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Accelerated 3D carotid MRI using compressed sensing and parallel imaging

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Introduction

Imaging of the carotid artery with black-blood MRI can be used to identify plaques that are vulnerable for rupture [1,2]. 3D imaging is particularly interesting to overcome the SNR and volumetric coverage limitations of 2D multi-slice techniques. However, 3D scans are more susceptible to motion artifacts, particularly swallowing-related artifacts, due to the longer acquisition times [3]. Parallel imaging can be used to accelerate the acquisition, but acceleration is limited by noise amplification. An alternative acceleration technique is compressed sensing (CS) [4], where image compressibility can be exploited to undersample k-space without losing image information. 3D imaging is a natural candidate for CS, since higher dimensional data sets increase sparsity. We propose to combine CS and parallel imaging to increase the acceleration rate for 3D carotid imaging.

Purpose

Evaluate the feasibility of highly-accelerated 3D carotid MRI using CS and parallel imaging.

Methods

3D carotid MRI was performed in a healthy volunteer on a 3 T scanner (Siemens; Tim-Trio) using a custom 8-channel carotid coil array. Fully-sampled 3D fast spin echo data were acquired with T1-weighting. The relevant imaging parameters include: TE = 12 ms, TR = 800 ms, scan-time = 15 min, FOV = 190 mm ×143 mm × 44 mm, image-resolution = 0.3 mm × 0.3 mm × 2 mm. Acceleration was simulated by decimating the fully-sampled data along the phase-encoding (ky) and partition-encoding (kz) dimensions by factors R = 4, 6 and 8, using a random undersampling pattern to generate the required incoherence for CS. Combination of CS and parallel imaging was performed using a single joint reconstruction algorithm (JOCS: joint CS [5]) by enforcing joint sparsity on the multicoil images in order to exploit k-space redundancy and incoherence along the coil dimension. Finite differences along x, y and z were employed to sparsify the 3D data set. A standard GRAPPA reconstruction with simulated acceleration R = 4(2 × 2) was also performed for comparison purposes.

Results

Fig. 1 shows reconstructed images in an axial view and Table 1 shows the corresponding root-mean-square-error (RMSE) values. JOCS presented improved image quality over GRAPPA, which yielded more noise. Compared with R = 4, acceleration factors R = 6 and R = 8 presented more blurring and change of contrast in regions with low-value finite-differences, which are challenging for JOCS reconstruction. Fig. 2 shows intensity profiles through a carotid vessel. JOCS with R = 4 and R = 6 presented adequate profiles, whereas for R = 8 the epithelium-tissue border was considerably blurred.

Conclusion

JOCS enables higher accelerations than GRAPPA for 3D carotid imaging, which may markedly reduce sensitivity to motion. Future work will explore the use of geometrically-oriented wavelets to further improve image sparsity.

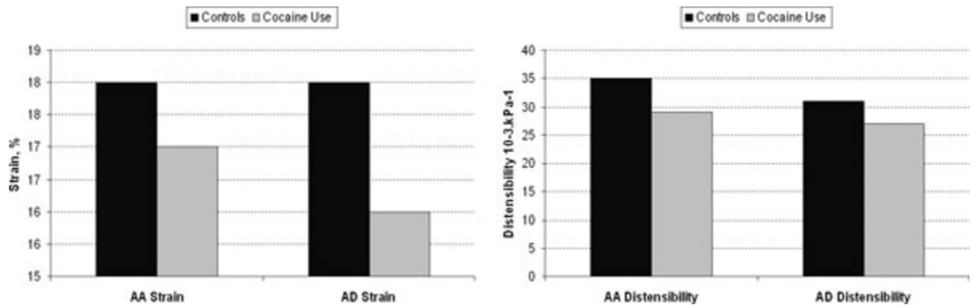

Figure 1

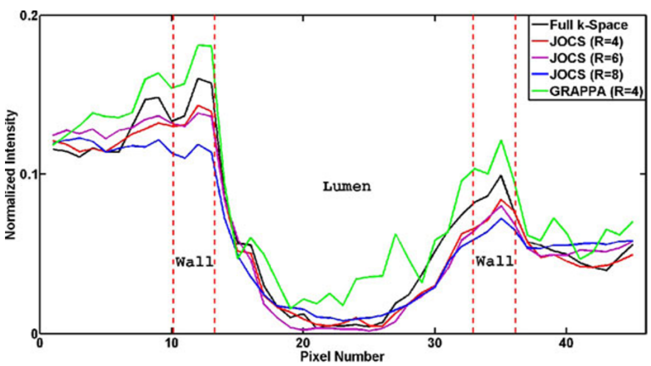

Fig. 2: Average of 3 adjacent intensity profiles through a carotid vessel. Red dotted lines denote the vessel wall boundaries.

Figure 2
Average of 3 adjacent intensity profiles through a carotid vessel. Red dotted lines denote the vessel wall boundaries.

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