MR Diffusion Tensor Imaging of the Kidney with Parallel Imaging – Initial Clinical Experience

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Purpose: As the predominant function of the kidneys is to transport water and structures like vessels, tubules and collecting ducts are oriented in a radial fashion, resulting in anisotropic diffusion properties[1], MR diffusion tensor imaging (MR-DTI) might add further information about the renal microstructure by determining the degree of diffusion anisotropy. The purpose of this study was to evaluate the feasibility of MR-DTI of the kidney with integrated parallel imaging in volunteers and patients with various renal diseases.

Material and Methods: Ten volunteers and 27 patients (mean age 56±14.3) with various renal pathologies (renal masses, renal artery stenosis) underwent breath-hold coronal fat-saturated echo-planar MR-DTI (6 directions, b=0 and 300sec/mm^2,TR 730msec/TE 72msec; 5 slices; slice thickness 6mm; inplane resolution 2.1x2.1 mm; acquisition time 26seconds) of the kidneys at 1.5T (Magnetom Avanto, Siemens Medical Solutions, Germany). Parallel imaging technique GRAPPA with an acceleration factor R=2 was applied. Using the Syngo DTI-task-card software (MGH-NMR-Center,USA) regions of interests were placed in the cortex, medulla and in renal masses if present. Fractional anisotropy (FA) and apparent diffusion coefficients (ADC) were determined and tractography was used to visualize the renal diffusion anisotropy. Statistical analysis was performed with the Wilcoxon signed-rank sum test and paired t-tests.

Results: In all volunteers FA was significantly ($p<0.05$) higher in the medulla (0.36±0.03) than in the cortex (0.21±0.02), whereas the ADC was significantly ($p<0.05$) higher in the cortex (2.43±0.19) than in the medulla (2.16±0.22). Tractography typically revealed a radial preferred direction of medullar diffusion (Figure 1).
FA/ADC of simple renal cysts (n=7) was 0.14 ± 0.05/2.86 ± 0.15. RCCs (n=10) showed a wide FA-range from 0.11-0.56. Using tractography the structural organization of RCCs, e.g. pseudocapsules (Figure 2) or diffuse infiltration (Figure 3) could be detected. In one patient with unilateral high grade renal artery stenosis the cortical ADC of the affected kidney was lower than on the contralateral side (1.77/2.27) and the FA was increased (0.33/0.18). The FA of the medulla was increased (0.70/0.41) and the ADC decreased (1.43/1.90).

Conclusion: Using parallel imaging MR-DTI measurements of the kidneys are feasible within a single breath-hold with good discrimination between cortex and medulla and allows visualization of renal architecture alterations, e.g. by tumors or parenchymal disease. Parallel imaging allows an increased number of slices and resolution. The results suggest that MR-DTI may be a useful tool to study and monitor renal ultrastructure.

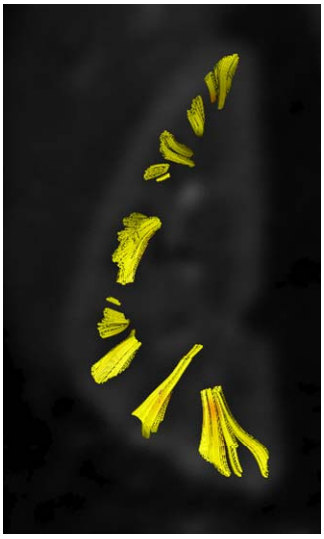

Figure 1: Tractography of a healthy volunteer

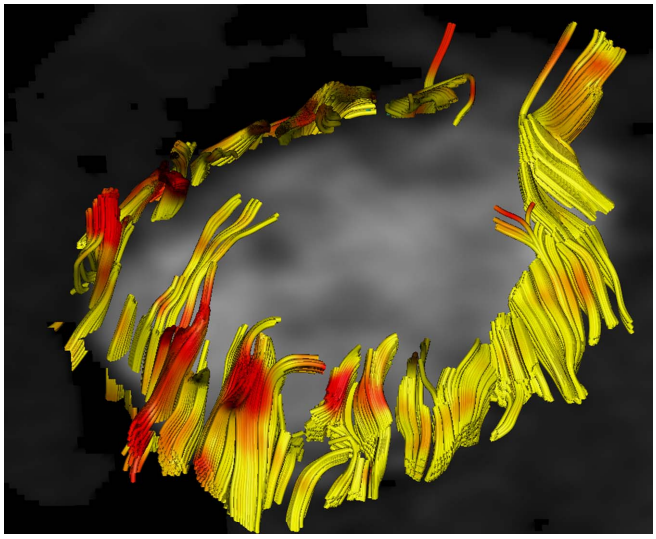

Figure 2: Tractography of a liquefied RCC with a surrounding pseudocapsule

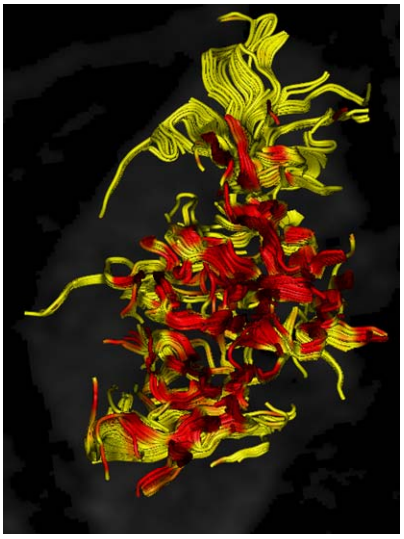

Figure 3: Tractography of a diffuse infiltrating RCC

References

1. Fukuda Y, Ohashi I, Hanafusa K, et al., Anisotropic diffusion in kidney: apparent diffusion coefficient measurements for clinical use. J Magn Reson Imaging, 2000. 11(2): p. 156-60.