Combining body and surface coils in high resolution

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Introduction

Methods that continuously move the patient table in conjunction with contrast enhanced MRA (CE-CMT) have been shown to be effective in keeping a single contrast bolus within the sensitive region of the MR scanner. Previously, modified elliptical centric (EC) view order was applied to CE-CMT that included k-space undersampling and 2D homodyne reconstruction [1]. With this method the table velocity required to capture the contrast bolus directly determined the available spatial resolution of the reconstruction. Once the sensitive FOV reached the patient's feet the table was stopped. Because acquired spatial resolution was no longer velocity dependent, k-space was sampled to significantly higher spatial frequencies. In related work, four-element arrays have been used in stationary acquisitions to image the vessels of the calf [2] with a similar k-space trajectory and reconstruction as Ref 1. This method demonstrated the high SNR and resolution available from the application of surface arrays.

The purpose of this work, was to incorporate the method of Ref. 1 which images the thorax to knee portion of the extended FOV with the method of Ref. 2 which gives high SNR and resolution in the calf region where the small vessels of interest are primarily located. The resulting technique acquires the image from the aortic arch to the feet with one contrast bolus injection while using only four data receivers.

Methods

A four element phased-array coil was placed at the most inferior region of the table motion about the calves. The initial imaging position was prescribed in a 3D volume containing the thoracic aorta. The sensitive FOV in the S/I (readout) direction was 36 cm. Twenty ml of Gd. contrast was intravenously injected at 2 ml/sec followed by 20 ml of saline flush at the same rate. Initially only the body coil was activated. A table velocity of 2.4 cm/sec was triggered fluoroscopically by monitoring the initial prescribed volume for the arrival of contrast. Once the moving sub-FOV reached the feet the table was stopped, the body coil was deactivated, and the four surface coils activated. Switching time was 500 msec. Prior to the CE-CMT scan a subtraction mask was acquired using identical parameters.

Results

Figure 1 shows sagittal and coronal MIPs from a volunteer study. The entire scan took approximately 60 seconds to accomplish. The superior region acquired with the body coil contains voxels of size 2.2(x) x 1.8(y) x 2.2(z) mm^3. The voxels of the lower region are 1.1(x) x 1.8(y) x 1.1(z) mm^3. While reduced in SNR, the major vessels-including the renal arteries-in the body coil region are distinct. Small vessels in the high SNR calf region are well visualized after surface coil reconstruction. Note some asymmetric filling below the popliteal arteries with reduced contrast visible in the right calf.

Discussion

The application of surface coil arrays has been shown to increase SNR in CE-CMT by several investigators [3, 4, 5]. When many receivers are available a large array of surface coils can completely cover the extended FOV and give increased SNR in CE-CMT. However, equipment with large numbers of receivers is not universally available. For scanner that are limited to four receiver channels this method of acquisition allows a CE-CMT scan to be performed in which a high SNR region is acquired. The SNR improvement is in the calves where the highest image quality is typically needed. The method should easily lend itself to parallel imaging methods [6] in distal peripheral vasculature. With parallel methods, one might acquire higher lateral resolution in the same scan time, acquire the same spatial resolution with significantly reduced scan time, or optionally apply time-resolved 3D MRA to image contrast bolus dynamics.

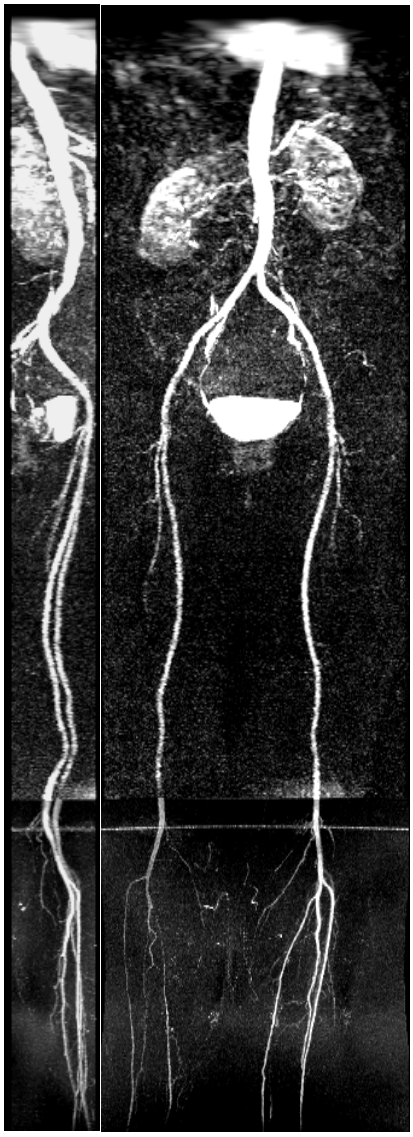

Figure 1

1. Madhuranthakam et al., ISMRM 2005, #2408
2. Madhuranthakam et al., ISMRM 2004, #8
3. Kruger et al., ISMRM 2003, #251
4. Fain et al. MRM 52: 1093-1102, 2004
5. Vogt et al., ISMRM 2005, #455
6. Weiger et al. Magma 14(1):10-19, 2002