Parallel microimaging studies on mice at 600 MHz

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INTRODUCTION

Parallel imaging methods such as SENSE [1] and GRAPPA [2] are used widely for anatomical and dynamic scans on human MRI systems. Parallel imaging on high field systems for MRI microscopy also holds great promise. Acquisition times for acquiring very high spatial resolution images (<50 μm isotropic) can be prohibitively long. Also, increased magnetic susceptibility artifact can render single-shot imaging methods, such as EPI, unusable. However, parallel imaging at high fields presents unique challenges. One is the construction of a phased array coil. A second potential problem is that using traditional SENSE reconstruction requires the use of a reference scan for sensitivity information [1]. Due to the strong interactions of the coil with the sample at high fields, a reference scan on a phantom may not translate to accurate sensitivity maps of the object of interest. The acquisition of a reference scan from the object to be imaged reduces the scan-time benefits associated with the parallel acquisition scheme. In this work, we present SENSE and GRAPPA EPI images demonstrating the performance of our array coil for parallel imaging. We also demonstrate that for microimaging scans, the scan-time reductions of traditional SENSE acquisitions can be maintained by measuring relatively low resolution sensitivity reference maps.

METHODS

A phased array consisting of four curved surface coils was constructed and electrically isolated as described in [3]. All experiments were performed on a wide-bore (89 mm inner diameter) 14.1 tesla vertical magnet system (Oxford Instruments, Abingdon, UK). With the gradient set (Resonance Research, Billerica, MA) present, the clear bore is 46 mm. All experiments were performed using a Unity console (Varian, Palo Alto, CA).

RESULTS AND DISCUSSION

Figure 1 shows spin-echo EPI data sets (TE=47 ms, TR=2 s, 1 mm slice thickness, FOV 1.7 x 1.7 cm) from a mouse brain with: (a) a two-interleave EPI dataset, fully encoded 64x32x2 shots, (b) a four-interleave EPI data set, 64 x 16 x 4 shots, (c) a two-interleave EPI, GRAPPA factor-of two-reconstruction from 64 x 16 x 2 shots, and (d) a two-interleave EPI data set, SENSE reconstruction factor-of-two. Both the GRAPPA and SENSE reconstructions show a significant reduction in susceptibility artifact over the two-shot fully encoded data set. Next, we investigated the use of a reduction in the reference scan time for a SENSE experiment. We swapped the phase and frequency encoding directions in the sensitivity scans with respect to that used in the SENSE acquisition. This was done to maintain high spatial resolution in the direction for which SENSE reduces the aliasing artifact. Figure 2 shows the results for a spin-echo acquisition (TR=1s, TE=11ms, FOV 1.8 x 1.8 cm, 256 x 256 complex points, slice thickness 1mm) whereby the sensitivity reference scan had an acquisition matrix size of Lx256 complex points where L=128,96,64,32, or 16. The SENSE acquisition was then performed with 256xM complex points where M=128,86,or 64 for one-half, one-third, and one-quarter encoded acquisitions, respectively. Figure 2 shows that one can acquire one-eighth of the phase encode resolution to get sensitivity reference images of a 32x256 matrix size and use these effectively in a SENSE experiment with a factor of two reduction. This results in a net decrease in scan time even for a non-dynamic microscopy scan.

REFERENCES:

[1] Pruessmann, et al. Mag Res Med 1999; 42: 952-962.**[2]** Griswold, et al. Mag Res Med, 2002; 47: 1202-1210.**[3]** Zhang and Webb, J Magn Reson 2004; 170: 149-155.

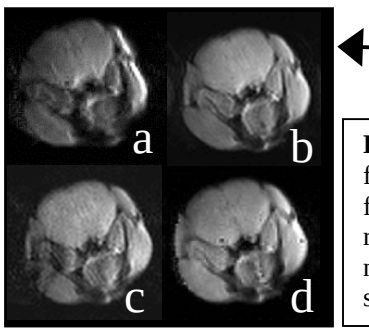

Fig 1. (a) 2-shot EPI (b) 4 shot EPI. (c) 2-shot GRAPPA factor of 2 (d) 2-shot SENSE factor of 2

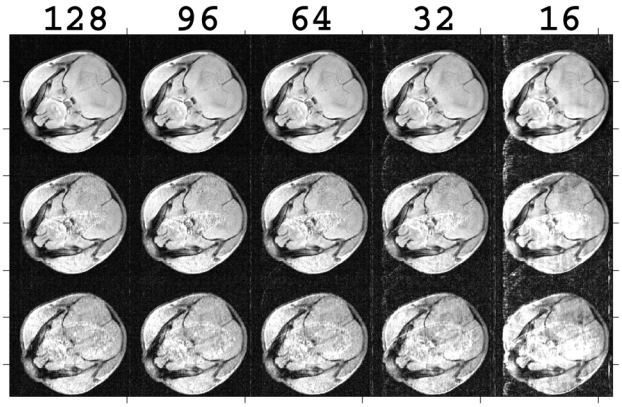

Fig 2. SENSE reconstructions from a mouse brain as a function of the SENSE reduction factor (rows) and the number of phase encoding steps for the reference map