TWO DIMENSIONAL PARALLEL IMAGING ACCELERATION WITH AUTOCALIBRATING RECONSTRUCTION FOR CARTESIAN SAMPLING (ARC) IN CONTRAST ENHANCED MRA

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INTRODUCTION

Contrast-enhanced MR angiography provides excellent noninvasive visualization of arterial structures, however its anatomic coverage and spatial resolution are limited by breath-hold duration. Parallel imaging methods [1-3] provide the ability to achieve increased volumetric coverage and/or increased spatial resolution by accelerating data acquisition. Among the various parallel imaging reconstruction techniques, autocalibrating methods that require no coil sensitivity map estimation have proven advantageous when the prescribed field-of-view (FOV) is smaller than the anatomy [3], a condition which is often encountered in MRA. This work investigates the feasibility of applying 2D-accelerated autocalibrated parallel imaging to 3D contrast-enhanced MRA to achieve improved spatial coverage and resolution. Previous work has combined 2D-accelerated parallel imaging based on conventional GRAPPA for abdominal MRA [4]. While parallel imaging acceleration in 2 dimensions offers larger net acceleration factors than are possible with 1D acceleration, the volumetric reconstruction is significantly more computationally demanding. Therefore, a new, computationally efficient method known as ARC (Autocalibrating Reconstruction for Cartesian sampling) was used in this work to reconstruct 2D-accelerated MRA images within clinically acceptable timeframes.

METHODS

After obtaining IRB approval and informed consent, two volunteers were imaged in the sagittal plane using a 3D spoiled gradient echo MRA pulse sequence with 2D parallel imaging acceleration. All imaging was performed on a 1.5T scanner (Signa HDx, GE Healthcare, Waukesha, WI) using an 8-channel phased array cardiac coil. Contrast was injected at a rate of 3-4cc/s and elliptic centric phase encoding was used after detection of the contrast bolus with a fluoro-triggering pulse sequence. Imaging parameters included TR/TE=4.5/1.8ms (full echo), flip angle 30˚, BW=±62.5 kHz, matrix = 256x224, 108 slices, slice thickness = 2.2mm, FOV=34x24cm, for a true spatial resolution of $\Delta x/\Delta y/\Delta z$=1.3/1.5/2.2 mm. The acceleration factor was 1.8 in the phase-encode and 1.7 in the depth-encode direction for a total effective acceleration of 3.1. A 32x32 fully sampled calibration region was acquired at the center of k-space. Total scan time was 28s with a total volume covering 34x24x24cm^3.

Parallel imaging reconstruction was performed using the ARC technique, an autocalibrating method that calculated reconstruction weights for a volumetric 3x7x7 (k_x, k_y, k_z) kernel neighborhood using a novel calibration procedure that exploited computational redundancies to significantly reduce the number of required computations. Final images were obtained by sum-of-squares coil combination. This new calibration method, combined with a hybrid-space synthesis technique [5], permitted efficient volumetric parallel imaging reconstruction in less than 3 minutes. Parallel imaging reconstruction was performed online using a prototype ARC reconstruction algorithm on a single-core processor.

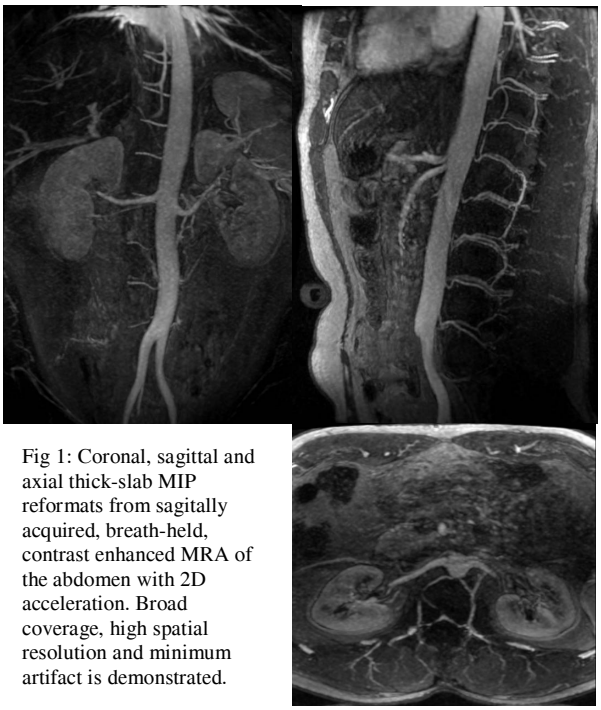

Fig 1: Coronal, sagittal and axial thick-slab MIP reformats from sagitally acquired, breath-held, contrast enhanced MRA of the abdomen with 2D acceleration. Broad coverage, high spatial resolution and minimum artifact is demonstrated.

RESULTS:

Figure 1 shows thick slab MIP reformatted images in the oblique coronal, oblique sagittal and straight axial orientations demonstrating excellent spatial coverage over the entire vascular anatomy of the abdomen. Excellent image quality was seen throughout all the images with minimal to no residual aliasing artifact. There was no evidence of local noise amplification, although this was not expected given the relatively low acceleration factors in each direction [6].

CONCLUSIONS:

This work demonstrates the feasibility of a two-dimensional parallel imaging acceleration method (ARC) in combination with contrast enhanced MR angiography. This is a promising new method that may greatly improve volume coverage, with high spatial resolution, in reasonable clinical scan and reconstruction times.

REFERENCES:

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