Compatible Dual-Echo Arteriovenography (CODEA) Imaging at 7T versus 3T

K. T. Bae[1,2], S-H. Park[1,2], C-H. Moon[1], and J-H. Kim[1]

[1]Radiology, University of Pittsburgh, Pittsburgh, PA, United States, [2]Bioengineering, University of Pittsburgh, Pittsburgh, PA, United States

Introduction

Ultra-high-field (UHF) MR imaging such as 7T imaging has shown markedly enhanced SNR, blood-to-tissue contrast, and susceptibility effect that improves the visualization of small arteries and veins in the brain (1,2). We have implemented and tested our newly developed 'compatible dual-echo arteriovenography (CODEA)' technique at 7T and compared the image qualities with those acquired at 3T. In the CODEA technique, time-of-flight (TOF) MR angiogram (MRA) and blood oxygenation level-dependent (BOLD) MR venogram (MRV) were acquired simultaneously using the scan parameters compatible between the MRA and MRV and applied to each echo through an echo-specific K-space reordering scheme.

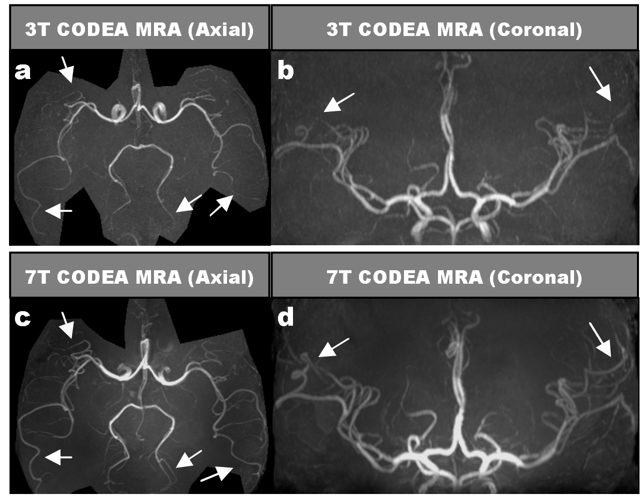

FIG. 1. **Comparison of CODEA MRAs acquired at 3T and 7T**

Material and Methods

All experiments were performed on a 3T and 7T scanners (Siemens Medical Solutions, Erlangen, Germany) with a vendor-supplied, circularly-polarized (CP) head RF coil (unless specified otherwise). Three normal male volunteers who provided informed consent were scanned in this study approved by the Institutional Review Board.

At both 3T and 7T, a single-slab, dual-echo arteriovenogram was acquired with a 3D gradient echo sequence with the first-order flow compensation applied to both the slab-select and readout gradients. The K-space center regions for the two echoes were separated through an echo-specific reordering where the initial ¼ of the K-space lines for the first echo were acquired at the end, while the final ¼ of the K-space lines for the second echo were acquired at the beginning along the 1st PE axis. Imaging parameters were: TR = 50 ms, TE = 3.2 / 24 ms, acquisition BW = 150 / 34 Hz/pixel, matrix size = 512×208×64, corresponding FOV = 220×179×88 mm^3, NEX = 1, and total scan time = 9.8 min. Partial (67%) and full echo samplings were used in the first and the second echoes, respectively. The 1st PE loop was located outside the 2nd PE loop. The K-space center region in the first echo (TOF-weighted region) was acquired with a minimum-phase ramped excitation pulse with flip angle of 25° (22.5°–27.5°), and the K-space center region in the second echo (BOLD-weighted region) with a minimum-phase flat-profile RF excitation with flip angle of 15°. A spatial presaturation pulse was applied only to 3T CODEA and MTC pulse was not used for any acquisition, so as to keep the specific absorption rate (SAR) low.

Only at 7T for one subject, an additional 3D dataset was acquired with a 8-channel head receiver-array coil. The scan parameter for this acquisition was the same as the abovementioned acquisition except matrix size = 709×284×74, TR = 47 ms, and total scan time = 15 min.

All the MRA datasets were displayed after maximum intensity projection over the entire volume and all the MRV datasets after minimum intensity projection over 10 mm thickness.

