Fast Separation of Multiple Metabolites with Radial Undersampling

J. Perry[1], C. Mistretta[1,2], S. Reeder[2], and O. Wieben[1,2]
[1]Medical Physics, University of Wisconsin - Madison, Madison, Wisconsin, United States, [2]Radiology, University of Wisconsin - Madison

Introduction: Rapid imaging of multiple metabolites with high spatial resolution is a challenging task in MR chemical shift imaging. However, applications that have sparse spectra such as fat-water separation, and metabolic imaging of pyruvate labeled with hyperpolarized C-13 [1], as well as tracking of SPIO labeled stem cells [2] have created interest in new chemical shift imaging methods [2,3]. For the acquisition of multiple images at various echo times with a single or multi-echo sequence, various image reconstruction techniques exist for the separation of metabolites with known off-resonances, including EPSI processing [4], Dixon methods [5], matrix inversion and iterative approaches [6]. These techniques vary in their ability to compensate for B_o inhomogeneity and reconstruction complexity. Here, we propose to use a radially undersampled acquisition to obtain chemical shift information of several chemical species to reduce total scan time.

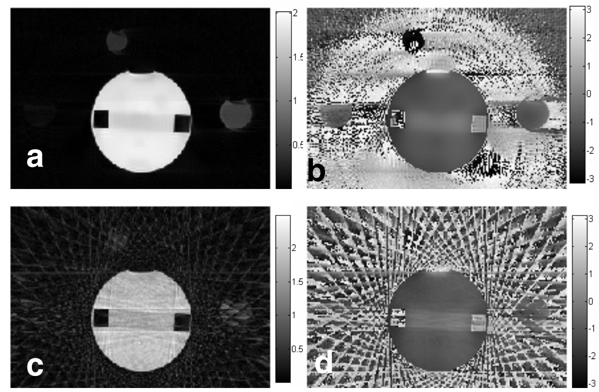

Fig. 1: Magnitude (a,c) and phase images (b,d) with different degrees of undersampling at TE = 10ms. Images (a) and (b) contain 256 projections and images (c) and (d) only 26 .

Materials and Methods: We implemented a 2D radial gradient recalled echo pulse sequence that acquired data at multiple echo times. Currently, repeated single echoes are acquired to avoid signal distortions from multi-echo readouts. A QA phantom and vials filled with acetone, silicone and peanut oil were placed in a clinical 1.5 T system (GE Healthcare, Waukesha, WI). We acquired 8 images at the following echo times: 10, 11.08, 12.16, 13.24, 14.32, 15.4, and 16.48 ms and a TR of 35 ms. Other scan parameters included: FOV = 30cm, BW = ±15.6kHz, slice = 10 mm, and a 256 readout. We reconstructed the images at each echo time with 256 projections, 52 projections and 26 projections per image, corresponding to radial undersampling factors of 1.6, 7.7, and 15.4 relative to the Nyquist criterion. Images were reconstructed offline (Matlab, The Mathworks, Natick, MA) via complex backprojection (see Fig. 1). A matrix inversion was used to reconstruct 4 spectral images at frequencies, obtained from a fieldmap generated from these echos (-10Hz, -110Hz, -195Hz, and -280Hz).

Results and Discussion: The results for metabolite separation at various degrees of undersampling are demonstrated in Fig. 2. Images reconstructed with 256 projections show no signs of undersampling artifacts and good separation of water, acetone, and oil. However, some signal leakage from the dominant water into all metabolites and from fat into the silicone frequency band can be observed. When fewer projections are used, streak artifacts become more apparent from the QA phantom, as it occupies the largest region in the image. The other metabolites suffer much less from the undersampling, since they are contained in a smaller local FOV that is still supported by the undersampled radial data. The results could be improved by better shimming across the FOV.

Conclusions and Future Work: This pilot study demonstrates the feasibility of radial undersampling for the imaging of small number of metabolites. The increase in data sparsity by the separation of the metabolites allows for higher degrees of undersampling. In future work, we aim to implement a multiecho sequence for improved scan efficiency and a reconstruction technique that incorporates an off-resonance map [6] for improved results.

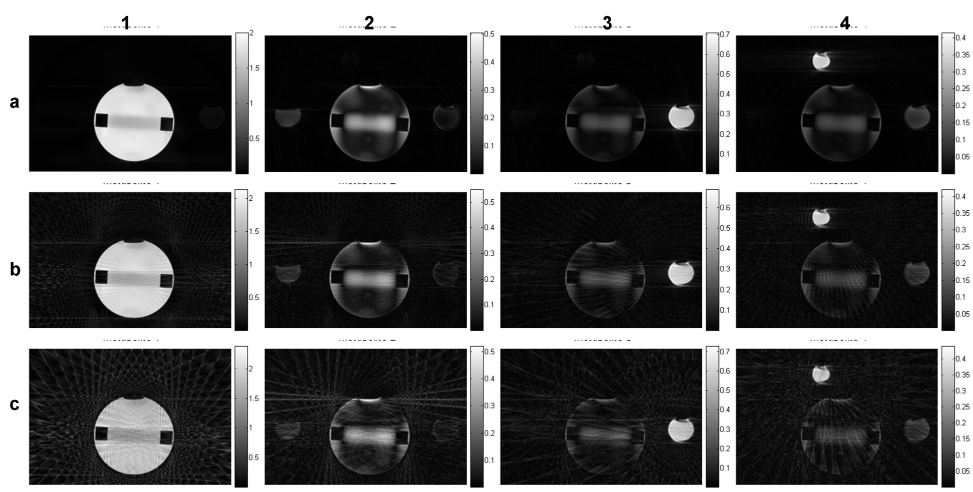

Fig. 2: Images reconstructed at specific frequencies with different undersampling factors. The frequencies in columns are -10Hz (1), -110Hz (2), -195Hz (3), -280Hz (4), and the underampling factors in rows are 1.56 (a), 7.7 (b), and 15.4 (c).

Acknowledgements: We gratefully acknowledge GE Healthcare for their assistance.

References:
[1] K Golman et al., *Acad Radiol* 13:932-42, 2006. [2] S Reeder et al., ISMRM 2006, p430. [3] O Wieben et al., ESMRMB 2004, p162. [4] S Posse *et al., MRM* 33:34-40, 1995. [5] G Glover et al., MRM 18: 371-83, 1991. [6] S Reeder *et al., MRM* 51:35-45, 2004.