom, and (c) schematics of cross-section of anisotropic structure phantom.

Results: Figure 2 illustrates the conductivity maps and a plot for σ_1, σ_2, and σ_3 for uniform phantom (Fig. 1b), and the values were 1.66, 1.68, and 1.67 S/m, respectively. Those for anisotropic phantom (Fig. 1c) were measured at 1.23, 0.86, and 0.75 S/m, respectively, as shown in the plot in Fig. 3.