

Assessing Native and Transplant Kidneys with Diffusion Weighted MR Imaging: Mean vs Delta ADC

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Introduction:

A variety of renal cortical and medullary average diffusion coefficient (ADC) values have been reported using diffusion weighted imaging (DWI)^{1,2}. Two studies have demonstrated decreased ADC in native kidneys with diminished function compared with normally functioning kidneys^{3,4}. The purpose of our study is to evaluate the mean cortical and medullary ADC values in both native and transplant kidneys with normal function versus diminished function, and determine the utility of using the corticomedullary ADC difference (delta ADC) to differentiate between these groups.

Material and Methods:

This study was approved by our human subjects committee and is HIPPA compliant. DWI was performed on 22 patients, 11 with renal transplants (7 with normal function, 4 with diminished function) and 11 with native kidneys (8 with normal function, 3 with diminished function). Normal renal function in native kidneys was defined as eGFR >60 mL/min/1.73m². Normal renal function in the transplant group was defined as an eGFR >50 mL/min/1.73m² and no change in the subject's eGFR since transplantation. A lower eGFR was chosen for the transplant group, as subjects with transplanted kidneys have a single kidney and therefore their eGFRs are expected to be lower. Each patient was scanned twice a day on two separate days for a total of 4 scans. Scans were performed on a 1.5T system (GE Excite II, Waukesha, WI). 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 on a separate workstation 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. The ADC values for all 4 scans were then averaged to produce a single mean cortical and medullary value per patient. The difference between the cortical ADC and medullary ADC (delta ADC) was calculated as: delta ADC = cortical ADC – medullary ADC. Statistical analysis of the mean cortical, medullary, and delta ADC values was performed using the two-sample t-test, between each group.

Results:

All patients had four DWI scans each, with the exception of one diminished function native patient, two normal transplant patients, and three diminished function transplant patients who had only 2 scans each. The mean and delta ADC values are displayed in the figures below. For all groups, the medulla demonstrates lower mean ADC values than the cortex (Table 1); however only the normal native group (p<0.005) and the normal transplant group (p=0.03) were statistically significant. There is a significant difference in the mean cortical ADC values of the normal ($2.68 \times 10^{-3} \text{ mm}^2/\text{sec}$) and diminished function ($2.23 \times 10^{-3} \text{ mm}^2/\text{sec}$) native kidney groups (p<0.001). No other significant relationship was identified between any of these groups with respect to either the mean medullary or mean cortical ADC values. In the delta ADC data set (Table 2), the mean delta ADC values for diminished function kidneys were lower than for normally functioning kidneys, however, significance was reached between only the normal native and diminished function native groups (p=0.017).

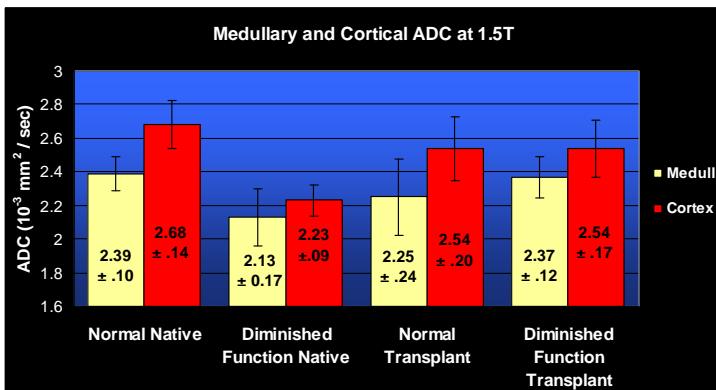


Table 1: Mean medullary ADC: No significant difference between groups.

Mean cortical ADC: Significant difference between normal and diminished function natives (p<0.001).

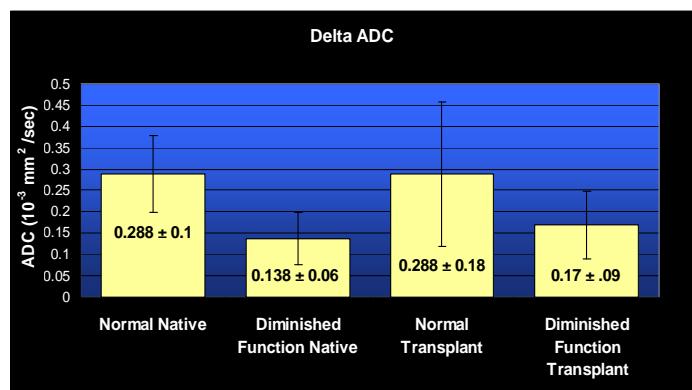


Table 2: Delta ADC in normal natives vs diminished function natives is significant (p=0.017). Delta ADC in normal transplants vs diminished function transplants is not significant (p=0.19).

Conclusions:

There was no significant difference between the mean medullary ADC values of any group, however, a significant difference was noted between the mean cortical ADC values of the normal and diminished functioning native kidneys. This confirms the findings of other studies^{3,4} in which restricted diffusion was noted in native kidneys with diminished function compared with normal native kidneys, likely related to restriction of free water due to fibrosis. While a decrease in delta ADC was noted between the normal and diminished functioning natives and normal and diminished functioning transplants, a statistically significant decrease was present only in the native kidneys. To our knowledge, the delta ADC value has not been previously utilized to differentiate kidneys with diminished function from those with normal function. While larger studies are needed to validate this method, delta ADC may be another tool, along with mean ADC values, to detect renal disease noninvasively.

References:

1. Chow et al. JMRI. 2003; 18:377-382.
2. Thoeny et al. Radiology 2006; 241(3): 812-821.
3. Fukuda et al. JMRI 2001;11:156-160.
4. Thoeny et al. Radiology 2005; 235:911-917.