Impact of Volume-of-Interest limited Registration to DCE-MRI of Human Kidney

Frank G Zöllner[1], Marcel Reich[1], and Lothar R Schad[1]

[1]*Computer Assisted Clinical Medicine, Medical Faculty Mannheim, Heidelberg University, Mannheim, Baden-Württemberg, Germany*

Introduction

Dynamic contrast enhanced imaging of the kidneys using magnetic resonance imaging (DCE-MRI) is a non-invasive method for determining the renal function. The renal blood flow and the glomerular filtration rate of the kidney can be measured using pharmacokinetic models. Major problems therein are motion artifacts due to breathing of the patient preventing a valid determination of the parameters. The kidneys move mainly in head-feet direction, however sometimes not synchronous (Fig. 1). This can lower the effect of motion correction, especially for rigid motion correction approaches. To overcome this effect, each kidney should be aligned separately. In this work, we propose a VOI-limited registration approach and compared rigid and deformable registration of DCE-MRI of kidney.

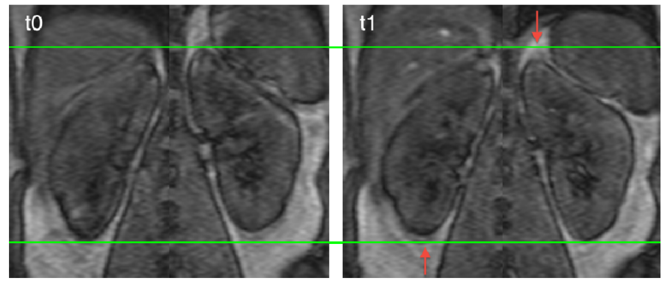

Fig. 1: Example of asynchronous movement of the kidneys. Kidney images are depicted at two time points (t0, t1). While the left kidney moves up, the right one moves down between the two time points. Green lines serve as cross-reference lines.

Materials and Method

Four DCE-MRI data sets were retrospectively analyzed. Briefly, the images were recorded at a 1.5T scanner using a 3D VIBE sequence with temporal resolution of 2.4 s and in-plane resolution of 1.6 x 1.6 mm^2. A total of 22 slice and 100 time points were recorded. Further image acquisition parameters were selected similar to [1, 2].

Image registration was performed using a variational approach allowing for a deformable registration model previously described for DCE-MRI of kidney [2]. We extended this algorithm to allow for VOI-limited analysis and implemented the algorithm as OsiriX plug-in. Rigid body registration was implemented following [3]. To select a VOI, a rectangular ROI encompassing the kidney and partly the spine was manually drawn on one slice of the reference frame (see Fig. 2). The ROI is then automatically propagated to all other slices of the 3D volume. When drawing the ROI a certain security margin should be included to include the moving kidney within the VOI over time.

Motion analysis was performed deriving the distance between the lower pole of the kidney and the bottom of the image for each time point as described in [4]. The variation of this distance from the distance measured in the reference image is considered as an indicator for motion and called 'coronal motion'.

Fig. 2: Checkerboard images of data set 2. Left: VOI-limited deformable registration with parameter settings obtained from [2], right: with optimized parameters.

Results

For three out of four data sets, a reduction of motion could be achieved. Parameter settings of the algorithms were kept the same as in [2] for all experiments. Table 1 and 2 show the results of the two VOI-limited registration approaches compared to the unregistered data sets. For data set 2, we optimized the registration parameters (smoothing kernel 10 mm; correlation limit 0.9; stepping 12) to investigate the low performance of the registration. These results are denoted by 2* in Table 2.

Data set	S_{unreg} [mm]	S_{reg} [mm]	% change
1	2.4	1.1	56
2	1.0	0.3	70
3	4.9	2.0	59
4	19.1	2.5	87

Table1: Results of VOI-limited rigid body registration. S_{unreg} and S_{reg} describe the standard deviation of coronal motion from the reference image.

Data set	S_{unreg} [mm]	S_{reg} [mm]	% change
1	2.4	0.6	75
2	1.0	2.7	-108
2*	1.0	0.3	70
3	4.9	3.7	25
4	19.1	11.6	40

Table2: Results of VOI-limited deformable registration.

Discussion

The presented VOI-limited registration could reduce coronal motion in the data sets by 50%. Even data sets with large motion artifacts (data set 4) could be corrected to a certain point. Comparing VOI-limited deformable and rigid registration, the VOI-limited rigid registration performs better than the deformable registration. However, the deformable registration was performed with parameters obtained from [2]. Optimizing these parameters might improve the results of the deformable registration, as demonstrated for data set 2. In conclusion, VOI-limited registration should be employed over global image registration if the movement of several objects should be corrected.

References

[1] Zöllner FG et al, Comp Med Imaging Graph, 33:171-181, 2009
[2] Merrem A et al, ISMRM, 19:815, 2011
[3] Ibanez I et al., ITK software guide, 2005
[4] Lietzmann F et al, J Magn Reson Imaging, 35:868-874, 2012