Diffusion-weighted MRI in the kidney pre- and post-transplantation in donor-recipient pairs

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Introduction

After kidney transplantation, patients are monitored closely since early detection of renal dysfunction is important in prolonging the life of an allograft. Water diffusion measured with MR diffusion weighted imaging (DWI) has been suggested as a means of studying tissue microstructure changes and can potentially be estimated using the apparent diffusion coefficient (ADC) [1,2]. Previous studies have shown a difference between cortex and medulla ADC, and demonstrated changes in the cortical-medullary ADC ratio in transplanted kidneys [2]. Using donor-recipient pairs, this study aims to understand the normal response of water diffusion in kidneys undergoing transplantation compared to the remaining donor kidney.

Methods

To date in this study (IRB-approved; HIPAA compliant), transplants from 15 donor/ recipient pairs and the remaining native kidney from 14 donors have been imaged, after consent, one day prior to transplantation and at 3-months follow-up; 3 donors and 4 recipients have been imaged at 12-months. A conventional spin echo EPI DWI (b=0, 500s/mm^2) sequence was used (1.5T Signa HDxt, GE Healthcare, Milwaukee WI) with an 8-channel cardiac coil, during a 24s breathhold. (Other parameters: TR/TE/BW = 1800ms/72ms/±250kHz; FOV/Matrix/Sl.Thickness/Spacing = 34-40cm/200x160/8mm/2mm; 3 NEX; 3 obl. coronal slices.) ROI's were drawn in the cortex and medulla of each kidney (nominally six 50-100mm^2 ROI's in each region), with mono-exponential fitting used to estimate ADC.

Fig 1 Example ADC maps for a kidney (a) at baseline (i.e. in the donor subject pre-transplantation); and in the recipient at (b) 3 months and (c) 12 months. T1w & T2*-w (d) images helped guide ROI placement.
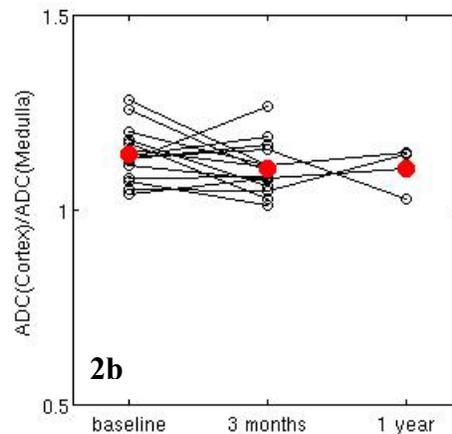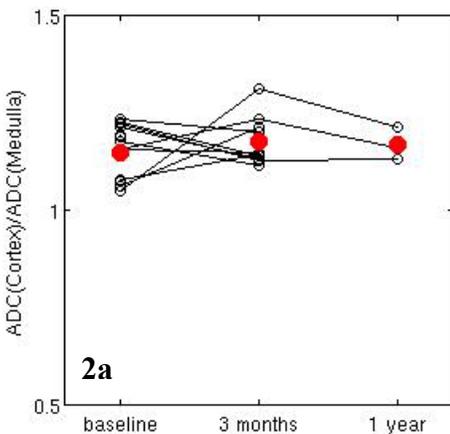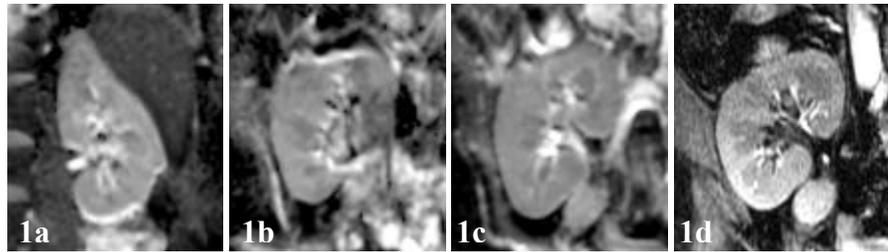
◄ **Fig 2** Cortex/medulla ADC ratio for (a) remaining donor and (b) transplanted kidneys at baseline, 3 & 12 months.

▼ **Table 1** Measured cortex (C) and medulla (M) ADC at baseline and 3 mo.

ADC (x10^{-3} mm^2/s)	Baseline	3 months
ADC$_{C,Donor}$	2.16±0.24	2.33±0.18
ADC$_{M,Donor}$	1.89±0.28	1.99±0.23
ADC$_{C,Recipient}$	2.11±0.17	2.06±0.27
ADC$_{M,Recipient}$	1.85±0.20	1.87±0.30

Results

Three months post-transplant, there was little change in mean ADC values in the cortex (ADC$_C$) and medulla (ADC$_M$) in both transplanted (Recipient) and remaining donor kidneys (Table 1). Moreover, cortex and medulla ADC differentiation did appear to be maintained in this study at 3 months as shown in Figure 2.

Discussion and Conclusion

Similar to previous studies of native kidneys, ADC$_M$ was lower than ADC$_C$ for pre-transplantation kidneys and this difference was maintained at 3 months for both the remaining donor kidney and the transplanted kidney. The number of subjects at 12-months post-transplantation is currently limited; in the future, imaging will also be performed at 12 and 24 months post-transplantation.

Mono-exponential DWI as used here has limitations in the body, particularly in the kidneys which have a large fast decay component due to perfusion and other flow effects [2, 3]. Reproducibility with this DWI sequence has been previously demonstrated [4], and combined imaging with BOLD [5] and perfusion imaging [6] might shed light on post-transplantation tissue changes.

References [1] Muller MF, *et al., Radiology* **193:**711–15 (1994). [2] Thoeny HC *et al, Radiology* **241:** 812-21 (2006). [3] Zhang JL, *et al, Radiology* **254**: 783-92 (2010). [4] Garrett RL, *et al. Proc. 17th ISMRM* (2009). [5] Sadowski EA, *et al. Radiology* **236:** 911-19 (2005). [6] Artz N, *et al. Magn Reson Imag*, in press (2010).