Real-Time Large-FOV MRI with a Massively Parallel 32-Channel MRI System and Detector Array

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Synopsis

The advantages of very large array sizes for high-speed 2D MRI were explored using a 32-channel parallel-MRI torso array and a custom 32-channel 1.5 T MRI system. Real-time large field-of-view (FOV) imaging was performed using an interleaved echo-planar pulse sequence, and body survey imaging with a repeated single-shot fast-spin-echo (SSFSE) sequence. Variable FOV shifting and parallel imaging techniques were used to accelerate image acquisition. The use of a high number of coils allowed expansion of the FOV during rapid imaging while maintaining relatively high frame rates and spatial resolution.

Introduction

Raising the number of channels in multi-coil imaging beyond the usual 4 to 8 can potentially yield a wide variety of benefits, including improved signal-to-noise ratio (SNR), larger FOVs, and/or faster imaging speeds. These may have important applications in overcoming cardiac, respiratory, and peristaltic motion during body imaging, and for delivering and monitoring therapy under MRI guidance. Here we explore the possibility of using a 32-coil torso parallel array to perform improved high-speed, large-FOV 2D imaging of the abdomen and pelvis.

Methods

A 32-channel parallel MRI torso array comprised of 4 rows of 4 coils (each 79 mm x 105 mm) was built on 2 identical clamshell formers (one half outlined in Fig. 1). Coils were spaced by 16 mm in the right/left (R/L) direction and overlapped by 18 mm in the superior/inferior (S/I) direction, to provide optimal SNR for parallel imaging (1). One former was positioned on the patient table and the other over the subject’s torso. A 32-channel fully parallel MRI system was assembled from multiple GE 1.5 T phased-array receiver systems. Custom real-time imaging software was developed to collect data from all 32 channels across multiple computers, reconstruct images, and display them on the scanner monitor.

Real-time imaging was performed with the use of an interleaved echo-planar pulse sequence. In addition, a large-FOV body-survey mode was developed, which employed a repeated SSFSE sequence to generate 0.5-1 sec images at a rate of 1-2 per sec. To expand the FOV for coronal imaging (etc) while maintaining image resolution and high frame rates, the readout gradient was oriented in the S/I direction, and limited-FOV images were acquired. Different FOV shifts were applied during image acquisition to each pair of L/R rows of coils (one row on the anterior clamshell and the other directly opposite on the posterior clamshell). Parallel encoding was applied in the L/R direction, with a speedup factor typically of 2-3. Composite images from each row were combined by shifting each composite image and taking the square root–of-the-sum-of-the-squares in the overlapped regions of the images.

Results

The interleaved echo-planar sequence produced images at up to 12 frames per second, over an FOV of 40 cm, with 3 mm resolution. The SSFSE pulse sequence yielded detailed images of the abdomen, as shown in Fig. 2. Each image is an aliased composite from a 4-coil L/R row in the anterior clamshell. Figure 3 shows the result of unfolding the aliasing in each row with use of a low-resolution reference, and then combining rows from both anterior and posterior clamshells into an overall large-FOV image. Here we have doubled the FOV in both the readout and phase-encoding directions (for 4 times the area coverage), without sacrificing resolution or imaging speed.

Discussion

We have built and demonstrated for the first time, a massively parallel, 32-channel real-time MRI system with a 32-channel torso parallel array. The use of a high number of coils allows expansion of the FOV during rapid 2D imaging while maintaining relatively high frame rates and spatial resolution. This should be useful for rapid monitoring during body imaging, with potential applications in cancer screening and cholangiography, and for guiding therapeutic interventions in oncology, cardiology and elsewhere. Although we were limited here to performing parallel imaging separately within each row of coils and then combining the composite accelerated images into an overall image, we anticipate improving the SNR by parallel imaging using all 32 coils to provide speed-ups in the L/R direction, while continuing to apply separate FOV shifts to each row.

References

1) Y Zhu, et al., 11th ISMRM, submitted. This work was supported by NIH grant RO1 RR15396-01A1.