Automatic region tracking for motion correction in MR perfusion imaging of the kidney

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Purpose/Introduction:

Contrast-enhanced dynamic MRI acquisitions give access to renal physiological parameters like measurement of blood flow, blood volume and glomerular filtration. The principle relies on the observation of a Gadolinium bolus through the kidney. The contrast agent is initially filtered in the cortex, subsequently passes through medulla before being eliminated through the excretory system. Consequently, the observation of the signal evolution in the cortex of a T1-weighted dynamic MR-series gives access to the renal perfusion and filtration.

Since the rapid bolus passage hampers the use of gated sequences, rapid T1-weighted sequences have to be employed while free-breathing. As a result, the acquired data contain motion artefacts caused by the respiratory cycle, spontaneous movements and drifts which limit the quantitative analysis of the data. Additional challenges for motion correction arise from the fact that image amplitude changes not only due to motion but also due to the contrast change during bolus passage.

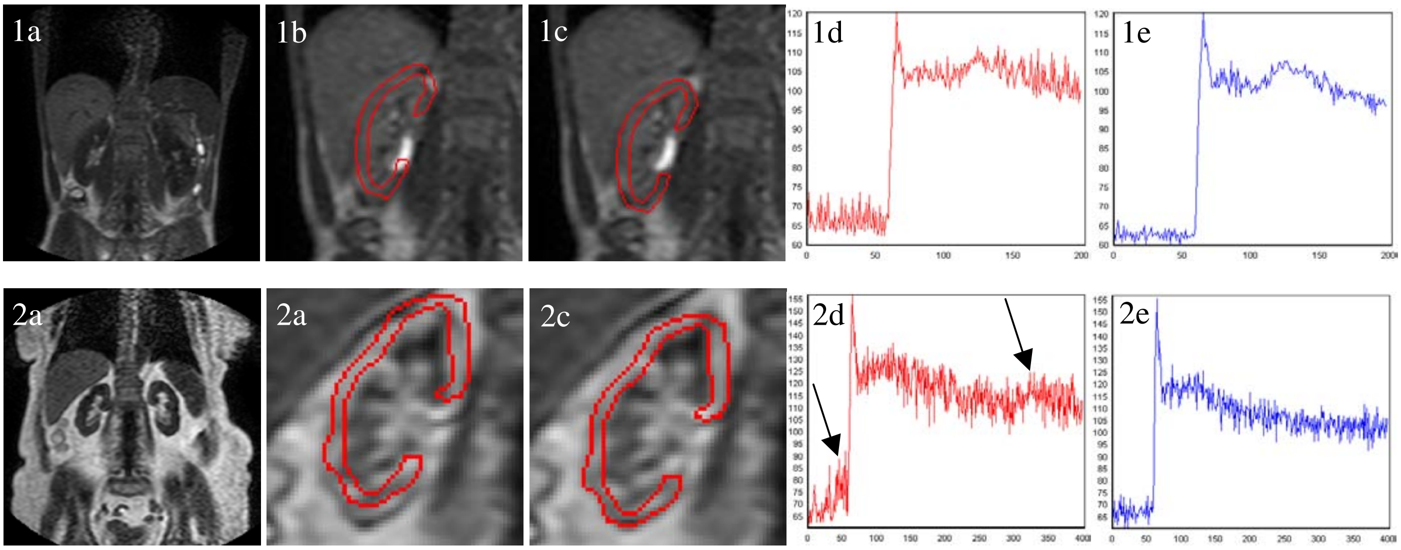
This study proposes a 2D region tracking method for retrospective motion correction without sacrificing temporal resolution which addresses the latter point by a preparative learning phase.

Methods:

<u>MRI:</u> Five patients suspected of renal disorders were examined with a gadolinium enhanced (1/3 dose) dynamic T1-weighted gradient recalled echo sequence (Philips ACSNT 1.5T) with the following parameters: TE=1.2ms, TR=2.3ms, 5 slices of 10mm, matrix 128x83, FOV=40x40cm2, Taq/dyn= 1.7s, non selective inversion preparation. Slice orientation was chosen parallel to the main displacement direction of the kidney (caused by respiration), in order to limit motion perpendicular to the slice plane and the bolus injection was given after 50 dynamic images in order to obtain sufficient training data for the correction algorithm.

<u>Post-processing:</u>

The main processing step is a gradient driven descent algorithm maximizing the similarity (inter-correlation coefficient) between a reference image and the current dynamic image assuming a rigid body displacement restricted to a chosen ROI containing the kidney. This method is first applied to the training data prior to bolus injection in order to establish a lookup table associating each image with a displacement vector. In a second step, each image during bolus passage is compared to this lookup-table using the corresponding pre-calculated displacement vector as a starting point for a new estimation. The adopted strategy prevents the convergence of the algorithm to local maxima caused by the contrast changes induced by the bolus passage.



Results/Discussion:

Figure 1 and 2 show two typical examples of the patient study. While the motion corrected image data maintains the kidney within a predefined ROI on the cortex as evidenced in figure 1c and 2c, the uncorrected data shown in 1b, 2b shows periodic mismatches that lead to an inaccurate quantification. This effect is also apparent comparing the uncorrected signal intensity time-course averaged over the ROI (1d, 2d) with the values obtained from the corrected data (1e, 2e). The corrected time-course shows significantly less signal fluctuations caused by mismatch of the ROI with the cortex, during respiratory and spontaneous motion and is also corrected for the effects of motion drift (see arrows 2d). The large signal fluctuations of the uncorrected data at the late excretory phase (1d) can be explained by contamination of the ROI by the signal from the excretory system (1b).

Conclusion:

Since the proposed method is well able to correct for periodical and spontaneous motion associated with free-breathing MRI data acquisition, it is an interesting candidate for the quantitative bolus passage analysis in the kidney.

References:

1-Grenier N., et al [2003], Abdominal Imaging, 28:164-175.
2-Barron J.L., et al [1994], International Journal of Computer Vision, 12:43-77.