Fast Macromolecular Proton Fraction Mapping at 0.5 Tesla

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The effect of the magnetization transfer (MT) caused by cross-relaxation between the protons of water and macromolecules is widely used in MRI to modify tissue contrast. Of interest are maps of macromolecular proton fraction (MPF), especially for detecting brain pathologies. To calculate the MPF map, one need to build maps: T_1 and proton density (PD) and analyze the MT-weighted images (MT-WI). To obtain the last ones, MT saturation pulse (RF pulse with a large detuning Δ - $10^2 \div 10^4$ Hz) is entered at the beginning of the scanning pulse sequence. While the conventional analysis of MT-WI requires at least three samples [1], the single-point method [2] provides accurate MPF maps from one sample, if the amplitude of the MT-pulse and Δ are set optimal. In this case, to build MPF map, it is sufficient to perform only three scans: two of them are needed to build a T_1 and PD maps, and one more - to obtain MT-WI.

So far, fast MPF mapping has been implemented only at high magnetic fields ($\geq$1.5T). We present the first implementation of this method in low-field MRI. A 0.5T clinical scanner Bruker Tomikon S50 was used for this. It is equipped with a 2 kW transmitter LPPA 2120 and a 16.86 mT/m gradient system (0.5 ms rise time). The 3D spoiled gradient echo method was used with TR/TE=30/5 ms and voxel size of 1×1×1.3 mm^3. The total study time was 22 min. To construct T_1 and PD maps, variable flip angle (VFA) method was used, for which the FA was set to 30° and 5° (1 ms pulse). To obtain an MT-WI we set FA=10°. Spoiling gradient area was 14 mT·ms/m. 8 ms MT-pulse had a Gaussian shape. Its parameters (Δ=1.5 kHz, FA=600°) were in accordance with the recommendations of studies [2,3]. T_1, PD and MPF maps were calculated using custom-written software. Fig. 1 shows the results of study for a 22-years old female. It was found that MPF values for different brain structures are close to those obtained in stronger fields. In particular, it concerns the average values for the white and gray matter of the brain -14.2 and 7.5, respectively.

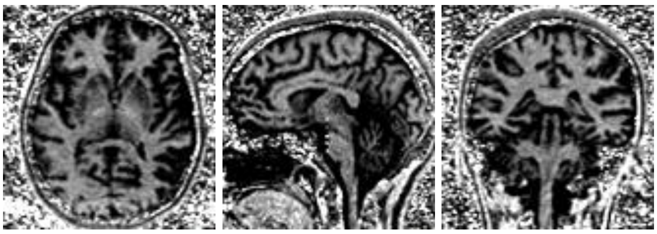

Fig. 1. MPF map of the human brain in orthogonal projections.

In additional proof-of-concept experiment we obtained MPF maps of the rat brain with a similar technique – Fig. 2. For this purpose, a 3 cm (3 turns) ring receive coil was made. The scans were performed with the above parameters with resolution 0.25×0.25×1 mm^3. Eight signal averages were applied with the total study time of about 1.5 hour. According to preliminary data, the values of MPF in white and gray matter structures were close to those reported for ultra-high field measurements [3].

In summary, this study proves the independence of MPF on magnetic field strength, since quantitative MPF estimates obtained using a low-field scanner (0.5T) are close to those reported for high-field machines (from 3T to 11.7T). The possibility of fast MPF mapping for low field allows us to hope that the method will also be applicable to open-type magnets and compact portable magnetic systems.

Fig. 2. MPF map of the rat brain.

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