Full Brain High Resolution 3D-MRSI at 7 Tesla within 30 Minutes via 3D-CONCEPT

Lukas Hingerl, Bernhard Strasser, Philipp Moser, Stanoslav Motyka, Gilbert Hangel, Michal Považan, Eva Heckova, Stephan Gruber, Siegfried Trattnig, Wolfgang Bogner

High Field MR Centre, Departement of Biomedical Imaging and Image-guided Therapy, Medical University of Vienna, Waehringer Guertel 18-20, 1090 Vienna, Austria (L.H., P.M., S. M., G.H., E.H., S.G., S.T., W.B.);
Martinos Center for Biomedical Imaging, Deportment of Radiology, Massachusetts General Hospital, Harvard Medical School, Boston, Mass, United States (B.S.)
Russell H. Morgan Department of Radiology and Radiological Science, The Johns Hopkins University School of Medicine, Baltimore, MD, United States (M.P.)
F. M. Kirby Research Center for Functional Brain Imaging, Kennedy Krieger Institute, Baltimore, MD, United States (M.P.)
Christian Doppler Laboratory for Clinical Molecular MR Imaging, Vienna Austria (S.T., W.B.);

Introduction

The most common MRSI acquisitions for the brain offer two-dimensional coverages of the brain-slice of interest, however for clinical applications whole-brain coverages are highly desirable, because of the potential to detect spread diseases via full brain acquisitions [1]. Main effects preventing 3D-MRSI are: SNR-insensitivity, scan time limitations, low spatial resolutions, B0 inhomogeneities, insufficient spectral separations and RF pulse imperfections. To partly overcome these challenges, the most efficient solution is going to higher field strengths of about B0=7T together with additionally incorporating acceleration methods such as spectro-spatial encoding (SSE). One already published and efficient two-dimensional implementation of a SSE technique is the concentric circle echo-planar readout trajectory (CONCEPT, [2,3]). Here we present a 3D extension (3D-CONCEPT) via FID-MRSI [4] for high-resolution whole-brain mapping at 7T.

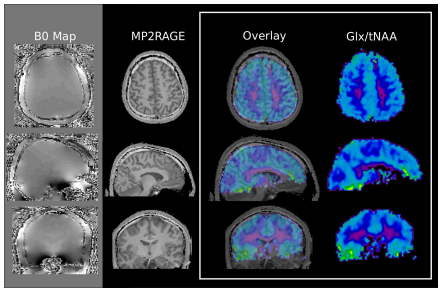

Figure 1: B0 maps, MP2RAGE and Glx/tNAA maps for the healthy control.

Methods

We measured two subjects: one healthy volunteer and one multiple sclerosis (MS) patient. All subjects were measured on a 7T MR scanner with a 32-channel head coil. We used a FID-based SSE sequence with 2D-CONCEPT readout in phase and read dimension combined with an encoding of the slice dimension via elliptical partition encoding. The parameters read: TR in 600 ms, acquisition duration 302 ms, acquisition delay = 1.3 ms; flip angle = 42 °; 3-lobe sinc-shaped pulse for full-brain excitation; variable temporal interleaves; spectral bandwidth = 2778 Hz. The VOIs covered the whole brains: FOVs = 220x220x130 mm^3, VOIs = 220x220x80 mm^3, matrix size = 80x80x47 resulting in a nominal spatial resolution of 2.75x2.75x2.75 mm^3; TA < 30 min. Data (110 GB) were reconstructed partition-wise and coil-wise via conventional convolution gridding. Additionally we acquired B0 maps, FLAIRs and MP2RAGEs.

Results

Figures 1 and 2 show metabolic ratio maps for the healthy volunteer (Glx/tNAA) and the MS patient (Ins/tNAA).

Discussion

3D-CONCEPT offers detailed anatomical maps and has, despite the high accelerations, sufficient SNR for metabolic quantification (for the given parameters). We observed some partial volume effects especially at the ventricles together with B0 inhomogeneities in the frontal part of the brain. The signal intensities of some metabolic maps are slightly off in some low-SNR areas due to false quantification, which leads to wrong metabolic ratios at those regions. Concerning the MS patient, not all FLAIR-lesions match the neuro-information provided by the Ins/tNAA map.

Conclusion

We presented 3D-FID-MRSI acceleration technique which can acquire nominal resolutions of 2.75x2.75x2.75 mm^3 within 30 minutes.

References

[1] Lecocq A et al J Magn Reson Imaging 2015;42:280–289.
[2] Furuyama JK et al. Magn Reson Med 2012;67:1515–1522.
[3] Hingerl L et al Magn Reson Med 2018.; 79:2874-2885.
[4] Bogner W et al NMR Biomed 2012;25:873–882.

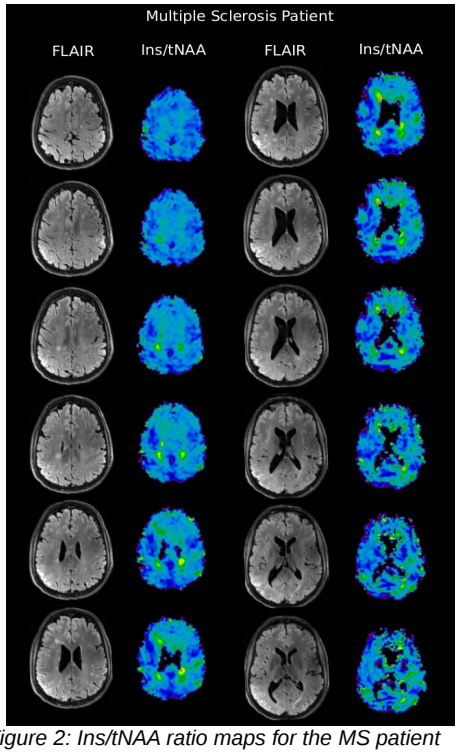

Figure 2: Ins/tNAA ratio maps for the MS patient together with FLAIR images.