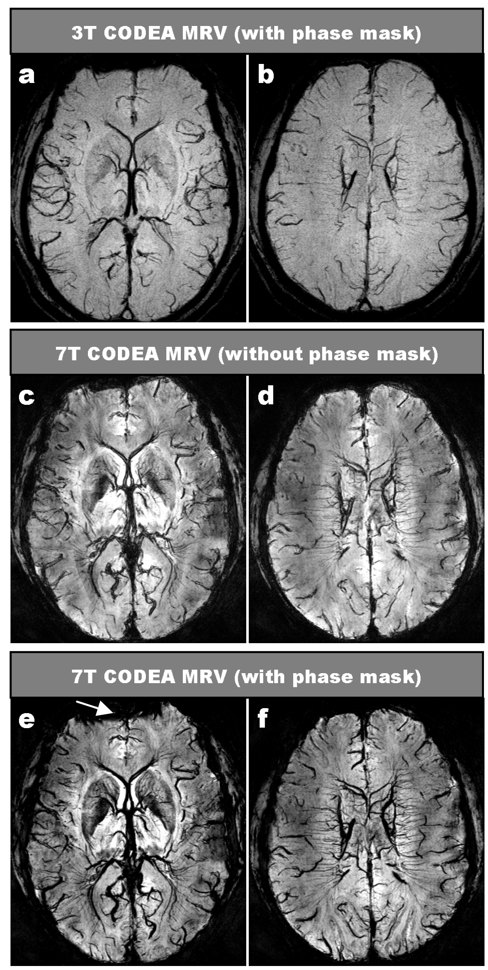

FIG. 2. **Comparison of CODEA MRVs acquired at 3T and 7T with a CP coil**

Results and Discussion

CODEA MRA at 7T allowed improved visualization of small cortical arteries, compared to 3T (arrows in Fig. 1). CODEA MRV at 7T depicted far more detailed small cortical veins and venules in the cerebral cortex than at 3T (Fig 2). We used TE of 24 ms for CODEA MRV at 7T which was longer than the optimal TE reported previously for phase-mask filtering (~15ms at 7T (2,3)). Even without phase-mask filtering, small veins were depicted in detail (Fig. 2c and d). The venous contrast was further enhanced by phase-mask filtering of CODEA MRV at 7T with the longer TE (Fig. 2e and f). The effect of the longer TE was evident with increased susceptibility artifact (arrow in Fig. 2e). These observations were consistent for all subjects.

While the background signal intensity throughout the brain was homogenous at 3T, we observed the signal intensity of the periphery of the brain lower than the center using the CP coil at 7T (Figs. 1c and d and 2c-f). Although this relative inhomogeneity at 7T did not appear compromising the delineation of small cortical arteries, these vessels seemed better visualized with the use of the 8-channel receiver-array coil and higher spatial resolution at 7T (Fig. 3).

In conclusion, CODEA technique at 7T allows improved visualization of small vessels in MRA and MRV due to greatly increased SNR and susceptibility contrast.

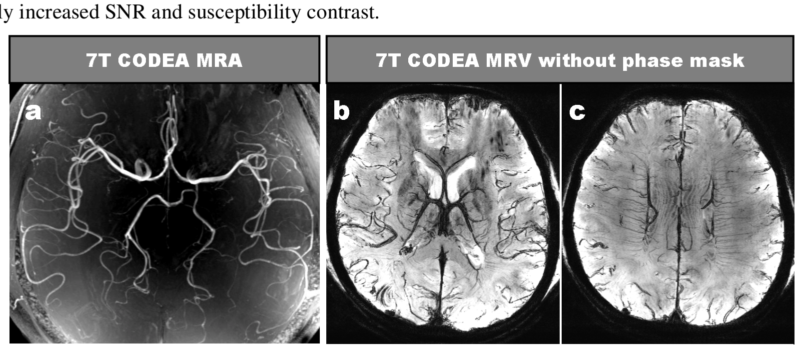

FIG. 3. **7T CODEA with an 8-ch receiver-array coil and higher resolution**

References

1. Morze et al, J Magn Reson Imag 26:900-904 (2007)
2. Koopmans et al. Magn Reson Mater Phy 21:149-158 (2008).
3. Deistung, Magn Reson Med 60:1155-1168 (2008)