3D B0-adjusted and sensitivity-enhanced spectral localization by imaging (BASE-SLIM) of patients with gliomas

Peter Adany[1], Phil Lee[1,2], Sarah Taylor[3], Roukoz Chamoun[4], and In-Young Choi[1,5]

[1]Hoglund Brain Imaging Center, University of Kansas Medical Center, Kansas City, KS, United States, [2]Molecular and Integrative Physiology, University of Kansas Medical Center, Kansas City, KS, United States, [3]Department of Internal Medicine, University of Kansas Medical Center, Westwood, KS, United States, [4]Department of Neurosurgery, University of Kansas Medical Center, Kansas City, KS, United States, [5]Neurology, University of Kansas Medical Center, Kansas City, KS, United States

TARGET AUDIENCE: Scientists and technologists who are interested in non-Fourier based spectral localization methods for advanced *in vivo* ^{1}H MRS for research and clinical applications.

INTRODUCTION: One important clinical application of ^{1}H MRS is the assessment of specific tissue types, e.g. gray matter (GM) or white matter (WM), and/or region specific metabolic alterations occuring in cancers, stroke and neurological disorders. Unfortunately, the widely available conventional MR spectroscopy localization techniques such as chemical shift imaging (CSI) and single voxel spectroscopy (SVS) have very limited ability to differentiate neurochemical information among neighboring regions due to limited spatial resolution. Spectral localization by Imaging (SLIM) is a non-Fourier based multi-voxel spectroscopy that reconstructs MRS signals using spatial information from high resoultion MRI. Recently, we proposed an advanced SLIM technique with simultaneous corrections for both B0 inhomogeneity and inhomogeneous coil sensitivity: B0-Adjusted and Sensitivity-Encoded (BASE)-SLIM. In this study, we have further developed our BASE-SLIM technique [1] into three-dimensional (3D) BASE-SLIM to achieve accurate spectral localization of different brain regions such as GM, WM and lesions. The 3D BASE-SLIM was applied to detect neurochemical alterations in lesions of patients with high grade gliomas.

METHODS: The 3D BASE-SLIM technique incorporates 3D B0 and B1 field inhomogeneity maps and utilizes spatial encoding by independent receiver coils [BASE-SLIM]. The 3D BASE-SLIM technique incorporates 3D k-space data from conventional CSI, while keeping the operating principle of 2D based SLIM and BASE-SLIM. All reconstructions were performed using in-house MATLAB programs. All experiments were performed on a Siemens Skyra 3 T MR system with a 16-channel receiver RF coil. SEMI-LASER [2] based localized CSI with high bandwidth localization pulses was performed on a 6-cm thick axial slab (TR/TE = 2000/35 ms, FOV = 16 x 16 x 8 cm, VOI = 10 x 10 x 6 cm^3, matrix size = 8 x 8 x 8). In addition, B0 and coil sensitivity maps and T2 and T1-weighted MRI were aqcuired. All image data were coregistered to the CSI orientation (FSL and MATLAB). Image segmentation of GM, WM and CSF as well as inter cranial cavity and lipid compartments were performed using automatic segmentation routines (BET, SPM8). Image segmentation of glioma lesions was performed manually using ROI editing software (Jim 6). The performance of 3D BASE-SLIM was tested on a three-compartment phantom containing various combinations of creatine (Cr), NAA, acetate and alcohol. The effectiveness of the 3D BASE-SLIM technique was validated through numerical simulation on synthesized data with three-dimensional multi-compartments: gray and white matter, CSF and lesion masks generated from segmented high resolution T_1-weighted images.

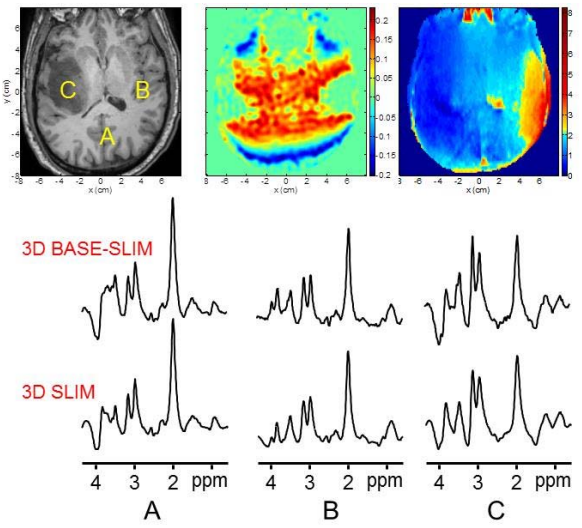

Fig. 1. Top: T_1-weighted MRI, B0 and B1 maps; MRS acquired using 3D BASE-SLIM (upper trace) and conventional 3D SLIM (lower trace), A: GM, B: WM, C: lesion

RESULTS AND DISCUSSION: Both 3D SLIM and 3D BASE-SLIM techniques provided minimum inter-compartmental contamination using three compartment pantoms. The comparisons of localization performance on phantom data showed significantly improved spectral quality using 3D BASE-SLIM over conventional 3D SLIM, demonstrated by narrower spectral linewidth (data not shown). Figure 1 shows *in vivo* MR data from the brain with gliomas. Spectra using 3D BASE-SLIM showed slight improvement of spectral quality over conventional 3D SLIM. Spectral patterns of GM and WM compartments were consistent with the varying ratio of choline to creatine, i.e., higher choline to creatine ratio in WM. Markedly elevated choline signals were deteced in the lesions in all patients with gliomas, consistent with the characteristics high-grade gliomas. Our results demonstrate that 3D BASE-SLIM can provide reliable compartmental separations and improvement in spectral quality by simultaneous compensation of both B0 inhomogeneity and inhomogeneous coil sensitivity in the human brain *in vivo* at 3T.

REFERENCES: [1] Adany et al. PISMRM 3967 (2013). [2] Scheenen et al. MRM 59:1 (2008). This work is partly supported by KUMC Cancer Center pilot grant (Choi), CTSA Frontiers Pilot and Collaborative Studies Funding Program (Choi) and the Hoglund Family Foundation.