Evaluation of normal and dysfunctional renal transplants using DTI

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Introduction: Recently, diffusion weighted imaging (DWI) has been proposed as a useful method for evaluating renal allograft. Studies have demonstrated decrease in cortical and medullary diffusion parameters in functioning renal allografts compared to native kidneys (1). One study showed decrease in cortical diffusion parameters and decreased corticomedullary differentiation in functioning human allografts. There was further decrease in cortical apparent diffusion coefficient (ADC) and corticomedullary ADC contrast with worsening renal function (2). These ADC changes may reflect changes in glomerular filtration rate (GFR) but do not necessarily allow differentiation between causes of allograft dysfunction. In patients with acute cellular rejection studies have shown inflammatory process in both the cortex and the medulla, with higher intensity changes in the cortex. Medullary inflammatory changes, however, had near 100% specificity in diagnosis of acute cellular rejection (3, 4). Tubular structure and function may be investigated non-invasively using diffusion tensor imaging (DTI) (5, 6) with fractional anisotropy (FA) measures reflecting tubular structural integrity/function. We hypothesize that measuring FA may allow differentiation of dysfunctional transplants from normal allografts and also discrimination of patients with rejection from other causes of allograft dysfunction.

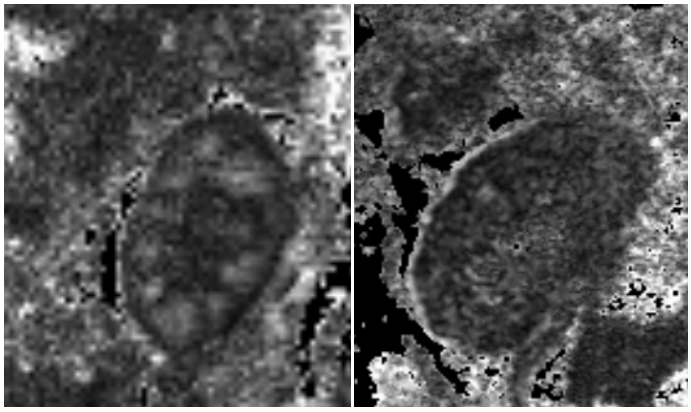

Figure 1: Fractional anisotropy (FA) maps for a (left) normal transplant (medulla FA = 0.38), and (right) a dysfunctional transplant with rejection (medulla FA = 0.24).

Methods: In this IRB approved HIPAA compliant prospective study, 6 patients with renal allograft (4M, 2F; mean age 48 years) underwent free breathing DTI imaging at 1.5T (Avanto, Siemens Medical Systems, Erlangen, Germany). 3 patients had normal allograft function (GFR 78) and 3 patients had transplant dysfunction (GFR 25). 2 patients were diagnosed with acute T-cell mediated rejection and 1 patient was diagnosed with mild acute tubular injury (ATI) without evidence for rejection at renal biopsy. Imaging parameters were as follows: TR/TE 1000/80 msec, 16 averages, 6 coronal slices, 2 x 2 x 6 mm resolution, 6 directions with b=0 and 500 s/mm$^{2.}$ Acquisition time for the study was 2-3 min. Averaging was performed at the scanner workstation and MD and FA maps were generated by standard DTI software (Siemens Syngo VB15). Regions of interest (ROIs) were placed over the cortex and medulla in the upper, middle, and lower poles of kidneys on the b0 images and copied to FA and MD maps for each patient. FA and MD values were compared between patients with healthy renal transplants and patients with transplant dysfunction.

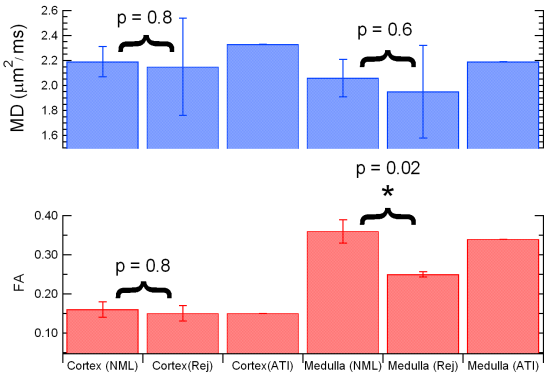

Figure 2: Group average MD and FA values for normal transplant (NML) and transplant rejection patients (Rej) and acute tubular injury (ATI).

Results: As shown in Figure 1, normal transplant demonstrates higher medullary FA than the patient with rejection, which has significantly lower medullary FA and little corticomedullary differentiation. Both acute rejection allografts have significantly lower medullary FA compared to normal and non-rejection transplant dysfunction (Figure 2). There was no significant difference in either cortical FA between normal and abnormal transplants or in MD between the rejection and normal transplants group ($p>0.5$).

Discussion: Inflammatory changes in the renal medulla due to acute rejection result in disruption of tubular structure and function and this may be reflected as a decrease in medullary fractional anisotropy, perhaps due to a larger intertubular space. This study suggests that medullary FA may be a sensitive marker of renal dysfunction and may discriminate acute allograft rejection from other causes of transplant dysfunction. Further studies are warranted to explore role of DTI in evaluation of renal allograft dysfunction.

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