Reduction of Motion Artefacts in Renal Perfusion DCE-MRI Data

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INTRODUCTION: Dynamic contrast enhanced MRI (DCE-MRI) has become an important method to study functional changes of renal perfusion in diseased kidney (1). Evaluation of perfusion parameters are based on fitting mathematical models to the time dependent intensity changes in the dynamic time series, caused by paramagnetic contrast media (2). The fitting process suffers from motion artefacts due to breathing during the long acquisition time of three to five minutes. However, an exact analysis of renal perfusion parameter in different tissues such as renal cortex, medulla and renal pelvis requires a sufficient image registration of the dynamic scan.

Registration in the presence of local intensity changes is still a challenging task. Most registration algorithms are based on the conservation of pixel intensity values. This will be violated through contrast media intensity changes. Hence, matching an image at the time of tracer uptake with a baseline image leads to unstable results. We circumvent this pitfall by evaluating a second dynamic time series using a filter operation in the time domain. In this time series fast intensity changes, caused by motion are eliminated and slow intensity changes caused by contrast media uptake are preserved. The images of this time series are used as templates for the non rigid registration algorithm. We demonstrate that our algorithm significantly reduces kidney movement and allows a more differentiated analysis of several kidney tissue types.

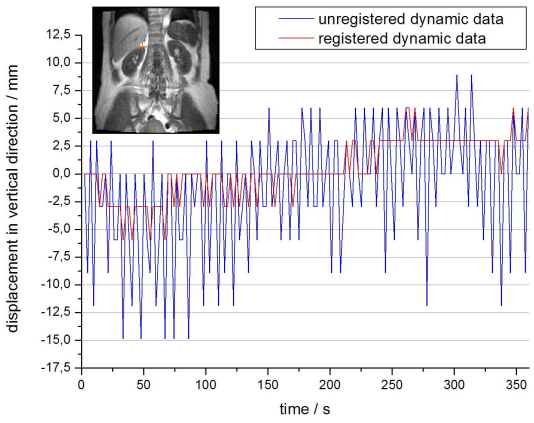

Figure 1: Displacement of the right kidney at the position marked with red cross for unregistered and registered DCE_MRI data

METHOD: In-vivo DCE-MRI data were obtained from routine examinations on a 1.5T MRI scanner (Siemens Symphony, Siemens Medical, Germany). A 2D FLASH sequence was used with the following parameters: FOV/TR/TE/α=380mm/480ms/1.38ms/12° with an image matrix of 128x128, slice thickness of 10.0mm and a temporal resolution of 2.4s for 5 slices and 150 time points. A dose of 0.05 ml/kg contrast agent (Omniscan®, Amersham Health AG, Switzerland) was injected intravenously via a power injector (Spectris; Medrad Inc., Indianola, PA, USA) at a rate of 2 ml/s, followed by 20 ml NaCl at the same speed.

A low-pass-filter is applied for every pixel on the dynamic time series with a cutoff frequency of 0.07Hz which was chosen experimentally. This filtered image series of 150 images does not contain fast intensity changes caused by moving organs due to breathing. Only low frequency changes induced by tracer uptake can be observed. Each image of this series is used as a target template to co-register the corresponding image of the original data. The non-rigid 2D registration algorithm optimizes a locally affine cost function with a global smoothness constraint (3). For evaluation of the vertical kidney displacement the upper corner of the kidney at constant horizontal position was chosen due to a high contrast between the renal cortex and the surrounding tissue. To analyse three regions of different kidney tissue, an image at the time of early tracer uptake of the co-registrated time series was used to identify the cortex, medulla and pelvis. Positions of these regions were stored and mapped onto the original data. All post processing was performed offline on a 2 GHz dual core PC. Software for post-processing was developed in house and programmed with Interactive Data Language (IDL 6.0, Research Systems Inc., USA) and Matlab (V 7.4, The MathWorks, Inc., MA, USA).

RESULTS: Figure 1 shows the vertical displacement of the kidney due to breathing for the unregistered and the registered time series. The unregistered dataset shows a maximum translation of six pixel (17.8mm) between two consecutive images. The proposed method reduced the movement to a maximum displacement of two pixel (5.9mm). The estimated tolerance for detecting the position of the renal cortex and the surrounding tissue is about ±1 pixel (3mm). The time course in Figure 2 shows a considerable reduction of intensity changes due to kidney movements. This allows a better differentiation of perfusion in renal tissue types such as renal cortex, medulla and renal pelvis.

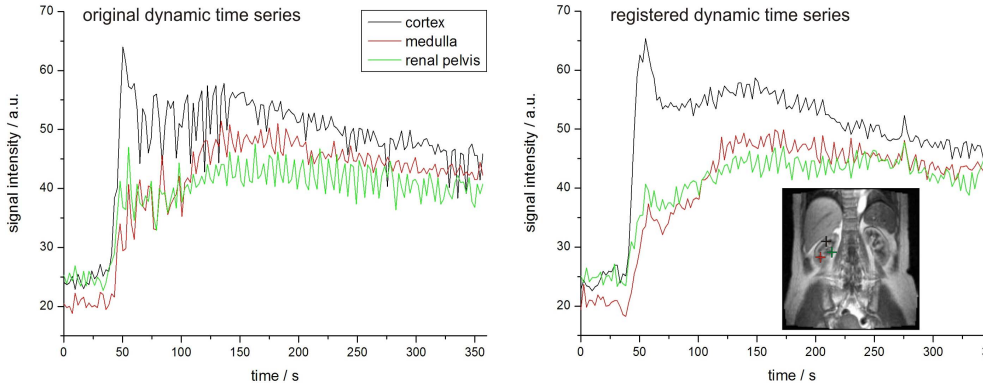

Figure 2: Time course of the unregistered (left) and the registered (right) DCE-MRI data in the renal cortex (black cross), medulla (red cross) and the renal pelvis (green cross)

CONCLUSION: Even the used registration algorithm takes into account small local intensity variations, a consecutive image registration of DCE-MRI time series fail due to fast intensity changes caused by tracer uptake. In this work we successfully demonstrated that a simple and fast pre-processing step can avoid the problem of registration in the presence of fast local intensity changes. The vertical displacement of kidney caused by breathing can be reduced nd makes the analysis of different tissue types more accurate. However, slow motion movements in the frequency range of tracer uptake can not be corrected with this algorithm and is still object of our research.

REFERENCES:

(1) Grenier N, Hauger O, Cimpean A, Pérot V. Update of renal imaging. Semin Nucl Med. 2006;36:3-15.

(2) Sourbron SP, Michaely HJ, Reiser MF, Schoenberg SO. MRI-Measurement of Perfusion and Glomerular Filtration in the Human Kidney With a Seperable Compartment Model. Invest Radiol 2008 Jan;43(1):40-48.

(3) Periaswamy S and Farid H. Elastic Registration in the Presence of Intensity Variations. IEEE Trans Med Imaging 2003;22(7):865–874.