High-Field Parallel NMR-Microscopy in Small Animals

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Introduction

Parallel Imaging (PI) has been one of the most important driving forces in the development of clinical MRI since its invention and due its benefits has gained an important part in the clinical routine imaging workflow. However, in small animal imaging it is not obvious that PI can provide similar advantages, in particular because of the limited SNR and the high spatial resolution required in such experiments. First results of the feasibility of Parallel Imaging in small animals were shown [1, 2]. Recently, it has been demonstrated that EPI studies at high field can significantly benefit from the use of PI [3]. The present study is focused on applications in small animals and demonstrate that the reduction of scan time using PI can also be used to increase the contrast-to-noise ratio in angiography of small rodents or to improve the quality of diffusion anisotropy maps in DTI studies.

Methods

This study was performed on a 4.7 T 40 cm bore *BioSpec*® system (Bruker BioSpin MRI GmbH, Ettlingen, Germany) equipped with 4 receiver channels. Two different 4-element coil arrays designed and optimized for high-field head imaging in rats and mice, respectively, were used for these experiments. For accelerated imaging a GRAPPA (GeneRalized Autocalibrating Partially Parallel Acquisitions) [4] algorithm was applied for image reconstruction.

3D time-of-flight (TOF) angiography was performed in the rat and mouse brain. For this purpose, a 3D-FLASH sequence with a TR/TE of 18.0 ms/1.9 ms was used. For visualization of the vessel structure a maximum intensity projection (MIP) was calculated.

Diffusion tensor imaging (DTI) was performed on a formalin-fixed rat brain using a conventional PGSE sequence. 6 diffusion directions were acquired in the conventional experiment and 12 directions in the accelerated DTI experiment.

Results

Figure 1 shows a comparison between a non-accelerated and an accelerated 3D-TOF experiment of the rat brain. Using a matrix of 256 x 256 x 128 a resolution of (117 x 148 x 250) μm^3 was obtained in a total scan time of approximately 10 min. Using PI with an acceleration factor of two, nearly the same image quality is obtained in a total scan time of 5.3 min.

Figure 2a shows the fractional anisotropy of a formalin-fixed rat brain calculated from a DTI experiment with 6 different diffusion directions. When PI is applied with an acceleration factor of two, 12 diffusion directions can be measured in the same total scan time. The additionally acquired information about anisotropic diffusion behavior results in a higher image quality of diffusion anisotropy. This can clearly be seen in Figure 2b.

Discussion & Conclusion

In case of angiography of the animal brain, PI can be used either to drastically reduce scan time, while keeping image quality, or to increase the spatial resolution and thereby improving the visualization of the vessel structure. Thus, the application of PI for angiography studies is crucial not only in the clinical environment but also in high-field animal imaging. For DTI the application of PI can be used to acquire more diffusion directions in the same total scan time. The calculated diffusion anisotropy map exhibits more information about diffusion anisotropy due to the more detailed direction sampling.

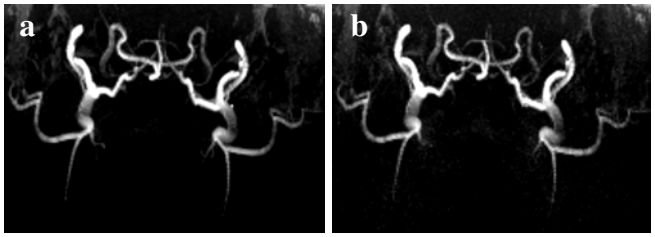

Figure 1: 3D-TOF of the rat brain:
a) Conventional acquisition with total scan time of **10 min**.
b) PI with Acceleration factor of 2 resulting in a total scan time of **5.3 min**.
Both acquisitions show nearly the same image quality.

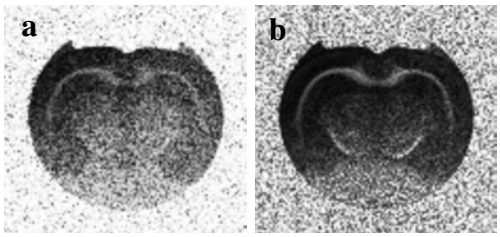

Figure 2: Diffusion anisotropy map of fixed rat brain:
a) 6 measured diffusion directions, without acceleration.
b) 12 measured diffusion directions and acceleration of 2 results in the same acquisition time as for a), but improved image quality of fractional anisotropy.

References:

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