Phase Imaging of the *in vivo* Rat brain at 14.1 Tesla

J. P. Marques[1,2], C. Cudalbu[1], C. Poitry-Yamate[1], V. Mlynarik[1], and R. Gruetter[1,3]

[1]Laboratory for functional and metabolic imaging, Ecole Polytechnique Federale de Lausanne, Lausanne, Vaud, Switzerland, [2]Department of Radiology, University of Lausanne, Lausanne, Vaud, Switzerland, [3]Department of Radiology, University of Lausanne and Geneva, Switzerland

Introduction

With the increase of magnetic field, susceptibility related contrast in GRE phase images holds promise to detect additional anatomical information, as has been demonstrated in human brain for veins and iron rich regions (1,2) and for contrast between WM and cortical GM (1,3). The aim of the present study was to assess contrast arising in conventional gradient echo (GRE) images at 14.1 Tesla.

Methods

Scans were performed in a 14.1T/26cm scanner (Varian/Magnex Scientific) using a home built 14mm quadrature coil as RF transceiver. Field homogeneity was adjusted using FASTMAP. 512x512 Gradient-echo images of the rat brain were acquired with a nominal in-plane resolution of ~30µm, slice thickness of 0.5mm and 1mm, FOV of 17x17mm, TR/TE=500/15ms) with an acquisition time of 10ms. Each acquisition took approx~ 4mins, and 4 repetitions were acquired for each slice thickness. The flip angle was set to allow deep brain coverage while avoiding 180 degree artifacts in the regions closest to the coil. The TE was chosen to approximately match the T_2^* of GM and hence optimize phase contrast (1).

A 2D Gaussian high-pass filter with a kernel size of 63 voxels and a width of 10 voxels was applied to all images to remove low-frequency phase drift ascribed to large-scale B0 inhomogeneities. Zero-filling was performed for data presentation purposes. An adult rat (Sprague-Dawley, 253g) was anesthetized using isofluorane, was fixated with a stereotaxic holder and kept within good physiological conditions throughout the scan session.

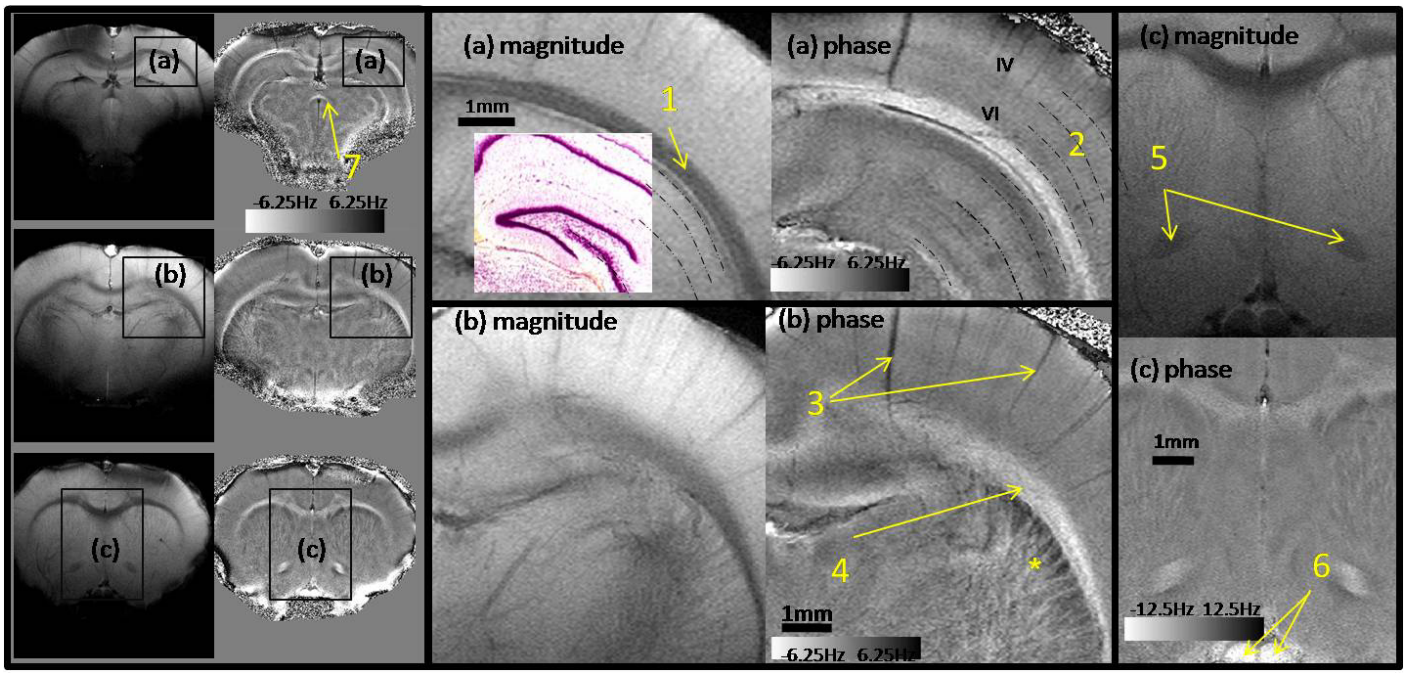

Figure 1 On the left, full field of view images of slices located approximately at position Bregma (a) 0.7, (b) -2.12 and (c) -4.80 mm (6) are shown. The squares represent the areas shown expanded on the right. The plate overlaid on the zoomed magnitude image (a) is from (6).

Results and Discussion

The effective high spatial resolution (and absence of motion artifacts) is illustrated by the detection of structures with widths of ~1 pixel such as some of the venules/capillary visible in the magnitude images. GRE magnitude and phase images on the rat brain not only depict a high number of venules orthogonal to the cortical surface (arrow 3 in Fig. 1b) originating from pial veins but also different layers in the somatosensory cortex (number 2) and fields of the hippocampus, consistent with stained brain slices (6). Phase images further allowed identification of dense bundle of callossal fibers (arrow 1) in the external capsule as well as projections from the external capsule (arrow 4) into the caudate putamen (striatum) (marked with an asterisk), also the anterior comissure (arrow 5), optic nerve (arrow 6) and posterior comissure (arrow 7) are visible. The calculated frequency shifts were within 0.012 ppm, except for the optic nerve (arrow 6).

Phase imaging resulted in an increased dynamic range in detection of related off-resonance effects by directly measuring the change in frequency offset, enabling for example a clear distinction between WM and veins that in magnitude images appear dark (both generate intravoxel dephasing) whilst in the phase have opposite contrasts (they have opposite frequency offsets). This allowed the robust visualization of the anatomy of the striatum and it's mixed constitution of GM and WM tracts, and some small structures such as the fornix, the mamilo thalamic tract (not shown). The contrast may be attributed to iron (heme or ferretin) or fat content (cholesterol and cerebroside) of the tissues..In conclusion, phase imaging at 14Tesla provides new contrast for microimaging of brain anatomy in rodent brain and may be of importance in studying myelination defects and neurodegenerative diseases such as Alzheimer disease.

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