

Detection of amyloid-beta plaques using phase imaging at 9.4 Tesla

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INTRODUCTION

Beta-amyloid (A β) plaques are one of the key pathologic features of Alzheimer's disease (AD). Magnetic resonance imaging is the only modality that can provide sufficient spatial resolution and image contrast to visualize individual A β -plaques noninvasively. Previously A β plaques have been visualized in images acquired using spin-echo and gradient echo sequences at 7 T [1] and 9.4 T [2]. At high fields, it has been reported that the increased susceptibility-related contrast resulted in additional anatomical information, such as delineation of veins and iron-rich regions in human brain [3, 4]. In this study, we show that the susceptibility-induced contrast in gradient-echo phase images can enhance detection of A β plaques.

METHODS

The MR images were acquired from the fixed brain of a transgenic PS/APP mouse. The doubly transgenic PS/APP mouse develops amyloid plaques similar to humans, thus providing an animal model to study disease mechanism and to test disease modifying strategies in Alzheimer's disease.

All MR scans were performed on a Varian 9.4 T MR scanner. A linear surface RF coil of 7-mm diameter was placed on the top or side of the brain phantom to transmit and receive the signal. The parameters for the spin-echo sequence were TE/TR = 25/1000 ms, matrix = 256 \times 256, field of view (FOV) = 1.024 cm \times 1.024 cm, and slice thickness = 0.2 cm. Accordingly the nominal voxel dimension was 40 \times 40 \times 200 μ m³. For the gradient-echo sequence, the same parameters were used except that TE/TR = 15/500 ms and flip angle = 40 $^\circ$. A high-pass Gaussian filter with a kernel size of 63 pixels and a width of 15 voxels was applied to the phase of the gradient-echo images to remove the low-frequency variation due to B₀ inhomogeneities. K-space zero-filling was used for data presentation purposes.

RESULTS AND DISCUSSION

The high spatial resolution of the spin-echo image is demonstrated by the detection of the A β plaques, as shown in Fig 1A. A closer view with an adjustment of window/level, such as Fig 1B, clearly identifies the plaques. In the magnitude of the gradient-echo images shown in Fig 1C, locations of the plaques correlate with those in Fig 1B, as indicated by arrow 1. In the phase of gradient-echo image (Fig 1D), the plaques are well localized with improved contrast, as shown by arrow 1. In the spin-echo and gradient-echo magnitude images, the white matter resulted in low signal intensity because of short T₂ or T₂*. In the phase image, the contrast between gray and white matter is different, and thus plaques in callosal fibers can be visualized, as shown by arrow 2. Similar observation can be found in Fig 2.

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It has been previously shown that the plaque locations in spin-echo images correlate with those with iron accumulation [1,2]. The colocalization of hypo intensities in the spin-echo images and the phase images suggests that the source of the phase contrast observed in the current study is from the accumulated iron in the amyloid plaques. This study shows that the phase image can be a viable tool for detecting fine structures, such as A β plaques.

REFERENCES

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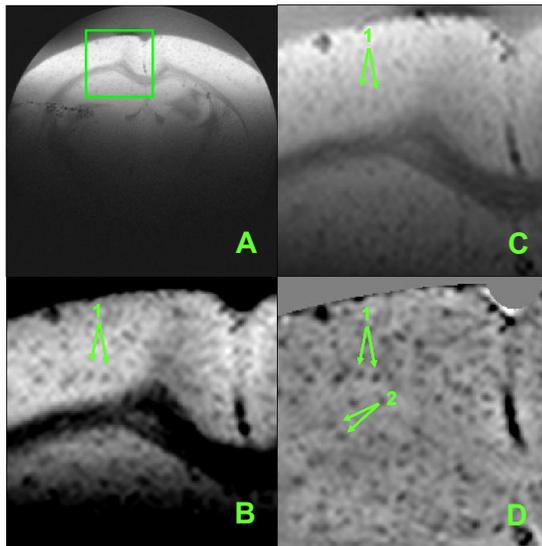


Figure 1. The spin-echo magnitude image of the brain phantom (A) with a neocortex region marked in the square. The zoomed-in of the marked region: spin-echo image (B), the gradient-echo image (C), and the gradient-echo phase image (D).

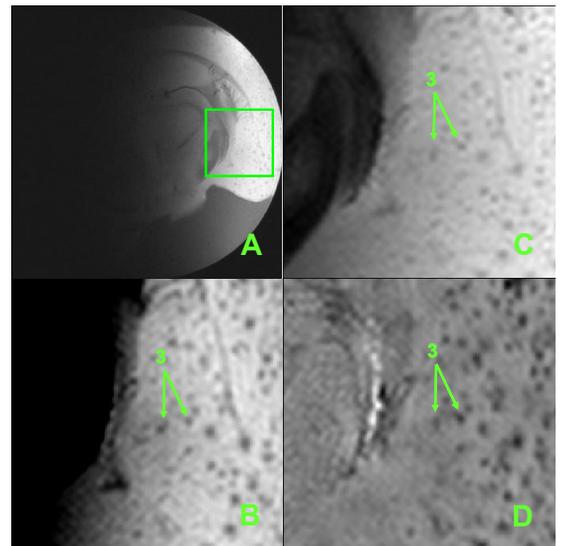


Figure 2. Same as Figure 1, except the surface coil was placed on the side of the brain phantom.