Case Report: Assessment of Renal Allograft Function with DTI and Tractography

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Introduction

Kidney transplantation is the therapy of choice for patients with end-stage chronic kidney disease. In our hospital, there are about 150 cases of renal transplantation each year. Intense monitoring of renal allograft after surgery is crucial to identify renal allograft's dysfunction at an early stage and thus to carry out appropriate treatment to prevent serious adverse effects.

Functional imaging with magnetic resonance imaging (MRI) is a fast-growing field in clinical application, which aims at characterizing function parameters and changes. Diffusion tensor imaging (DTI) provides diffusion measurements in at least six directions. Information obtained from DTI contains not only the amount of diffusion but also the anisotropy of diffusion, which is quantified by the fractional anisotropy (FA), ranging from 0 (no preferred diffusion direction, isotropic diffusion) to 1 (only one diffusion direction, completely anisotropic diffusion). In recent years, DTI has been used in assessing renal damage of chronic parenchymal diseases and diabetic nephropathy [1-3]. Here we used DTI and tractography in assessing the function of renal allograft at an early stage after transplantation.

Patient history

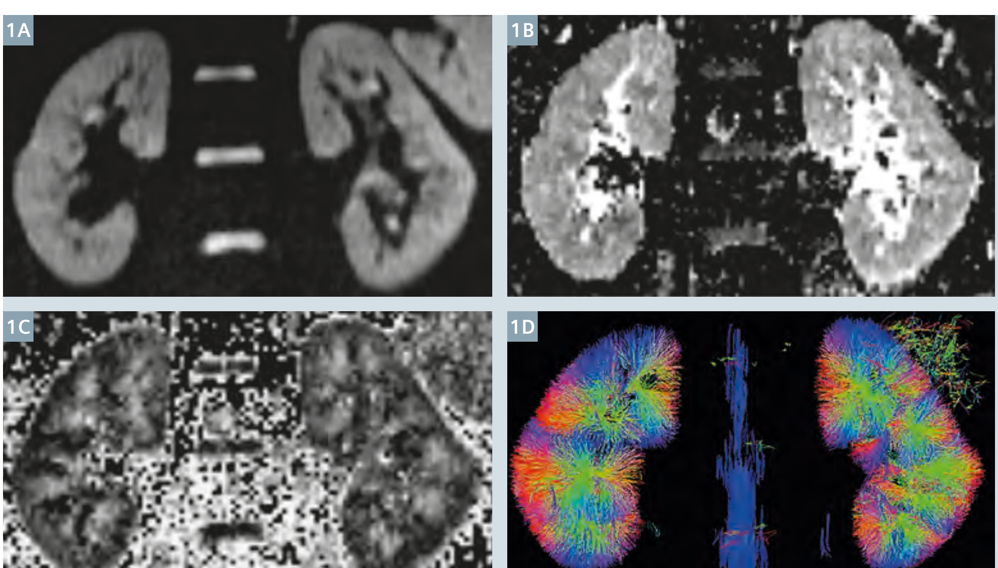
Three kidney-transplanted recipients and a healthy volunteer were examined to investigate the feasibility of DTI in assessing the function of allograft during the early post-transplantation period. Serum creatinine concentrations were obtained on the same day as the MRI examination and used to calculate estimated glomerular filtration rate (eGFR) by utilizing the modification of diet in renal disease formula.

Subject 1 (25-year-old, female) is a healthy volunteer without any history of renal disease, hypertension, diabetes or other vascular diseases.

Subject 2 (31-year-old, male, 14 days after kidney transplantation, eGFR = 93.5 ml/min / 1.73 m^2) is a recipient with good function (eGFR $\geq$ 60 ml/min / 1.73 m^2).

Subject 3 (24-year-old, female, 20 days after kidney transplantation, eGFR = 53.6 ml/min / 1.73 m^2) is a recipient with moderately impaired allograft function (30 $\leq$ eGFR < 60 ml/min / 1.73 m^2).

Subject 4 (28-year-old, female, 17 days after kidney transplantation, eGFR = 7.23 ml/min / 1.73 m^2) is a recipient with severely impaired allograft function (eGFR < 30 ml/min / 1.73 m^2).



