Determination of Technically and Physiologically caused Variation of Parameters from DTI and BOLD MRI in Native Kidneys: A Repeatability Study

Maryam Seif[1], Chris Boesch[1], and Peter Vermathen[1]
[1]*Depts. Radiology and Clinical Research, University Bern, Bern, Switzerland*

Background: DTI holds promise to noninvasively assess renal function and provides information on diffusion and potentially micro-perfusion properties with additional structural information[1,2]. BOLD MRI is a technique to measure intra-renal oxygenation[3,4]. DTI and BOLD techniques have gained acceptance to evaluate different physiological aspects of renal function[2,3]. However, a detailed analysis of the technically and physiologically determined reproducibility of the derived parameters, especially of the perfusion fraction from DTI, has not been performed, yet.
Purpose: to evaluate the reproducibility of DTI and BOLD MRI parameters in native kidneys from three scans. A secondary aim was to investigate whether renal oxygenation from BOLD MRI is correlated with diffusion parameters.

Methods: DTI and BOLD MRI were performed in 15 healthy subjects (28.7 ± 6.3 years) using a 3T scanner (Siemens, Trio). Subjects underwent the same protocol three times: Two scans were performed back-to-back with one hour break in between, followed by the third scan after three weeks. Subjects were asked to eat and drink moderately before and between two scans. A DW single shot echo-planar measurement was performed using respiration triggering with ten different b-values (0-700 s/mm^2) in 6 non-collinear directions (acq.=2, TR_{min}=3300ms, TE=56ms, slice thickn.=5mm, Matrix=192×192, FOV=300×300mm^2). ADC, fractional anisotropy (FA) and perfusion fraction (F_P) were calculated using an in-house developed program[4]. BOLD MRI was performed within a single breath-hold of 17 sec. per slice for a total of 3 coronal slices. Twelve echo times (6-52.3msec) were acquired (TR=65msec, Flip Angle=30^0, BW= 330Hz/px, FOV=400×400mm^2, Matrix=256×256, slice thickn.=5mm). R2* values were determined in cortex and medulla. To assess reproducibility, coefficients of variations within (CV_w) and between (CV_b) subjects were calculated using the square root of the residual mean square and are presented in percent of the mean. Correlations were assessed using Pearson linear regression.

Results: All 15 subjects were included in the analysis. The coefficients of variation within and between subjects for the three scans are presented in Table 1. For BOLD imaging very low CV_w and CV_b were obtained. CV_w and CV_b for ADCs in cortex and medulla were less than 4.1% and 5.5% respectively. The coefficients of variation were higher for FA (<14%) and for F_P, especially in the medulla. The variation within subjects was clearly smaller than between subjects for most parameters. The variation of parameters between the two back-to-back scans was similar to the variance between the scans separated by 3 weeks. Figure 1 shows that for all parameters the values of the third scan are close to those obtained in the first two back-to-back scans, i.e. the values are close to the identity line in medulla and cortex. R2* and ADC values in cortex and medulla of initial scans were significantly correlated (R=-0.58, P<0.03 & R=-0.59, P<0.03, respectively).

Table 1: *CV_w and CV_b for diffusion and BOLD parameters calculated from all three scans. (Data are given in percent of the mean value)*

	ADC		F_P		FA		R2*	
	Medulla	Cortex	Medulla	Cortex	Medulla	Cortex	Medulla	Cortex
CV_w	4.1%	4%	27.6%	16.5%	10.4%	12.4%	4.8%	3.9%
CV_b	5.5%	5.4%	34.8%	21%	13.4%	13.3%	7.3%	5%

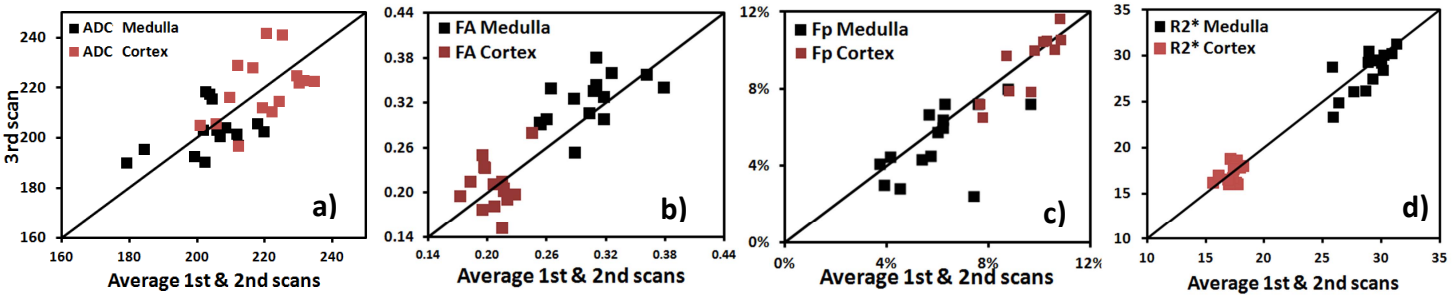

Fig. 1: *DTI and BOLD parameters of the average 1st and 2nd measurements (back-to-back scans) vs. the 3rd measurement (after 3 weeks) in medulla and cortex. a) ADC, b) FA, c) F_P, d) R2*. The values were mostly close to the identity line for individual subjects.*

Discussion & Conclusion: High reproducibility was obtained for ADC, FA, and R2* from DTI and BOLD measurements in kidneys of healthy volunteers for both, back-to-back measurements and measurements separated by 3 weeks. F_P showed relatively low variance in cortex, but a high variance in medulla. However the F_P values were still close to the identity line. This high variance for F_P is in concordance with the high variance betweens subjects found in other studies. The coefficients of variation between the scans separated by 3 weeks were similar to those for the back-to-back scans, indicating that the variances are primarily due to technically caused variances between scans rather than normal physiological variation over time. F_P values are lower than reported before[2], which is due to shorter echo times used in the present study, improved signal stability (lower spurious inclusion of signals from other tissue) and slight processing differences.

In conclusion, the results suggest applicability of the methods especially in longitudinal clinical studies and built the basis for power analyses. Despite the correlations between R2* and ADC the results suggest that DTI and BOLD yield complimentary information.

References: ***1.*** *Notohamiprodjo M, et al. Invest Radiol 2008;43:677-685;* ***2****. Sigmund EE, et al. Radiology 2012;263:758-769;* ***3****.Prasad PV, et al. Nephron Clin Pract 2006;103:c58-c6;* ***4****. Thoeny HC, et al. Radiol 2006;241:812-821.*

Acknowledgement: This work was supported by the Swiss National Science Foundation SNF grant #31003A-132935