Impact of Mechanical Vibration During DWI on Diffusion Parameter Estimation in Human Kidneys

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Introduction: DWI leads to patient table vibration that is clearly perceptible by the scanned subjects and that can involve movements of up to 0.5mm [1]. This may affect image quality, as has been demonstrated previously in phantom scans [1] and in brain scans [2]. However, to our knowledge no DWI study has been performed yet, comparing diffusion scans on subjects that are or are not in direct contact with the MR-system, i.e. the patient table. In the course of our efforts to improve the quality of DWI in abdomen, we therefore investigated the impact of mechanical vibration on diffusion parameters. It is well known that in DWI measurements of the abdomen in addition to diffusion, microperfusion contributes to the signal decay (intravoxel incoherent motion, IVIM model [3]). We were especially interested in the impact of vibration on the determination of this fast decaying component, i.e. the "perfusion fraction" (F_P).

Methods: Patient table preparation: The subjects were positioned within a 3T MR scanner (Trio, Siemens, Germany) on a wooden plank that was placed just above the patient table. The plank was once unlocked from the patient table and held by two wooden supports outside the magnet and once kept at the same position but supported by the table, i.e. restoring the table contact. This allowed for performing two scans at virtually identical subject positions once with and once without contact between patient table and subject. The setup permitted the usage of the spine matrix coil in combination with the flexible body matrix coil. Three young healthy subjects were investigated. The subjects clearly sensed the vibration during the scan performed with table contact, while no vibration was perceived for the unlocked scan.

MR Imaging: After morphological imaging, coronal single shot echo-planar DWI was performed. Respiratory (PACE) and pulse double triggering was applied and 10 diffusion gradient b-values (10-700 sec/mm^2) were used. Other parameter were: TR = 1 resp. cycle, TE = 52msec, FOV = 30x30cm^2, 7 slices, slice thickness 5mm, intersection gap 1mm, parallel imaging, 3 averages. The minimal acquisition time for each DWI scan was 5 min. Processing of the DWI data was performed I) by monoexponential fitting yielding a "total" ADC_T, and II) by biexponential fitting separating diffusion and perfusion contributions, yielding ADC_D (mostly determined by diffusion) and the perfusion contribution ("perfusion fraction", F_P). Three ROIs were selected in both, cortex and medulla at the upper and lower pole and at the mid-level for a number of slices covering large parts of the kidney.

Results: Figure 1 shows an example for calculated parameter maps obtained with and without direct contact of the subject with the patient table. The maps and correspondingly also the signal decay with increasing b-values in different ROI appear very similar. The quantitative analysis demonstrated that the fitted parameters, including ADC_D, ADC_T, F_P, and also signal intensities, did not yield substantial differences between scans with and without vibration in any of the three investigated subjects (see Table 1). This result was especially obvious in one subject with outstanding data quality, and nearly identical values in both scans for all determined parameters, e.g. F_P differed only by 0.2% between the two scans in both cortex and medulla.

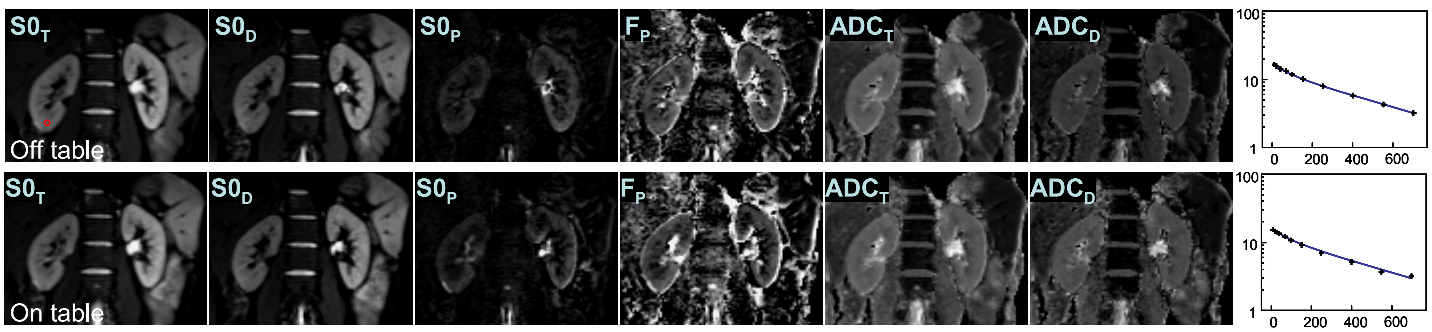

Fig. 1: Comparison of parameter maps obtained with (bottom row) and without (top row) direct contact of the subject with the patient table. The signal decay for one ROI (position indicated on the first image) is also shown. $S0_T$: Fitted total intensity at b=0; $S0_D$: Fitted intensity at b=0 without perfusion component; $S0_P$: Fitted intensity at b=0 without diffusion component; F_P: Perfusion fraction; ADC_T: Totol ADC; ADC_D: ADC mostly determined by diffusion.

Discussion: The results demonstrate that mechanic vibrations in DWI measurements of abdominal organs do not severely deteriorate image quality or affect processed values, including microperfusion contributions. Also the effect on signal intensity is at most only small. However, it should be noted that only b-values of up to 700 sec/mm^2 were applied since application of much higher b-values is not appropriate for DWI in kidney. Phantom measurements have also shown that for this b-value range the mechanical vibrations are acceptable [1]. A limitation of the study is that only DWI, but not diffusion tensor imaging (DTI) was performed. The impact of mechanical vibration on the fractional anisotropy was therefore not investigated.

Mean values		$S0_T$	$S0_D$	$S0_P$	F_P	ADC_T	ADC_D
Med.	off table	159	148	10	8.1	192	183
	on table	163	152	10	6.9	193	188
Cort.	off table	183	167	16	11.0	203	191
	on table	191	175	14	9.0	206	197

Table 1: Comparison of fitted parameters in medulla and cortex for three subjects. See Fig. 1 for abbreviations. F_P (%); ADC_T, ADC_D (x10^{-5}mm^2/s).

References:
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2. Gallichan, et al. Hum. Brain Mapp. 2009; DOI 10.1002/hbm.20856
3. Le Bihan, et al. Radiology 1988;168:497.

Acknowledgment: Supported by SNF 320000-111959.