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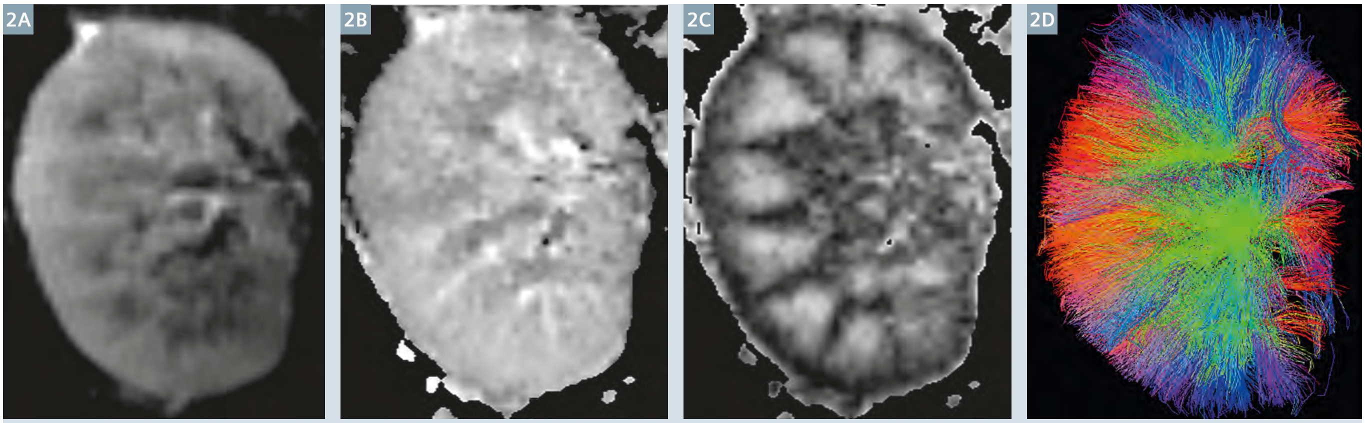
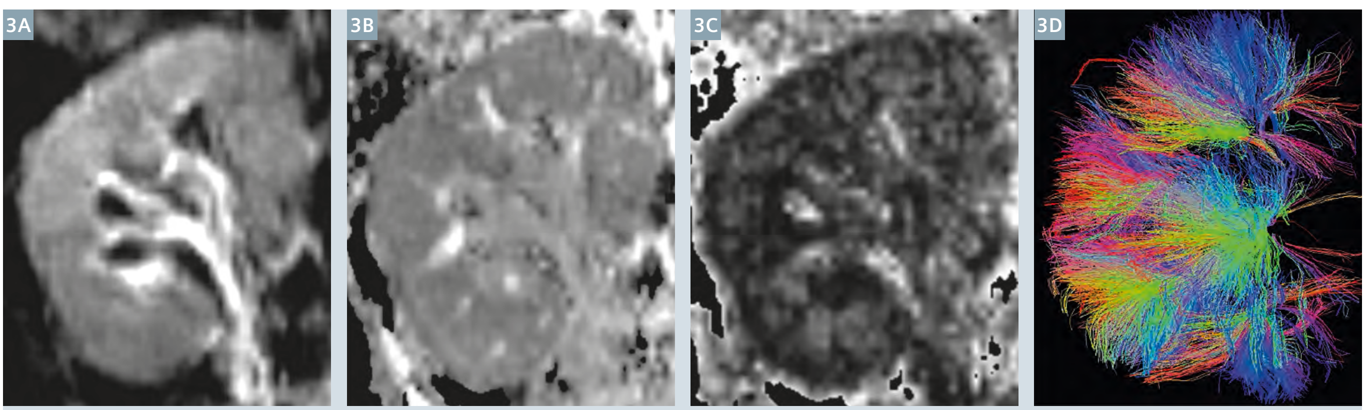
Healthy volunteer (25-year-old female) without any history of renal disease, hypertension, diabetes or other vascular diseases.



