Long Term Follow-up of Human Transplanted Kidneys by DWI and BOLD Imaging

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Introduction: Previously, we determined short term reproducibility of diffusion and oxygenation parameters in renal allograft recipients with stable renal allograft function compared to healthy native kidneys using DWI and BOLD MRI [1]. These two noninvasive functional techniques appeared to be feasible and reproducible in patients with renal allografts. Except for one very recent paper [2] this study is still the only DWI investigation performed in humans with transplanted kidneys.
The aim of the present study was to assess long term effects of kidney transplantation and to determine long term reproducibility of diffusion and micro-perfusion parameters from DWI and of R2* from BOLD MRI by measuring nine patients of our initial study again almost 3 years after the first scans.

Methods: Study Population: Nine patients (6 men, 3 women; mean age at initial scan: 49±15 years), who underwent kidney transplantation 7±3 months prior to the initial MR examination and who had initially no signs of kidney dysfunction were included in this follow-up study. The MR examination was repeated 32±2 months after the initial scan and included also determination of laboratory parameters. Eight of the nine patients had still good allograft function. One subject demonstrated a strong GFR decrease, indicative of renal dysfunction.
MR Imaging: MR imaging was performed on a 1.5T MR scanner (SONATA, Siemens) as previously described [1]. Coronal DWI was performed with 10 diffusion gradient b-values (0-900 sec/mm^2). Six averages were acquired using respiratory triggering (TR = 1 resp. cycle, TE=71msec, FOV = 40x40cm^2, parallel imaging, min. acq. time: 7:18min). Coronal BOLD-MRI was performed at the same slice positions using a mGRE-sequence with 12 different TE (6-52ms), TR=65ms, FOV=40x40cm^2 within a single breath-hold.
Processing: Processing of the *DWI data* was performed I) without separating diffusion and perfusion contributions, yielding a "total" ADC_T, and II) separating diffusion and perfusion contributions, yielding ADC_D (mostly determined by diffusion) and the perfusion contribution ("perfusion fraction", F_P). From *BOLD imaging* R2* indices were calculated. Three ROIs were selected in both, cortex and medulla at the upper and lower pole and at the mid-level for a number of slices covering large parts of the kidney.

Results: The eight subjects with good renal allograft function showed very similar values for ADC_T, ADC_D and F_P in the initial and the follow-up scan (Table). The coefficients of variation within and between subjects (CV_w and CV_b) were low. This is also demonstrated in Fig.1a. The values are close to the identity line. Also BOLD imaging demonstrated stable values, however slightly higher R2* values were obtained after 32 months, which was significant in cortex and indicated slightly reduced oxygenation (Table 1 and Fig.1b). The one subject with strongly decreased GFR at the time of the second scan had initially very high ADC_D and ADC_T values (see Fig. 1a, indicated by circles) and high F_P values. Similarly, R2* values from initial BOLD scan were very low (Fig. 1b). In Fig. 2 the MR parameter changes between the initial and the follow-up scan, i.e. ΔADC_T and $\Delta R2^*$, are compared with the changes in GFR. The GFR and MR parameter changes of the eight subjects with good allograft function scatter mostly around zero, i.e. demonstrate no substantial change. In contrast, ΔADC_T and $\Delta R2^*$ of the subject with decreased GFR appear clearly separated.

	ADC_T		ADC_D		F_P		R2*	
	Medulla	**Cortex**	**Medulla**	**Cortex**	**Medulla**	**Cortex**	**Medulla**	**Cortex**
1st Scan	206±11	206±10	182±9	182±8	22±3	21±3	13.6±1.9	11.2±0.3
2nd Scan	208±11	207±11	182±12	180±7	24±4	23±4	15.0±1.3	12.1±1.1
CV_w (%)	2.6	3.5	3.1	2.8	16.1	17.8	10.8	7.2
CV_b (%)	5.2	4.9	5.9	4.0	14.6	17.1	11.4	7.2

Table 1

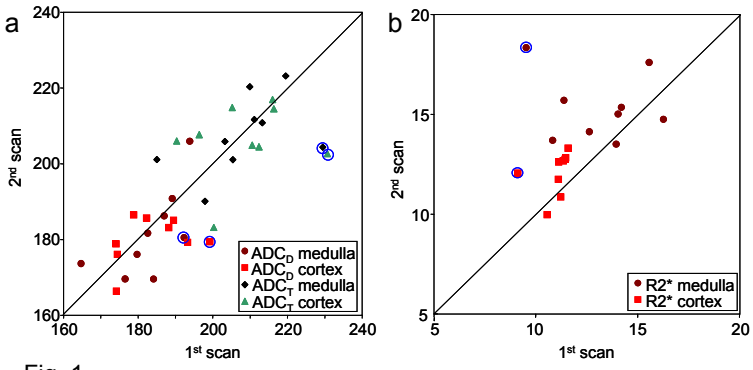

Fig. 1

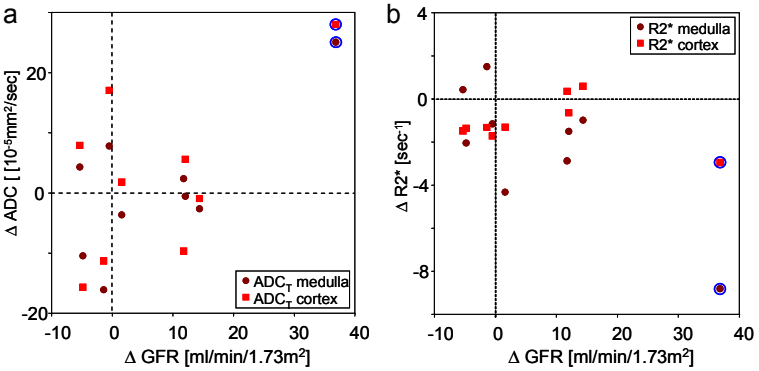

Fig. 2

Discussion: These results clearly demonstrate that DWI and BOLD measurements in human transplanted kidneys are feasible and they demonstrate the potential of these methods to potentially detect deterioration of renal function noninvasively at an early time point preceding morphological changes. The functional parameters were markedly stable with a slight tendency towards reduced oxygenation, potentially suggesting influence of medication or "normal ageing". Although based on the results of only one subject the strong deviation of several MR parameters may indicate their sensitivity to indicate renal dysfunction.

References:

1. Thoeny HC, et al. Radiology 2006;241:812.
2. Blondin D, et al. Rofo. 2009; DOI 10.1055/s-0028-1109511

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