

Reproducibility of diffusion weighted imaging at 1.5T and 3T over a range of eGFR in native and transplant kidneys

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Introduction:

Diffusion weighted MR imaging (DWI) is a useful tool for studying various renal disease processes at 1.5T¹⁻⁴. Previous studies have demonstrated the reproducibility of DWI measurements in normally functioning native kidneys^{2,3} and renal transplants⁴ at 1.5T, however the potential benefits gained from 3T diffusion imaging have not been tested. Establishment of reproducible results at 3T is important prior to future investigation of renal function with DWI at this magnet strength. The purpose of our study is to establish reproducibility of ADC measurements in normal and diminished function native and transplant kidneys at 1.5 and 3T.

Methods:

This study was approved by our human subjects committee and is HIPPA compliant. DWI was performed on 22 patients, 11 with renal transplants and 11 with native kidneys over a range of estimated glomerular filtration rates (eGFR). Each patient was scanned four separate times at 1.5T and twice at 3T. Scans were performed on a 1.5T system (GE Excite II, Waukesha, WI) and 3T system (GE Signa® Excite HD, Waukesha, WI). The same MRI parameters were used for both the 1.5T and 3T scans. Three coronal slices per kidney were obtained using a single breath hold diffusion-weighted echoplanar sequence (b0,500, TE 1800, TR 73, 8mm slice, 2mm gap, NEX=3, Freq 200, Phase 160, gradient strength 40mT/m). Diffusion images and color ADC maps were analyzed using Functool® on the Advantage workstation (GE Healthcare). A minimum of 3 cortical ROIs and 6 medullary ROIs were recorded for each kidney and averaged. A coefficient of variation (CV) analysis was performed for each patient using the mean cortical and medullary ADC values for all 4 scans at 1.5T and both scans at 3T using the formula: CV = standard deviation ADC/average ADC.

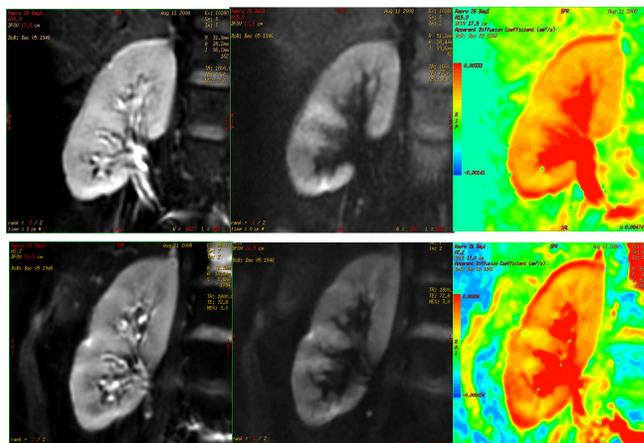


Figure 1: DWI at 1.5T (top) and 3T (bottom) in the same normally functioning renal transplant. From left to right: b0, b500, and color ADC maps.

Results:

At 1.5T, all native kidney patients received four scans, with the exception of one patient who only had two scans because of a scheduling conflict. In the transplant patient group at 1.5T, all patients received four scans, with the exception of two patients who received two scans due to a scheduling conflict and three patients who only had usable data from two scans due to artifact (either motion or susceptibility artifact). At 3T, all native kidney patients received two scans with the exception of two patients who had only been scanned on one day. All transplant patients had two scans at 3T with the exception of two patients who only had been scanned a single time. The range of eGFR for the native and transplant kidney groups were 19-102 ml/min/1.73m² and 21-74 ml/min/1.73m², respectively. Representative b0, b500, and ADC maps from the same normally functioning renal transplant patient at 1.5T and 3T are shown in **Figure 1**. While corticomedullary differentiation was generally subjectively improved at 3T, ADC value determination was considerably more difficult in a number of patients than at 1.5T due to increased susceptibility and motion artifact. Mean ADC value variability was low in both groups at 1.5T and 3T, with all mean CV measurements at or below 5% (**Table 1**). The range of CV measurements for each group is also provided.

| | ADC Coefficient of Variation (%) | | | |
|---------------------------|----------------------------------|---------------------|----------------|----------------|
| | 1.5T | | 3T | |
| | Medulla | Cortex | Medulla | Cortex |
| Native Kidneys | 2.6% (1.3%-7.4%) | 4.0% (1.0%-4.3%) | 4% (3%-6%) | 4% (2%-10%) |
| Transplant Kidneys | 4.2% (0.6%-10.5%) | 3.7% (0.3%-7.1%) | 4% (1%-14%) | 5% (1%-10%) |

Table 1: Average coefficient of variation (%) for either the cortex or medulla of each group (top number) at 1.5 T and 3 T and range of CV values obtained for each group (bottom numbers in parenthesis).

Conclusion: Diffusion weighted imaging is reproducible at both 1.5T and 3T over a range of eGFR in both native and transplant kidneys. Renal DWI is challenging at both 1.5T and 3T due to a variety of factors, including bulk motion and susceptibility artifact from adjacent bowel. While 3.0T offers improved signal to noise, which has the advantage of improved corticomedullary differentiation, in our experience the images obtained at 3T are more prone to artifact, making it less robust than DWI at 1.5T. Further advancements in DWI at 3T may improve the robustness of this technique, thereby enhancing the noninvasive evaluation of renal function.

References:

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