Image Registration in ASL-Perfusion Imaging of Kidney - Impact on Image Quality

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Introduction

Dynamic contrast enhanced magnetic resonance imaging (DCE-MRI) is an emerging technique for a more accurate assessment of local renal function [1]. Recent findings on NSF and disease status in certain patient groups permit the application of contrast agents. An alternative approach to non-invasive perfusion quantification is arterial spin labelling (ASL) [2]. However, ASL techniques suffer from low SNR and especially in abdominal imaging, from organ movements, e.g. breathing. In this work, we analyzed the impact of automatic image registration on signal quality and increase of SNR by averaging in ASL kidney perfusion imaging.

Materials and Methods

Imaging of healthy volunteers was performed at 3T (MAGNETOM Trio, A Tim System, Siemens Healthcare, Erlangen, Germany) using FAIR-trueFISP sequence [3] with TR/TE/FA=4ms/2ms/70° and TI=1200ms. Image resolution was 1.5x1.5x6mm³ and 256x256 matrix and one slice. Total acquisition for 32 images (16 tag, 16 control) was 3min 28s. Image registration was performed using a non-rigid image registration approach calculating the cross-correlation between reference and image frame [4]. In addition, a multi-resolution strategy was applied for faster calculations. To evaluate the registration we compared results to manual registration based on landmarks, calculated checkerboards on selected images, and compared the joint histogram of reference and current image before and after registration. SNR was estimated from carefully selected ROIs in the kidneys.

Results

Figure 1 depicts checkerboards of superimposed control images with and without registration. White arrows depict examples of motion artefacts that are recovered by registration. In Fig. 2 perfusion weighted images averaged over 16 single image pairs are given, again with and without registration. Comparing the manual registration (using landmarks, Fig.2b) to the automatic algorithm (Fig. 2c) no visible differences could be detected. Manual registration of 32 images requires about 7-10min and the automatic procedure is performed in ca. 13s.

SNR increases with higher number of averages as expected. In Fig.3a, a steeper increase in SNR is observed for number of averages below 10, afterwards the SNR increases steadily, and for more than 50 averages a plateau is reached. Comparing perfusion weighted images averaged over 16 and 64 image pairs (including registration), no visible differences are detected, i.e. 16 averages seem to be sufficient (cf. Fig. 3 b,c).

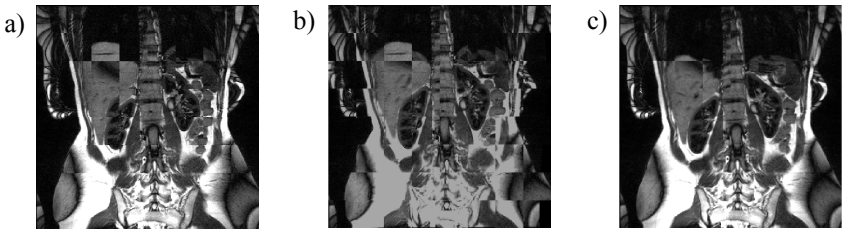

Fig. 1: *Checkerboards of 2 superimposed control images. a) Without registration, b) manual registration, and c) automatic registration.*

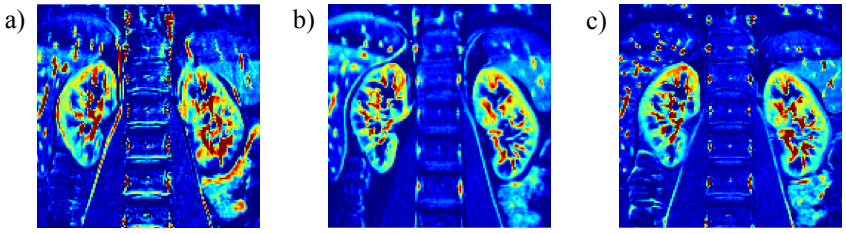

Fig. 2: *Perfusion weighted images averaged over 16 tag/ control-pairs. a)Without registration, b) manual registration, and c) automatic registration.*

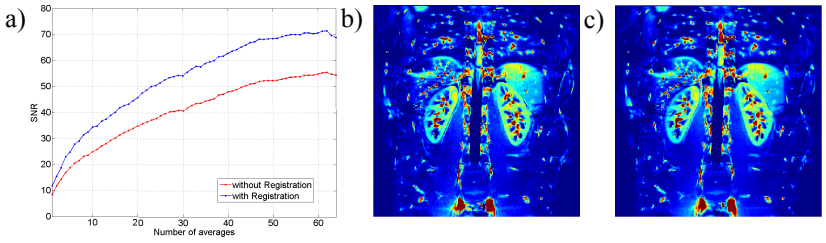

Fig. 3. *a) SNR-gain with averaging b) ASL image averaged over 16 tag/ control-pairs c) ASL image averaged over 64 tag/ control-pairs.*

Discussion

Both registration techniques improve the image quality significantly. However, the automatic registration is much faster then the manual registration, therefore it is the preferred method for large data sets. Thereby, also higher number of averages could be imaged, not hampering the quality of the ASL images. In addition, a higher SNR is reached contributing to reliable quantification. However, a higher number of averages also imply longer acquisition times. We demonstrated that 16 averages seem to be a good compromise between acquisition time and SNR gain. Next step in our work is to evaluate the perfusion weighted images with a quantification model [5] to investigate the differences in perfusion between healthy volunteers and patients with renal diseases or transplant kidneys.

References

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