ABDOMINAL FAT-WATER SEPARATION IN HIGH TEMPORAL AND SPATIAL RESOLUTION DURING FREE BREATHING

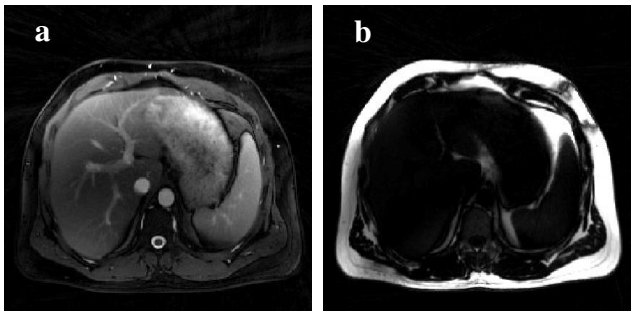
Riad Ababneh[1], Thomas Benkert[2], Martin Blaimer[2], and Felix A. Breuer[2]
[1]*Physics, Yarmouk University, Irbid, Jordan,* [2]*Research Center Magnetic Resonance Bavaria, Würzburg, Bavaria, Germany*

Target audience Physicists, clinicians.

Purpose Existing imaging strategies such as the Dixon method[1], direct phase encoding[2] (DPE) and IDEAL[3] are capable of separating fat and water signals. Because these methods typically require at least 3 images for the separation to be performed, it may be difficult to achieve good temporal and spatial resolution for dynamic objects. Robust fat water separation with dynamic objects remains a challenge, especially in the presence of the respiratory motion artifacts when imaging the abdomen. This work aims at separating the fat and water contents during free breathing at high temporal and high spatial resolution, by employing radial sampling with a golden angle increment. A radial TrueFISP sequence is used and modified to allow for different TEs for subsequent radial projections. The TE variation from echo to echo provides the basis for the separation of fat and water signals. The k-space-weighted image contrast (KWIC) radial filtering technique[4] was applied to enable high temporal as well as high spatial resolution. Finally, principal component analysis (PCA) was performed along the dynamic image series. Principal components with low eigenvalues are removed thereby reducing residual streaking artifacts and enhancing the signal-to-noise ratio (SNR) while simultaneously maintaining the important dynamic features.

Methods: The TrueFISP pulse sequence was modified enabling different TEs for subsequent radial projections at constant TR[5]. A sequence of 4 TEs ($TE_{1,2,3,4}$ = 1.6, 2, 1.6, 2.4 ms) was periodically repeated following a radial golden angle projection order. In total 2001 projections were acquired at 4 different TEs. 631 KWIC-filtered projections were used to reconstruct 4 images at different TEs at 21 different time-points. PCA was applied along the time series and principal components with small eigenvalues were removed. Finally fat-water separation according to Ababneh et al[5] was applied frame by frame. All experiments were performed on a 3T clinical scanner on healthy subjects. TR = 4.0 ms, matrix size = 256x256, flip angle = 40° and FOV= 400x400mm^2,

Results The figure shows calculated fat and water data acquired at a 3 T clinical scanner (Siemens, Erlangen, Germany) on a healthy volunteer. Water-only and fat-only results from one phase (out of 12) are shown in (a) and (b), respectively.



Discussion & Conclusion A novel approach to separate fat and water signals combined with the KWIC-filtered radial TrueFISP was presented which provides robust high temporal (~100ms) and high spatial resolution. The separation is achieved by changing the echo time TE from projection to projection, to force fat signals to behave in a conspicuous manner through time, so they can be detected and separated from water signals through temporal processing. The results of our study show that 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. PCA processing enhanced the image quality of the dynamic series. In conclusion, the approach was tested in time resolved abdominal imaging. Good separation without respiratory motion artifacts was obtained in all studied cases. This method is expected to allow for e.g. accurate tracking of contrast agent bolus in time under free breathing in fatty tissue.

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

References:

1. Glover et al. Three-point Dixon technique for true water/fat decomposition with B0 inhomogeneity correction. MRM 1991; 18:371–383.
2. Xiang et al. Water-fat imaging with direct phase encoding. JMRI 1997; 7:1002–1015.
3. Reeder et al. Multicoil Dixon chemical species separation with an iterative least-squares estimation method. MRM 2004; 51:35–45.
4. Song et al. Dynamic MRI with Projection Reconstruction and KWIC Processing for Simultaneous High Spatial and Temporal Resolution. MRM 52:815–824 (2004)
5. Ababneh et al. Fat-Water Separation in Dynamic Objects Using an UNFOLD-Like Temporal Processing. JMRI 32:962–970 (2010).