Highly accelerated multi-contrast carotid imaging using sharable information

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TARGET AUDIENCE:

Scientists and clinicians interested in highly accelerated MRI.

PURPOSE:

For accurate depiction of carotid lesions, multi-contrast protocols are utilized in research and clinical application of carotid MRI[1]. The multi-contrast scheme usually requires long scanning time (30 min), thus scanning cost is high and image quality is vulnerable to patients' involuntary motions. Partially parallel imaging (PPI) has been applied to accelerate carotid imaging in previous works[2]. However, limited by the geometry of the receiver coils, the signal to noise ratio (SNR) of PPI accelerated carotid images is usually too low for diagnosis. In this work, sharable information from multiple contrast carotid images were extracted and applied to enhance PPI. The target is to achieve 3 times faster acquisition without degrading the diagnostic information.

METHODS:

In multi-contrast carotid imaging, 2D sequences (T1w: QIR[3], fast spin echo: 6min 11 sec, T2w: MDIR[4], fast spin echo: 3 min 40 sec) require longer acquisition time than 3D sequences (3D TOF: 2min 4sec, 3D MERGE[5]: 2min 26 sec, 3D MP-RAGE: 3min 14sec), thus these two multi-slice axial scans were used in the experiment. T2w images were first scanned with low acceleration factor (R=2, 1min 50sec) which is achievable using conventional PPI. T1w images were acquired with higher reduction factor (R=3,2min 4sec; R=4, 1min 33sec). Structural boundary information, implicit coil sensitivity and nonlocal graph weight were extracted from the T2w images. Spatially adaptive regularization weight was calculated from the boundary information. Then the T1w data was reconstructed using a nonlocal regularized SPIRiT algorithm[6,7].

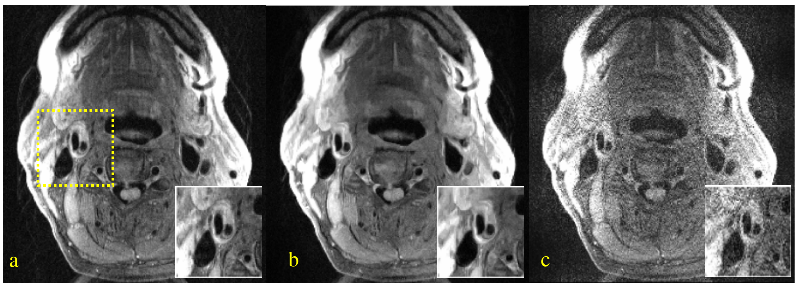

Fig. 1 Comparison of reconstruction performance of proposed method and GRAPPA when R=3. a) reference image; b) results of proposed method; c) GRAPPA results. Zoomed-in ROIs are shown in the right corner.

All data were acquired from four healthy volunteers and four patients on a Philips 3T system (Philips Healthcare, Best, the Netherland) with a homemade neurovascular coil which provides 11 channels for carotid imaging (2 elements in phase encoding directions). A conventional equally space acquisition scheme was used. One set of data were directly acquired from the scanner with reduction factor of 3, other sets of data were fully acquired and artificially under sampled. The images reconstructed with full k-space were used as the reference images. Images of patients reconstructed with different methods and different reduction factors (2 – 4) were rated by two licensed radiologists using a 4-point scale (1, low SNR limits use, arterial wall and vessel margins are unidentifiable; 4, high SNR with minimal artifacts, vessel wall, lumen and adventitial margins are well defined).

RESULTS:

Using the proposed method, the total acquisition time was dramatically reduced from 9 min 51 seconds to 3 min 54 seconds (R=3) or even 3 min 23 seconds(R=4). Fig. 1 shows the results of the proposed method and the traditional GRAPPA with artificially under sampled patient data. As shown in Fig. 1, GRAPPA results are so noisy that the image structures are not distinguishable. However, images with high CNR and sharp vessel wall boundaries are achieved by the proposed method. Fig. 2 shows the results of the proposed method using data partially acquired from the scanner, demonstrating its feasibility of clinical application. Table 1 shows the average scores provided by radiologists, indicating that with reduction factor of 2, the proposed method can achieve similar image quality as the reference image and with higher reduction factor, image quality is mostly preserved. On the contrary, GRAPPA fails to give satisfactory results with R=2 and lost diagnostic value with higher reduction factor.

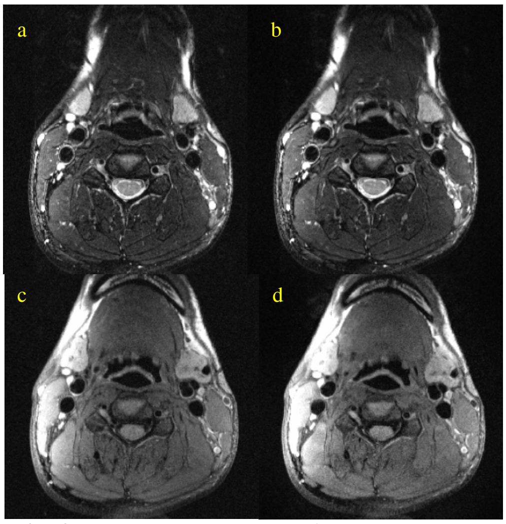

Fig. 2 a) T2w and c) T1w are images reconstructed with fully acquired data. b) and d) are images reconstructed with partially acquired data (T2: R=2, T1: R=3) using the proposed method.

DISCUSSION

By using the sharable information among images with different contrast, the implicit coil sensitivity maps were accurately extracted. Moreover, the spatially adaptive regularization parameter calculated from the sharable structural information can help to protect fine structures when regularization was applied in the reconstruction. In the proposed method, data were under sampled uniformly, thus it can be directly implemented into clinical application with minor requirement for sequence modification.

Table. 1 Image quality (1: worst, 4: best) obtained from the proposed method is compared with GRAPPA and reference images(R = 1)

		R = 1	R= 2	R= 3	R= 4
T2	Proposed Method	3.21±0.49	2.79±0.75	N/A	N/A
	GRAPPA	3.21±0.49	2.00±0.52	N/A	N/A
T1	Proposed Method	3.54±0.65	3.21±0.58	2.71±0.54	2.63±0.64
	GRAPPA	3.54±0.65	2.08±0.51	1.08±0.19	1.00±0.00

CONCLUSION:

In conclusion, application of sharable information in carotid PPI may bring major impact to reduce the cost while preserving or even improving the image quality.

ACKNOWLEDGEMENT:

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