Renal 3D Diffusion Tensor Imaging in a single Breath-hold using single shot 3D GRASE

M. Guenther[1], K. Oshio[1], D. A. Feinberg[1]
[1]Advanced MRI Technologies, Sebastopol, CA, United States

Introduction:

Since diffusion imaging is very sensitive to body motion, its image quality is severely degraded by respiratory motion and arterial pulsation. Therefore, to date, abdominal diffusion measurements can be performed only for a small number (one or three) of directions and for a few slices within a single breath-hold. This limitation on the number of diffusion encodings and slice coverage is problematic since rotationally invariant measurements are needed to assess diffusion in kidneys and other abdominal organs. Here, we present the first sub-second 3D diffusion imaging, which allows for acquisition of full tensor (six independent directions plus b=0) for up to 16 slices within a single breath-hold. ECG-triggered measurement is performed within the breath-hold scan.

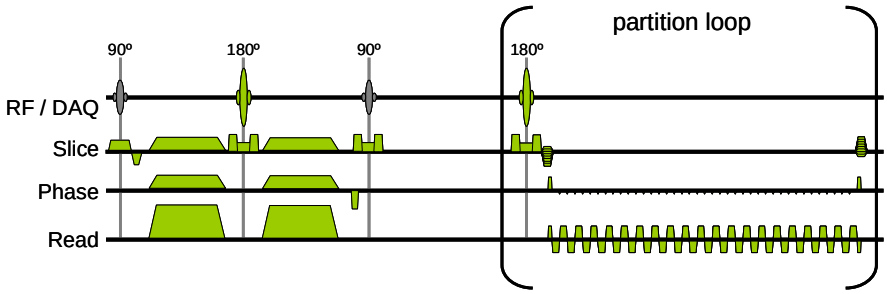

Fig 1: Sequence scheme of diffusion-sensitized single-shot 3D-GRASE.

Material and Methods:

A clinical 1.5T scanner (Magnetom Sonata, Siemens, Erlangen, Germany) was used for imaging. Maximum gradient strength was 40mT/m with a slew rate of 200mT/m/ms.

ECG-triggering was used followed by a slab-selective saturation to make the sequence insensitive to magnetization variations due to changing recovery times. After a fixed recovery time of TS=2000ms a diffusion-sensitized single shot 3D-GRASE [1] was applied. The resolution relevant parameters of the single shot 3D-GRASE sequence were: matrix size 64x41, reconstructed to 128x80, field-of-view 256mm x 160mm, nominal 20 partitions with no oversampling, partition thickness 4 mm, 5/8 Fourier encoding was used to reduce the number of measured partitions to 13. Thus, yielding an isotropic resolution of 4 mm $\times$ 4 mm $\times$ 4 mm. Other parameters include: echo time TE=113 ms, total echo train length 430 ms, b-value = ~390 s/mm^2, directions of diffusion gradients: [(0,0,0); (1,1,0); (0,1,1); (1,0,1); (0,1,-1); (1,-1,0); (-1,0,1)], inter RF-spacing = 22 ms, bandwidth = 2694 Hz. Saturation pulses above and below imaging slab were used to reduce infolding artifacts.

The diffusion tensor was calculated following the equations given in [2]. Eigenvalues were extracted from this data to estimate ADC and relative anisotropy.

Results:

Figure 2 shows the calculated ADC and relative anisotropy of 10 out of 20 slices. Good differentiation of medulla and cortex is seen. Mean ADC values for the medulla and the cortex were (3.8±0.9) and (4.5±0.8) $\cdot 10^{-3}$ mm^2/s, respectively. The (average) repetition time was ~2.5 s, resulting in approx. 18 s acquisition time.

Discussion and Conclusion:

The diffusion-weighted 3D-GRASE sequence reliably eliminated artifacts caused by motion induced phase variations. To provide sufficient signal a rather small b-value had to be chosen. Nonetheless, the diffusion tensor could be calculated in all slices. The whole kidneys could be covered with isotropic resolution of 4 mm. This was sufficient to differentiate between medulla and cortex.

We have presented a method to acquire full renal diffusion tensor images with up to 20 slices within a single breath-hold. The proposed technique can also be used for other abdominal diffusion measurements, including spine. It is expected that rotationally invariant diffusion measurements will improve reliability and quality of renal functional experiments.

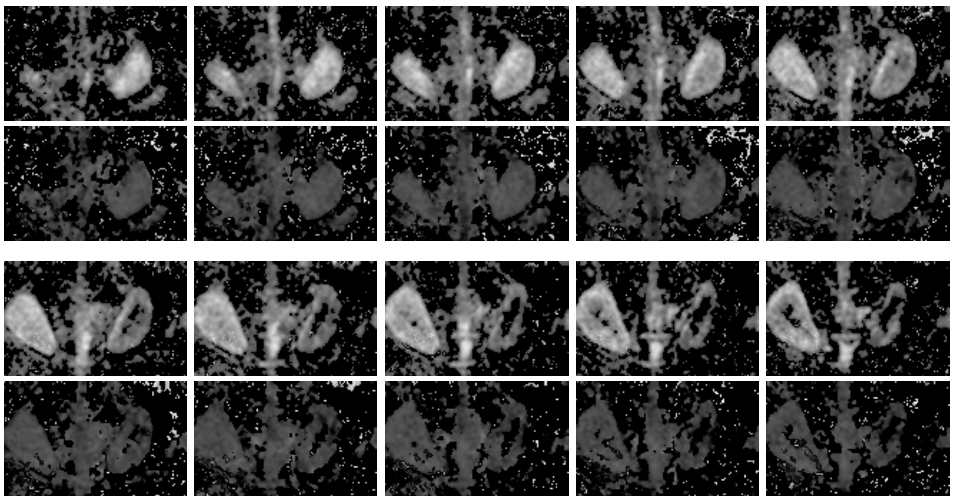

Fig.2: Renal ADC (Row 1 and 3) and relative anisotropy (Row 2 and 4) of 10 out of 20 slices. Diffusion tensor images were acquired within a single breath-hold of 18s.

Acknowledgments: This work was funded by NIH-grant R01RR13618-01A1 from the National Center for Research Resources.

References:

1.) Guenther M, Oshio K, Feinberg DA: Physiological Measurements using Single-Shot 3D-GRASE: Diffusion- and T2*-Weighting, In: Int. Society for Magn. Reson. in Med. (ISMRM), eds. Book of Abstracts, 2003, Toronto, p.2133

2.) Westin CF, Maier SE, Mamata H, Nabavi A, Jolesz FA, Kikinis R: Processing and visualization for diffusion tensor MRI, Medical Image Analysis 6 (2002): 93-108