Performance Optimized Lipid Artifact Removal (POLAR) with BASE-SLIM of Full FOV Human Brain 1H MRS

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TARGET AUDIENCE: Scientists and technologists who are interested in new non-Fourier based spectral localization methods and lipid elimination strategies for *in vivo* ^{1}H MRS measurements.

INTRODUCTION: *In vivo* measurement of ^{1}H MRS in the cortical regions is challenging due to the brain strutural contour and interference by lipid signals that are orders of magnitude stronger than metabolites. Lipid signals in ^{1}H MR spectra overlap with various metabolites of interest and cause severe baseline distortion. Outer volume suppression (OVS) provides limited lipid suppression close to the cortical regions. However, the retangular nature of the OVS does not allow measurement of metabotes near the edge of the brain, especially cortical gray matter (GM). Recently, we developed a B0-Adjusted Sensitivity Encoded Spectral Localization by Imaging (BASE-SLIM) technique [1,2] that addresses B0 field and coil sensitivity (B1) inhomogeneities in the framework of SLIM. BASE-SLIM allows spectral localization of brain regions with spatial encoding as well as corrections by measured B0 and B1 profiles [1,2]. In this study, we demonstrate Performance Optimized Lipid Artifact Removal (POLAR) as an application of BASE-SLIM. Our goal is to achieve a robust ^{1}H MRS with clear removal of lipid signals in the cortical gray matter of the human brain.

METHODS: All experiments were performed on a Siemens Skyra 3 T with a 16-channel receiver RF coil. SEMI-LASER [3] based localized CSI with high bandwidth localization pulses was used (phantom: TR/TE = 2000/35 ms, FOV = 16 x 16 x 12 cm3, VOI = 16 x 16 x 12 cm3, matrix = 8 x 8 x 6; in vivo: TR/TE = 2000/35 ms, FOV = 20 x 20 cm2, VOI = 20 x 10 x 1.3 cm3, matrix = 16 x 16). B0 and coil sensitivity (B1) maps were acquired for BASE-SLIM reconstruction.

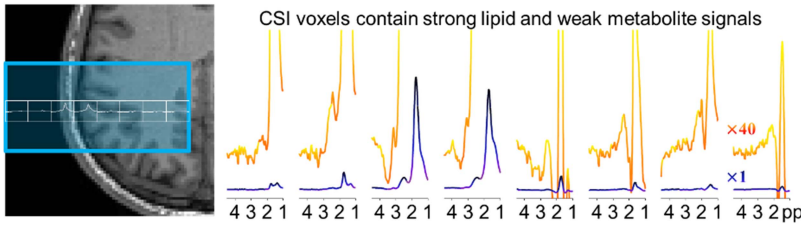

Fig. 1. ^{1}H MR CSI of cortical areas demonstrating strong subcutaneous lipid signals present in neighboring voxels.

3D T1-weighted MRI were acquired using an MPRAGE sequence and the images were co-registered to the CSI FOV (FSL and MATLAB). Image segmentation of GM, WM, CSF and lipid compartments were performed using automatic segmentation routines (BET, SPM8) with additional manual editing (Jim 6). Reconstruction by BASE-SLIM was tested on a multi-compartment phantom containing combinations of creatine, NAA, acetate, isopropyl alcohol, and oil. The effectiveness of the BASE-SLIM was validated through numerical simulation on synthesized data with 3D multi-compartments: GM, WM, and lipid boundary masks derived from segmented high resolution T1-weighted images.

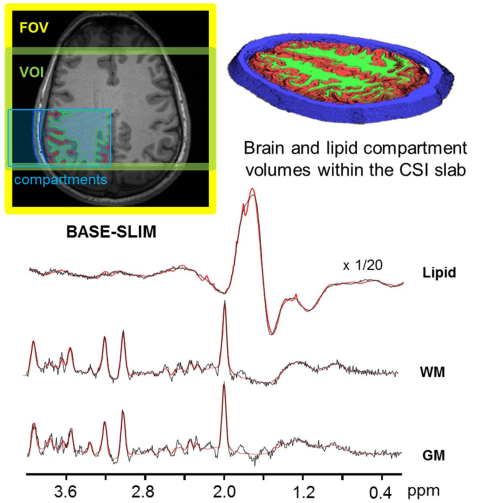

Fig. 2. POLAR BASE-SLIM reconstruction of ^{1}H CSI in the human brain: GM, WM and subcutaneous lipid compartments.

RESULTS AND DISCUSSION: The results of POLAR BASE-SLIM demonstrated excellent lipid suppression in compartments in close proximity to lipid compartments in phantom and human brain (Fig. 1 & 2) at 3 T. In phantom studies, the residual lipid signals in metabolite spectra were <1% of those from lipid spectra. In addition, BASE-SLIM yielded spectra with sharper peaks compared to conventional SLIM. In the human brain, the excellent performance of POLAR BASE-SLIM was further demonstrated not only by lipid suppression but also by the signal separation between GM and WM (Fig. 2) compartments. Spectral patterns of GM and WM were consistent with the varying ratio of choline-to-creatine, i.e., higher choline to creatine ratio in WM. The combined use of both complex-valued B1 sensitivity maps and B0 field maps enabled point-specific phase correction and compartment-based spatial localization, thereby yielding a significant improvement in the accuracy of spectral reconstruction with an effective removal of lipid contamination in spectra from metabolite compartments adjacent to compartments with intense lipid signals.

REFERENCES: [1] Adany et al., *PISMRM* 3967 (2013). [2] Adany et al., *PISMRM* 3734 (2014). [3] Scheenen et al., *MRM* 59:1 (2008). This work is partly supported by the National Institutes of Health (S10RR29577, UL1TR000001) and the Hoglund Family Foundation.