Respiratory Triggered Diffusion Tensor Imaging MR of the kidney at 3T

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Introduction: Diffusion tensor imaging (DTI) has been widely used in brain neural tractography. The application of multiple gradient directions, needed to assess tissue anisotropy, requires increased scanning time for DTI compared to Diffusion weighted imaging (DWI). The kidney is a very appealing target for study with DTI because of the radial architecture of the renal medulla. Previous authors have demonstrated the anisotropic structure of the kidney on fractional anisotropy (FA) maps using single breath-hold (BH) techniques (Figures 2A and 2B) [1-4]. The breath-hold approach has physiologic limits to acquisition time, which can be overcome using respiratory-triggered acquisition. Respiratory-triggering allows for longer acquisition times, which can be used to increase the signal to noise ratio by increasing the averages, or to increase the number of gradients directions. The aims of this study are to**: 1) demonstrate that respiratory-triggered DTI of the kidneys is feasible at 3T** and **2) compare FA and apparent diffusion coefficient (ADC) values obtained using different b values.**
To achieve these aims, we: 1) calculated the FA and ADC values and compared them with those reported by others; 2) calculated the differences in FA and ADC values obtained using sequences with different b values.

Methods: Respiratory triggered DTI MRI was performed with 3T scanner (Siemens, Trio) on 6 healthy volunteers with no history of renal disease and not receiving any regular medication. 3 different DTI acquisitions were performed with 3 different pairs of b values: 0 and 150 s/mm^2 (A); 0 and 400 s/mm^2 (B), 0 and 800 s/mm^2 (C). Acquisition time was 98 seconds, with total scan time per sequence ranging between 212 and 329 seconds. Other parameters (A,B, and C): FOV = 350x350 mm, Matrix = 128x128, voxel size 2.7×2.7×3.0 mm, slice thickness 3 mm, TE = 84 ms, TR 2500 ms, EPI factor 128, bandwidth 2056 (Hz), diffusion directions 6 + 1 null, slice number 10, signal averages 8. Fat saturation was used to avoid chemical shift artifacts. Regions-of-interest (ROI) were selected in the renal medulla and renal cortex on the ADC and FA maps of the 6 imaged kidneys. ADC and FA values of the renal medulla and renal cortex were compared using t-test (significance $p<0.05$).

Results: Figure 1 shows representative coronal images of the kidneys in the same subject for different b values. The mean ADC and FA values of the renal medulla and renal cortex are reported in table 1. The ADC and FA values were in the range of those reported in previous publications [1-4]. There was a significant difference between the ADC and FA values of the renal cortex vs. medulla ($p<0.01$ for all b values). There was a significant difference between the ADC and FA of the renal medulla when this was calculated using lower b values (0, 150 s/mm^2) vs. higher b values (0, 800 s/mm^2). This difference was a FA decrement of 27% and an ADC decrement of 24% for higher b values.

Discussion: This study demonstrates that respiratory-triggered DTI of the kidneys is feasible at 3T, and the ADC and FA values calculated with this sequences are in the range of those already published [1-4]. This study also demonstrates a very similar decrease (percentage wise) in both the renal medulla FA and ADC when measured using higher b values. It has been demonstrated that ADC values calculated using low b values (up to 300 s/mm^2) are influenced by microcirculation flow [5], however the microcirculation component is reduced when higher b values are used. We speculate that at lower b values the FA is due to the combined effects of the radially oriented vessels and tubules, while at higher b values the measured FA is mainly due to the tubular structure/flow.

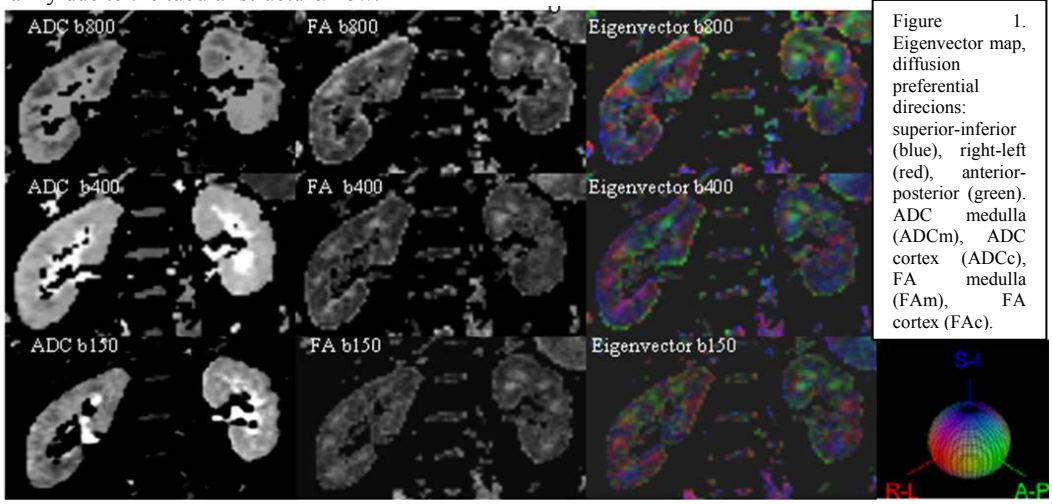

Figure 1. Eigenvector map, diffusion preferential direcions: superior-inferior (blue), right-left (red), anterior-posterior (green). ADC medulla (ADCm), ADC cortex (ADCc), FA medulla (FAm), FA cortex (FAc).

	ADCm	ADCc	FAm	FAc
b 0, 150	2.77±0.47	3.24±0.43	0.52±0.11	0.26±0.05
b 0, 400	2.21±0.50	2.59±0.32	0.51±0.06	0.18±0.03
b 0, 800	2.12±0.35	2.22±0.13	0.38±0.04	0.16±0.03

Table 1. Legend: ADC (x 10^{-3} mm^2/s). ± standard deviation

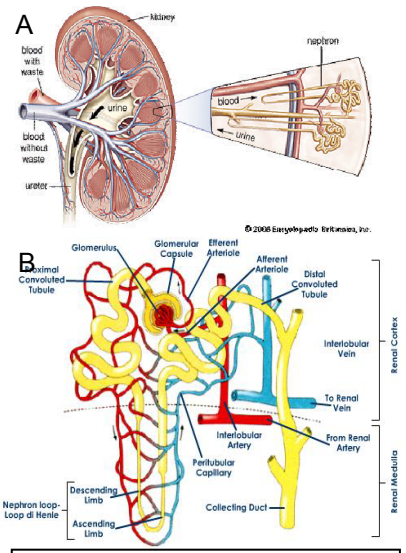

Figure 2. The kidney cortex and medulla are very well organized. The microscopic structure of the tubules (A) and microvasculature (B) can be studied with DTI, and the fractional anisotropy can quantify the directionality of the kidney microstructure.

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