

Assessment of renal allograft function early after transplantation with diffusion tensor imaging

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Target audience: Kidney transplant surgeons and abdominal radiologists.

Purpose: Early allograft function is strongly correlated with long-term graft survival for transplant recipients. With advances of MR technology, DTI and tractography have been successfully applied in kidney and show high potential in detecting changes of renal function and microstructure in patients with chronic renal diseases¹ and diabetic nephropathy². This study was designed to investigate the feasibility of diffusion tensor imaging (DTI) and tractography in assessing the function of renal allografts at the early stage after kidney transplantation.

Methods: 51 renal allograft recipients 2-3 weeks after transplantation and 26 age-matched healthy volunteers were involved and examined using a fat-saturated echo-planar DTI sequence at 3T (Magnetom Trio Tim, Siemens AG, Erlangen, Germany; TR/TE=4600/103 ms, diffusion directions=6, $b=0$ and 300s/mm^2 , 6 averages, with respiratory triggering). Patients were divided into three groups according to the estimated glomerular filtration rate (eGFR): good and stable allograft function ($\text{eGFR} \geq 60 \text{ ml/min/1.73m}^2$, $n=24$); moderately impaired allograft function ($30 \leq \text{eGFR} < 60 \text{ ml/min/1.73m}^2$, $n=19$); severely impaired allograft function ($\text{eGFR} \leq 30 \text{ ml/min/1.73m}^2$, $n=8$). Apparent diffusion coefficient (ADC) and fractional anisotropy (FA) values were measured separately for cortex and medulla. ADC and FA between groups were compared by using the one-way analysis of variance test and the Bonferroni post-test. Pearson correlation coefficients were calculated to analyze the relationship between eGFR and ADC, FA of renal allografts. Whole-kidney DTI tractography was performed using the Diffusion toolkit software package with FA threshold of 0.10 and angle threshold of 60 degrees³.

Results and Discussion: Mean cortical ADC was higher than medullary ADC in the healthy group ($p<0.001$), lower in the group with good and stable allograft function ($p<0.05$) and no differences in the groups with moderately and severely impaired allograft function ($p=0.53, 0.36$, respectively). Mean cortical FA in the healthy group was higher than in the other three groups ($p<0.001$ for all), but there was no differences between the groups of allograft recipients ($p>0.05$ for all). There is a significant positive correlation of eGFR with medullary FA ($r=0.812$, $p < 0.001$), cortical ADC ($r=0.756$, $p < 0.001$) and medullary ADC ($r=0.757$, $P < 0.001$) (Fig.1). Compared to the healthy group and good allograft function group, the cortical-medullary discrimination decreased obviously in the groups with moderately and severely allograft function. Whole-kidney DTI tractography also showed that the number and density of tracks severely reduced in kidneys of moderately and severely allograft function (Fig.2 and 3).

Conclusion: DTI is a promising way to noninvasively assess renal allograft function at the early stage after transplantation, and quantitatively and visually distinguishes transplants with different degrees of function.

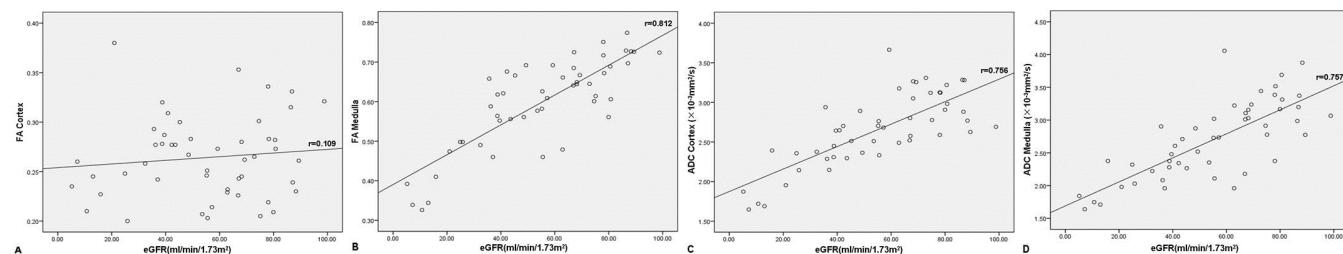


Fig.1 Correlation between cortical FA (A), medullary FA (B), cortical ADC (C) and medullary ADC (D) with eGFR of renal allograft recipients.

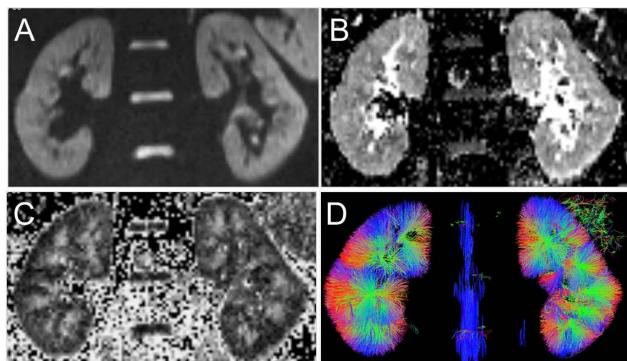


Fig.2 B0 (A), ADC (B) and FA (C) maps, and whole-kidney DTI tractography (D) of healthy subject.

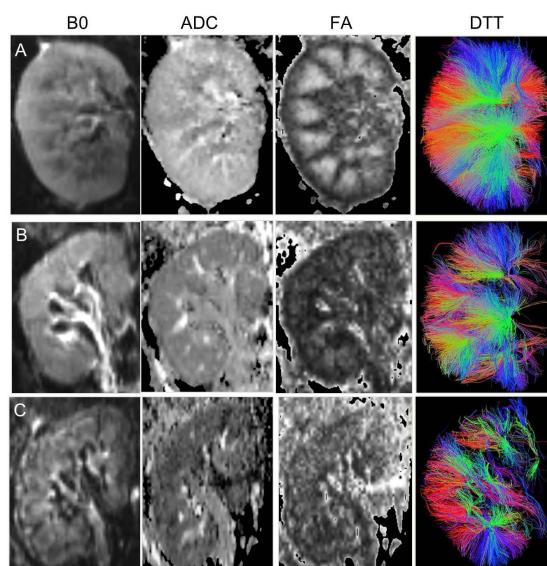


Fig.3 DTI images of an allografts with good function (A, $\text{eGFR} \geq 60 \text{ ml/min/1.73m}^2$), moderately impaired function (B, $30 \leq \text{eGFR} < 60 \text{ ml/min/1.73m}^2$) and severely impaired function (eGFR $\leq 30 \text{ ml/min/1.73m}^2$).

[1] Gaudiano C, et al. Eur Radiol. 23(6):1678-85 2013. [2]. Lu L, et al. Am J Nephrol. 34(5):476-82 2011. [3]. Wang R, et al. Proc Int'l Soc Mag Reson Med. 40:476-82 2011.