Renal Blood Oxygenation Level-Dependent Imaging in Longitudinal Follow-up of the Donated and the Remaining Kidney in Renal Transplantation

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Background: Early detection of changes in renal tissue oxygenation level in remaining kidneys[1] as well as in transplanted kidneys after living allograft donation can play an important role in investigating renal dysfunctions. Blood oxygenation level-dependent (BOLD) magnetic resonance imaging (MRI) can assess intra-renal oxygenation status in native and transplanted kidneys[2-5] by measuring the apparent transverse relaxation rate (R2* =1/T2*). R2* is negatively related to the partial pressure of oxygen within the blood. **Purpose:** Previously, we presented a DWI study in living donors and corresponding recipients showing that DWI is capable to monitor renal changes in the remaining and transplanted kidney within one year follow-up[6]. The current study is performed in the same living kidney donors and their recipients of the DWI study to determine potential renal oxygenation changes associated with transplantation in both, remaining kidneys and transplanted kidneys over time.

Methods: 13 healthy kidney donors (9 female, 4 male, 55 ± 12 years) without a history of renal disease and their corresponding recipients (4 female, 9 male, 50 ± 10 years) underwent kidney BOLD MRI at 3T. BOLD MRI was performed in donors one week before uninephrectomy (Pre) and in donors and recipients at day 8 (D08), month 3 (M03) and 12 (M12) after transplantation. Coronal BOLD MRI was performed using a mGRE sequence (12 echoes of 6-52msec, TR=65msec, flip angle=30°, FOV=40×40cm^2, BW=330Hz/pixel, slice thickness=5 mm, 5 slices 17sec breathold each, matrix=256×256). R2* values were determined in cortex and medulla. Serum creatinine concentrations were obtained at each MRI examination and the estimated glomerular filtration rate (eGFR) was calculated. R2* values are presented as mean ± standard deviation.

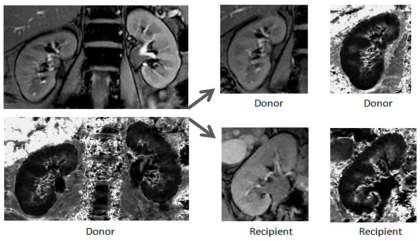

Fig. 1: T2*-weighted images & R2*maps.

Results: The BOLD measurements of all subjects were included in the analysis. Figure 1 shows as an example T2*-weighted images of the first echo and the R2* map of the donor before allograft donation and of the transplanted kidney in the corresponding recipient. Figure 2 shows that the R2* values of all donors decreased in the remaining kidney after explantation of the contralateral kidney. R2* values decreased highly significantly in the remaining kidneys early after uninephrectomy both in medulla and in cortex (P<0.003 and P<0.002, respectively, Fig. 3, Table 1) and remained significantly decreased in both medulla and cortex at month 3 and 12 (P<0.01, Table 1). No significant change was observed at day 8, month 3, and month 12 in recipients (Fig. 3). There was a significant decrease (P<0.004) between the cortical R2* parameter of the donated kidney in donors before uninephrectomy and in recipients after transplantation of the same kidney at day 8. R2* values remained stable in transplanted kidneys after transplantation. R2* values in the living donors as well as in recipients showed no significant correlations with the corresponding diffusion parameters obtained in the previous study[6]. The cortical R2* in the remaining kidneys of donors were significantly and negatively correlated with eGFR values (R=-0.47, P< 0.001, Fig. 4).

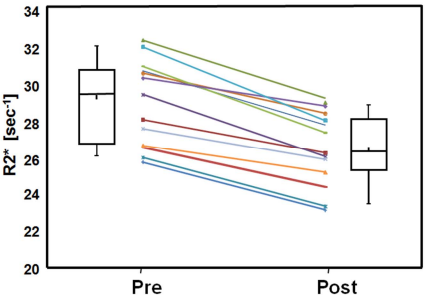

Fig. 2: Individual medullary R2* decreases in the remaining kidney of donors ("Pre": before explantation, "Post": average R2* value of the three post explantation scans).

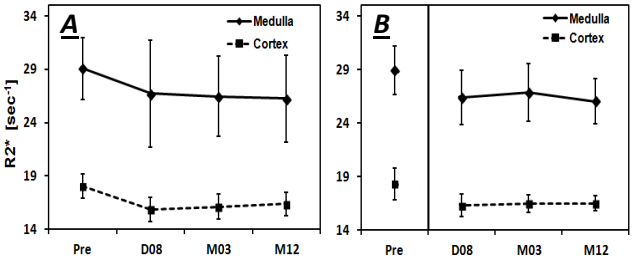

Fig 3: Corticomedullary R2* changes of donors A & recipients B

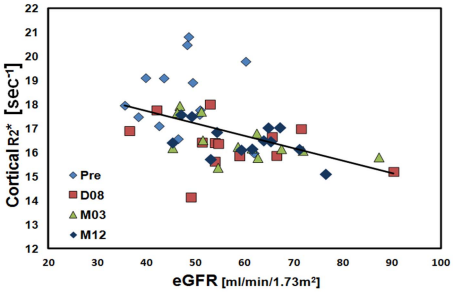

Fig. 4: eGFR of the kidney vs. R2* values in donors for all measurements.

Discussion & Conclusion: Our findings showed that the R2* values of the remaining kidney in donors significantly decreased after nephrectomy and remained decreased over time (within 1 year). In donors the R2* changes indicate a very early compensatory adaption mechanism, i.e. increased tissue oxygenation of the remaining kidney after explantation. The medullary and cortical R2* values of donated kidney in recipients decreased compared to the same kidney in donors before nephrectomy, which may be associated to the known reduced tubular fractional reabsorption of sodium and oxygen consumption in renal transplantation, due to CsA-induced tubular dysfunction [5]. It can however not be excluded that this difference may be due to a changed shim status because of the altered position of the transplanted kidney. The highly stable R2* values in recipients over 1 year indicate constant renal function. In conclusion, the results suggest potential of BOLD MRI to monitor renal functional changes in remaining kidneys and corresponding transplanted kidneys.

References: **1.** Prasad PV, et al. Nephron Clin Pract 2006;103:c58-c65; **2.** Li LP, et al. Magn Reson Imaging 2004;19:610-616; **3.** Thoeny HC, et al. Radiol 2006;241:812-821; **4.** Song T, et al. Urology 2014;83:1205; **5**. Vermathen P, et al. J Magn Reson Imaging 2012;35:1133-1138; **6.** Eisenberger U, et al. Radiol 2014;13:122588.

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	Remaining kidney				Donated kidney	
Time	**Med. R2***	**p-value**	**Cort. R2***	**p-value**	**Med. R2***	**Cort. R2***
Pre	28.9 ± 2.3		18.3 ±1.5		29.1 ± 2.9	18.0±1.1
D 08	26.4 ± 2.5	<.003	16.3 ± 1.0	<.002	26.7 ± 5.0	15.8±1.1
M 03	26.8 ±2.7	<.01	16.5 ± 0.8	<.01	26.5 ± 3.8	16.1±1.2
M 12	26.0 ± 2.1	<.002	16.5 ± 0.7	<.01	26.3±4.1	16.4±1.1

Table 1: Medullary and cortical R2* of the remaining and transplanted kidneys.