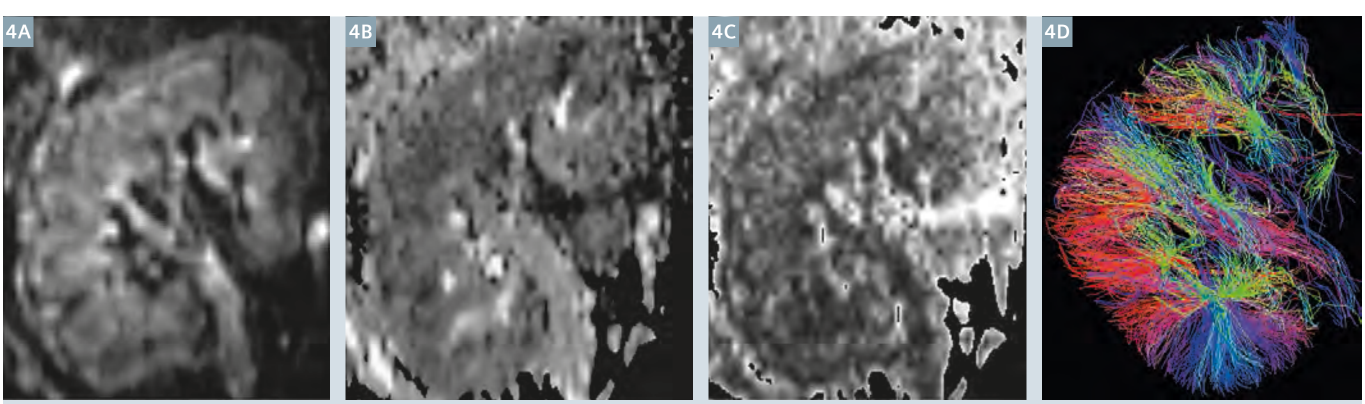
b0-map | ADC-map | FA-map | Tractography

2 Recipient with good allograft function, 31-year-old male, 14 days after kidney transplantation, eGFR = 93.5 ml/min / 1.73 m^2.



b0-map | ADC-map | FA-map | Tractography

3 Recipient with moderately impaired allograft function, 24-year-old female, 20 days after kidney transplantation, eGFR = 53.6 ml/min / 1.73 m^2.



b0-map | ADC-map | FA-map | Tractography

4 Recipient with severely impaired allograft function, 28-year-old female, 17 days after kidney transplantation, eGFR = 7.23 ml/min / 1.73 m^2.

Sequence details

MR imaging of the kidney was performed at 3T (MAGNETOM Trio a Tim System, Siemens Healthcare, Erlangen, Germany) with a 32-element surface coil and with the spine coil integrated into the table.

In all subjects, axial breath-hold turbo spin-echo T1-weighted images and coronal fat-saturated single-shot spin-echo T2-weighted images were obtained for morphological analysis. DTI images were acquired with a fat-saturated oblique-coronal multi-section echo-planar imaging sequence with the following parameters: 6 diffusion directions, b-values 0 and 300 s/mm², TR 1800 ms, TE 103 ms, 9 averages, 30 slices at a slice thickness of 1.8 mm with no intersection gap, FOV 230 × 230 mm², matrix 128 × 128, voxel size 1.8 × 1.8 × 1.8 mm³, parallel imaging acceleration factor 2. To weaken the impact of respiratory motion, respiratory-triggered technique was conducted in the healthy volunteer. For the renal allograft recipients, the respiratory-triggered technique was not applied because respiratory motion was negligible in the transplanted kidney owing to their location in the iliac fossa.

The Neuro 3D software (MAGNETOM Trio a Tim System, Siemens Healthcare, Erlangen, Germany) was used for DTI data analysis.

A 3D whole-kidney tractography was created by using Diffusion Toolkit software package (http://trackvis.org/) with an FA threshold of 0.1 and angle threshold of 60°.

Imaging findings

For the healthy volunteer, FA-map demonstrates perfect cortical-medullary discrimination with much higher signal of the medulla, while the signal of the cortex is much higher in ADC-map. Tractography illustrates numerous tracts with a distinct radial arrangement and closely convergence into pyramids, matching the anatomical arrangement of the renal parenchyma (Fig. 1).

For the allograft with good function, manifestations of FA-map and tractography are nearly identical to the healthy kidney. ADC-map shows unclear cortical-medullary differentiation with slightly higher signals of both the cortex and the medulla compared to the healthy kidney (Fig. 2).

For the allograft with moderately impaired function, signals of ADC-map and FA-map apparently decrease with poorly cortical-medullary discrimination. Meanwhile, the number and density of radial tracts also decrease with partly loose arrangement in tractography (Fig. 3).

For the allograft with severely impaired function, ADC-map and FA-map both show significantly lower signals with much worse cortical-medullary discrimination compared to the healthy kidney and allograft with good function. In tractography, the radial tracts arrange more loosely with many hallow spaces compared to the other three cases, especially in the upper pole (Fig. 4).

Conclusion

As these cases demonstrate, DTI and tractography is a promising way to quantitatively and visually assess renal allograft function after kidney transplantation.

References

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