LONGITUDINAL EVALUATION OF RENAL OXYGENATION IN KIDNEY DONORS AND RECIPIENTS USING BOLD MRI

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Introduction: Routine monitoring of transplanted kidneys is important for early detection of dysfunction. Renal allograft function is most commonly assessed by measuring serum creatinine; however, this method has limitations, as changes in serum creatinine occur late in chronic disease processes [1]. BOLD MRI is sensitive to tissue oxygenation and may provide a noninvasive means of assessing functional changes within renal allografts. This technique has been shown to detect changes in oxygenation during acute rejection and acute tubular necrosis [2]. One pilot study of two donor-recipient pairs used BOLD MRI to show changes in medullary oxygenation one month following transplantation [3]; however, longer term longitudinal studies are currently lacking. Here we present renal oxygenation measurements for donor-recipient pairs up to one year post-transplantation in an ongoing longitudinal study.

Methods: This study is HIPAA compliant and IRB approved. Nine kidney transplant recipients and their donors were included. BOLD MRI examinations were performed on the donor prior to surgery (baseline) and on both donor and recipient at 3 months and 1 year post-surgery. Each exam consisted of 5 coronal slices acquired on a 1.5-T General Electric Signa HDx scanner with an 8-channel phased array cardiac coil. A T_2*-weighted multi-gradient-recalled echo sequence was used (16 echoes, TR/TE = 87ms/7-41.8ms, flip angle = 40°, BW = 62.5 kHz, and FOV = 32-34cm; 16-second breath-hold per slice).

R_2* maps were calculated by fitting a decaying exponential equation to T_2*-weighted images at 16 echo times (**Figure 1**). Cortex and medulla were identified using the T_2*-weighted images and five regions of interest (ROIs) were drawn in each tissue type. These ROIs served as a mask for the R_2* map, and the mean R_2* across all ROIs was calculated.

A Wilcoxon signed-rank test was used to evaluate statistical changes in cortical and medullary R_2* between baseline and 3 months. The 1-year R_2* values were not statistically evaluated due to the small number of data available at the time of submission.

Results and Discussion: R_2* values for each subject at baseline, 3 months, and 1 year are presented in **Figure 2**. Mean values at each time point are reported in **Table 1**. Medullary R_2* decreased by 11% in the transplanted kidney between baseline and 3 months ($p = 0.0098$), indicating increased oxygen availability within this tissue and corroborating previous results [3]. This may reflect decreased tubular metabolism. No changes in R_2* were observed after 3 months in the donors' remaining kidneys or in the cortex of the transplanted kidneys.

In the few data presently available at 1 year, medullary R_2* in transplanted kidneys trends toward baseline values. More data will be acquired in this ongoing study to further assess changes at 1 and 2 years post-transplantation.

Conclusions: An increase in oxygenation was observed in the medulla of transplanted kidneys after three months, suggesting metabolic or hemodynamic changes in this tissue. It is not yet clear whether this is a transient or long-term adaptation, but this will be clarified as more patients return for 1-year BOLD MRI exams. Ultimately this study will contribute to a greater understanding of changes in renal function associated with transplantation.

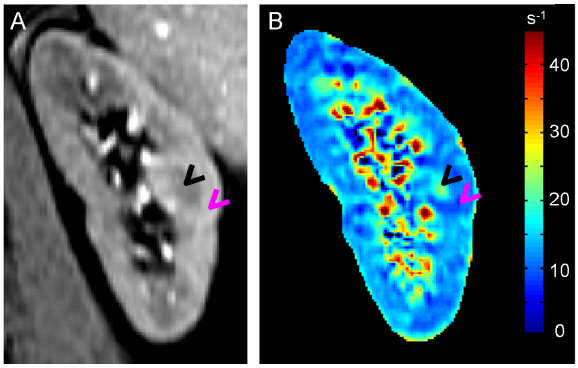

Figure 1. (A) T_2*-weighted image of the kidney showing contrast between the medulla (black chevron) and the cortex (pink chevron). (B) Corresponding R_2* map. Relatively high (green) and low (blue) R_2* values correspond with locations of the medulla and cortex, respectively, in the T_2*-weighted image. Very high R_2* values (red) are attributed to blood vessels.

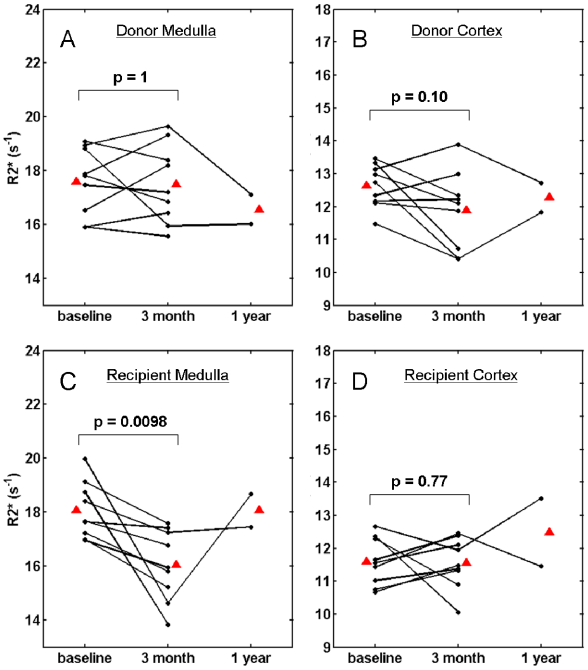

Figure 2. R_2* values for the medulla (A) and cortex (B) of the donor's remaining kidney and the medulla (C) and cortex (D) of the transplanted kidney at baseline, 3 months, and 1 year. Red triangles indicate the mean R_2* values at each time point.

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References:
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Table 1. Mean R_2* values in s^{-1}. Standard deviations are given in parentheses.

		Baseline	3 months	1 year
Donor's remaining kidney	Medulla	17.6 (1.25)	17.5 (1.46)	16.6 (0.77)
	Cortex	12.6 (0.66)	11.9 (1.18)	12.3 (0.64)
Transplanted kidney	Medulla	18.1 (1.05)	16.1 (1.32)	18.1 (0.86)
	Cortex	11.6 (0.72)	11.6 (0.77)	12.5 (1.46)