Diffusion weighted imaging in native and transplanted human kidneys at 3T. Initial experience.

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Introduction

Few studies have used diffusion-weighted imaging (DWI) to assess renal function in native kidneys. However, to our knowledge no diffusion study has been reported in human kidneys at a field strength of 3T or higher. Recently, we have applied DWI in a study on native and transplanted kidneys using a 1.5T Scanner. Determination of diffusion parameters was highly reproducible [1]. Substantial differences between transplanted and native kidneys were observed. In this study we performed DWI in native and transplanted human kidneys on a 3T MR-scanner. Primary aim of this feasibility study was to establish a protocol for reliable determination of diffusion parameters, including apparent diffusion coefficients (ADCs), and analysis of micro-perfusion contributions [2].

Methods

The native kidneys of nine healthy subjects and two patients with transplanted kidneys were measured on a 3T MR scanner (Trio, Siemens) using a 6-channel body coil. After morphological imaging, coronal diffusion–weighted multisection single shot echo-planar imaging was performed, applying parallel imaging (SENSE, acceleration factor of 3). Two different acquisition schemas were used: (a) Untriggered acquisition with 10 b-values (b=0, 10, 20, 50, 100, 180, 300, 420, 550, 700 sec/mm^2), 6 averages and 3 orthogonal gradient directions, TR=2.8s, TE=68ms, slice thickness 5mm, scan time ~8min; (b) Multiple breath-hold acquisition with 4 pairs of 2 b-values, each and 3 orthogonal gradient directions (b=0, 500; 10, 400; 20, 300; and 50, 200 sec/mm^2), 3 averages were acquired with TR=1.6s, TE=65ms resulting in 12 breath-hold acquisitions of 16-19s. To roughly match SNR with the untriggered scan, a slice thickness of 7mm was used. Parameters for both scans include: 11 slices, FOV: 40cm, matrix size = 128x128. Multiple scans were merged before analysis. Processing was performed by I) monoexponential fitting, yielding ADC_T, and II) biexponential fitting, yielding ADC_D (mostly determined by diffusion) and the contribution of the fast decaying component ("perfusion fraction", F_P).

Results and Discussion

Homogeneous maps for ADC_D and ADC_T were obtained for most subjects (Figs.1, 2). While for higher b-values (> 100 sec/mm2) a good linear correlation was observed (ln(Intensity) vs. b-values), the signal intensity for low b-values was less stable (reducing reliability of F_P estimation). This is probably due to blood flow, and suggests using cardiac triggering for future studies. Geometric distortions that are commonly observed in EPI-based sequences at higher field strength were relatively low (Figs. 1,2), due to parallel imaging allowing for short TE times. Dielectric effects were observed in a number of subjects reducing signal intensity locally. However, ADC values are less susceptible for this problem; the maps were still relatively homogeneous, though reduced in SNR (Fig. 2). Breath-hold acquisitions did not improve reliability compared to untriggered scans (Fig.1). ADC_D values for both transplanted kidneys and F_P for one were close to previously determined values in 15 transplanted kidneys at 1.5T [1]. F_P in the other transplanted kidney was lower. However, currently it is uncertain if this is due to methodological or to physiological reasons. In contrast to native kidneys no difference between cortex and medulla was observed in transplanted kidneys, confirming our previous results at 1.5T.

Conclusion

The current study clearly demonstrates that DWI is feasible at 3T and does provide reliable results. Breath-hold scans did not yield more reliable results for ADC_T, ADC_D and F_P than untriggered acquisitions. Potential reasons may include different breath-hold positions between scans, or that multiple signal averages for each pixel effectively average out respiratory motion effects. Currently, DWI at 3T of human kidneys does not provide better results than at 1.5T (at least in this study), possibly mostly due to dielectrical effects. In future studies we will consider using dielectric pads, as has been suggested for abdominal MRI [3]. Other factors reducing the advantage of higher field strength include higher susceptibility, especially in combination with motion, reducing signal yield in EPI-based sequences. Geometric distortions play a minor role, if parallel imaging is employed allowing for short TE times.

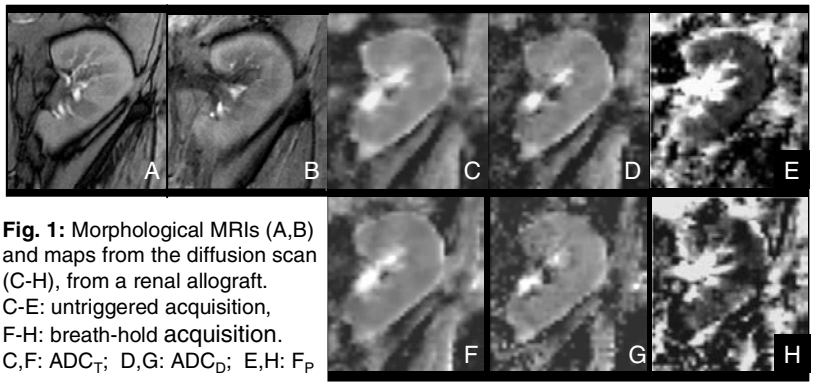

Fig. 1: Morphological MRIs (A,B) and maps from the diffusion scan (C-H), from a renal allograft. C-E: untriggered acquisition, F-H: breath-hold acquisition. C,F: ADC_T; D,G: ADC_D; E,H: F_P

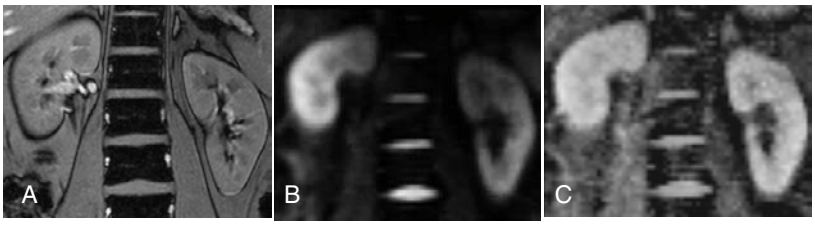

Fig. 2: (A) Morphological MRI, (B) EPI-image for b=0sec/mm^2, (C) ADC_T from the diffusion scan of a native kidney to demonstrate dielectric effects.

References

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