Diffusion tensor imaging of the kidney with respiratory triggering: optimization of the parameters to demonstrate anisotropic structure on FA map

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Introduction

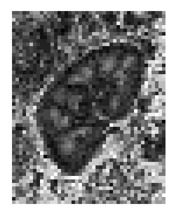
Diffusion tensor imaging (DTI) evaluates diffusion anisotropy in tissues and widely used in brain imaging. Although the use of DTI outside the brain is hindered by strong respiratory motion (1), the potential to reveal underlying structure and disease process has been suggested in several organs including liver (2), prostate (3) and kidney (4). Ries et al. elaborated the sequence with single breath-holding technique and demonstrated the anisotropic structure of the kidney on fractional anisotropy (FA) maps (4). To overcome the limited imaging time within single breath-hold to obtain more detailed structures, respiratory triggered acquisition is a possible solution. Carefully coordinated triggering under quiet respiration produces excellent image with minimum motion artifact and enables the increase of number of signal averaging. Multiple breath holding may be another option, although breathing pattern becomes more variable than respiratory triggering (Resp.Trig). The purpose of this study is to demonstrate that DTI of the kidney is feasible with Resp.Trig or multiple breath-holding (BH) and to explore the best imaging parameters for cortex-medulla differentiation. Standard deviation (SD) of the ROIs on FA maps was used to quantify the noise of the image. ADC values were also measured.

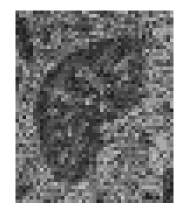
Material and methods

MR imaging of 7 healthy volunteers were obtained by 1.5T (Symphony:Siemens) MR unit using 6-channel phased array coil. Six different coronal DWI sequences (table 1) were used with the following common parameters: FOV=320-350mm, parallel imaging (sense factor:2), slice number: 5. The DT imaging datasets (4 image series or 10 image series per sequence) were transferred to a workstation and processed by using DtiStudio software, version 2.3 (H. Jiang, S. Mori; Johns Hopkins University, mri.kennedykrieger.org) to obtain FA map, Color map, and ADC map. One slice was carefully selected to include maximum renal area among 5 slices and to avoid renal vessels in right kidney. Two different regions of interest (ROI) were placed over the cortex and medulla on upper and lower pole. Signal intensity and SD were measured. ROI on FA map was copied to the ADC map to measure ADC value. The FA difference between cortex and medulla on FA map were computed to quantify the cortex-medulla contrast.

Table 1. Parameters of the six different sequences

	Acquisition technique	Thickness (mm)	TR/TE (msec)	Number of signal averaging	Number of series	b value s/ mm^2
1	**Resp.Trig**	**3**	**2000/ 74**	**3**	**4**	**0, 200**
2	Resp.Trig	3	2000/ 74	3	4	0, 400
3	Resp.Trig	3	2000/ 74	1	10	0, 200
4	BH	3	1000/ 74	1	10	0, 200
5	Resp.Trig	5	2000/ 74	3	4	0, 200
6	BH	5	1000/ 74	1	10	0, 200





Seq 2: Resp. 3 mm **Seq 4:** BH 3 mm

Results

One volunteer was excluded from the analysis due to severe motion artifact. Figure 2 shows the difference of FA between cortex and medulla (largest in Sequence1 and 2: Resp.Trig, 3mm slice. Table 2 shows FA value and ADC value obtained with 6 different sequences. Although both value differed slightly with different sequences, SD tend to be smaller in Sequence 2: b=400. Sequence 4 (BH, 3mm) tend to show the largest SD.

Figure1. Difference between cortex / medulla on FA map In 6 sequences (mean and 95% CI)

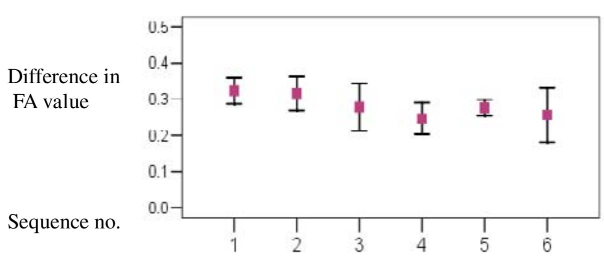


Table 2. FA and ADC value of renal cortex and medulla

	FA		ADC (x10^{-3})	
sequence	Cortex (mean±SD)	Medulla (mean±SD)	Cortex (mean±SD)	Medulla (mean±SD)
1	0.17±0.05	0.49±0.07	2.70±0.22	2.11±0.21
2	0.15±0.04	0.46±0.04	2.32±0.12	1.95±0.13
3	0.20±0.06	0.47±0.09	2.62±0.23	2.07±0.24
4	0.21±0.06	0.45±0.10	2.40±0.24	1.79±0.31
5	0.18±0.05	0.45±0.07	2.78±0.13	2.30±0.27
6	0.20±0.05	0.46±0.08	2.58±0.18	1.93±0.21

Discussion

This study has demonstrated that the DTI of the kidney with respiratory-triggered acquisition is feasible, with excellent cortex-medulla contrast. 3 mm slice thickness, three averaging, with b value of 400 or 200 resulted in the best image. As renal medulla consists of tubular cells and play an important role in water transport, the abnormal anisotropy or FA detected by DTI can be an non-invasive tool to reveal renal patho-physiology and add new information on conventional MR imaging, isotropic diffusion weighted imaging and ADC value. To further improve the image quality, navigator triggered prospective acquisition correction (6) or the scanner with higher magnetic field would be the next approach

References

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