Fat-water separation in the abdomen during free-breathing by using stack-of-star (SOS) 3D radial TrueFISP Imaging

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Target audience Physicists, clinicians.

Purpose In three-dimensional (3D) MRI, fat water separation in dynamic imaging application is challenged to provide high spatial and temporal resolution. In this work we propose a fat-water separation[1-3] strategy in the abdomen during free breathing by employing 3D stack-of-stars (SOS) radial sampling technique. Radial trajectories are less sensitive to motion and have higher sampling density for central k-space allowing for better performance in capturing dynamic information. To this end a 3D radial TrueFISP sequence was modified enabling the echo time TE to change from projection to projection, where all z-phase encoding were acquired at one projection angle before the next projection angle is acquired Fig.1. The fat signal forced to behave in a peculiar and readily recognizable fashion through time. Using temporal processing, the temporal variations imposed on fat signals can be recognized, and fat signals can be separated from water signals.

Material and Methods A 3D radial TrueFISP pulse sequence was modified, with radial stack-of-stars k-space sampling in the xy-plane and Cartesian encoding in the z direction, in this technique all lines corresponding to first radial angle were acquired sequentially before moving to the next angle Fig.1. TE was made to vary between subsequent spokes. Specifically, a series of 4 TEs was employed and periodically repeated following a radial golden angle projection order; thereby distributing the acquired fat signal over the temporal frequency domain[4]. Experiments were carried out on a 3.0T clinical scanner using following imaging parameters: Number of projections =1500, number of partition = 28, TR = 4.0 ms, flip angle = 40°, FOV= 400x400 mm^2, radial readout points = 256 and TEs of TE1 = 1.6, TE2 = 2.0, TE3 = 1.6, TE4=2.4 ms. Signals within each partition were used to generate images at different TEs using non-uniform fast Fourier transform (NUFFT) gridding[5]. Finally fat-water separation according to Ababneh et al[4] was applied frame by frame and the separation achieved for all reconstructed partitions.

Results Figure (1) shows the illustration of the stack-of-stars sampling pattern. Figure 2 shows calculated fat and water data acquired for one partition number at a 3T clinical scanner (Siemens, Erlangen, Germany) on a healthy volunteer. Water-only and fat-only results from one phase (out of 4) are shown in (a) and (b), respectively.

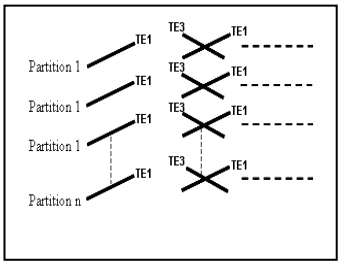

Fig.1: The stack-of-stars sampling

Discussion & Conclusion A robust approach to separate fat and water signals using stack-of-stars 3D radial acquisition combined with non-uniform fast Fourier transform (NUFFT) gridding of different respiratory phases in free-breathing was presented. The technique reduces blurring artifacts caused by respiratory motion and enhances the image resolution. The images suffer from banding artifacts due to off-resonance effects, which could be minimize through the use of one of the known methods. The results of our study show that 3D TrueFISP with radial acquisition during free-breathing is feasible for abdominal MRI studies and shows that also even small variations in TE (0.4 ms) were sufficient to separate fat and water in dynamic objects. In conclusion, the approach was tested in time resolved abdominal imaging. Good separation without streaking artifacts or blurring due to respiratory motion was obtained in all studied cases. The concept has been demonstrated in 3D, future work will be targeted on extending the method to self-gated 3D radial imaging for robust fat-water separation in the abdomen.

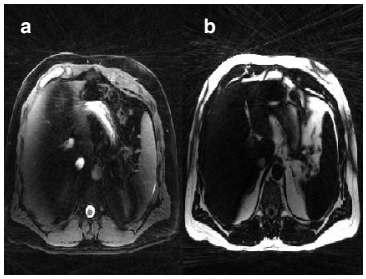

Fig.2: The calculated water (a) and fat (b).

Acknowledgements: The Deutsche Forschungsgemeinschaft DFG BR 4356/2-1 for funding, SIEMENS, Healthcare Sector, Erlangen, Germany.

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