Parallel Imaging with concomitant motion compensation of the Carotid vessel wall at 3T

R. T. Seethamraju[1], G. C. Wiggins[2], K. Furie[3], R. Cury[4], and D. Hinton-Yates[2]

[1]MR R and D, Siemens Medical Solutions, Malden, MA, United States, [2]Athinoula A. Martinos Center for Biomedical Imaging, Charlestown, MA, United States, [3]Neurology, Massachusetts General Hospital, Boston, MA, United States, [4]Radiology, Massachusetts General Hospital, Boston, MA, United States

Objective

The aim of this work is to assess the impact of signal averaging with iPAT for motion compensation and noise reduction on 3.0T carotid images. The measure of vessel wall area obtained from the segmentation of 3.0 T black blood images was utilized as the bench mark image metric. The overall research endeavor is to obtain high resolution segmentable images so as to ultimately provide biomarkers on the stage and stability of atherosclerotic disease for clinical decision making and therapeutic agent trials.

Introduction

At 3.0T the SNR gain improves spatial resolution which in turn will improve quantitative image analysis and reproducibility. However imaging small anatomical structures as the carotid artery wall demands high resolution that puts a premium on acquisition time. Even at 3T, where signal averaging requirements can potentially be reduced, the total acquisition time has sufficient motion that can blur these small anatomical structures. A potential method to compensate temporal demands is to use parallel imaging techniques like iPAT which will reduce the acquisition times. This approach has not been investigated for small FOV applications but may be an approach to compensate motion such as that arising from breathing, swallowing and vessel pulsatility, however this compensation comes at price. The SNR gain at 3T is lost with the use of parallel imaging techniques. Here we propose to use signal averaging with iPAT to compensate for the noise and thereby boost the loss of noise from iPAT.

Methods

Four male subjects ranging in age from 28 to 45 participated upon giving informed consent with all studies conducted according to institutional IRB guidelines. All subjects were imaged on a 3.0T Siemens TRIO using an in-house constructed unilateral four-channel array receiver coil. The parameter ranges for axial carotid images using double inversion (black blood) TSE were 9 ETL, 12 cm FOV, 320x320 matrix, ECG trigger 1 R-R for TR, TE= 12 ms (T1). EKG triggering was used for all black blood scans and the double inversion time delay varied in the range of 400-600 ms depending on heart rate. A single reader performed the image analysis using both manual and semi-automated segmentation routines.

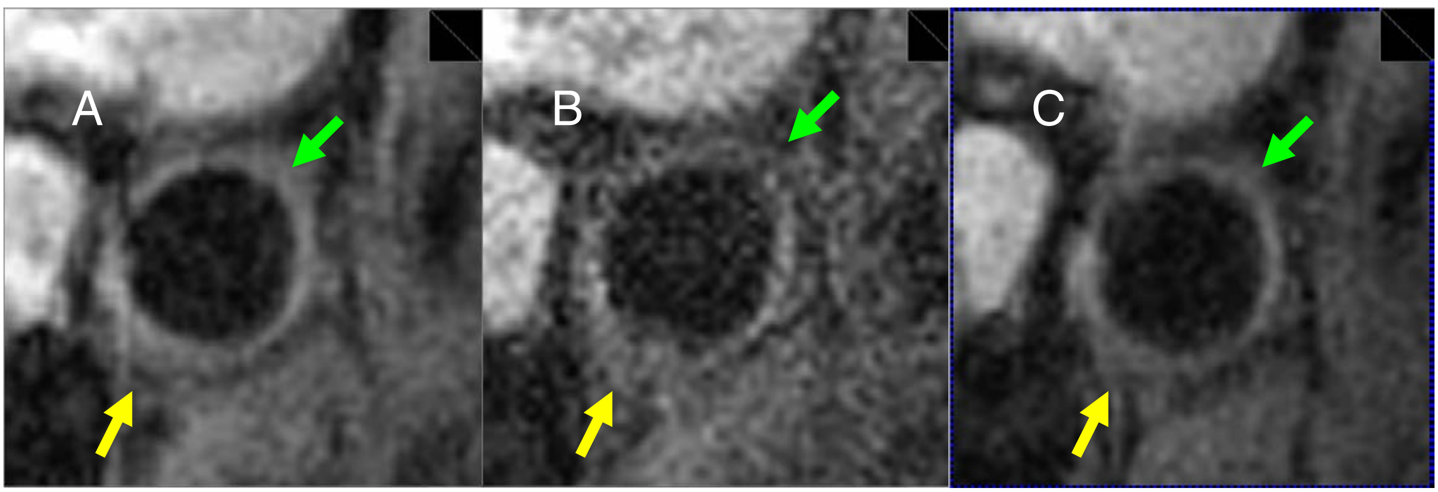

Fig 1. 3T axial images of the carotid artery. (A) TSE T1 weighted image with no iPAT and Nex=1, (B) TSE T1 weighted image with iPAT=2 and Nex=1 and (C) TSE T1 weighted image with iPAT=2 and Nex=2. Green and yellow arrows indicate regions of vessel wall that show improvement with iPAT=2 and Nex=2.

SNR	iPAT=0 Nex=1 TA=33.8ms	iPAT=2 Nex=1 TA=16.9	iPAT=2 Nex=2 TA=31.7
Vessel wall	31.26	2.12	30.78
Lumen	7.85	2.64	4.54
CNR	23.40	-0.52	26.24

Table 1. SNR and CNR comparison between the Vessel wall and Lumen for all three cases considered here.

Results

Fig 1 shows axial images of the carotid artery taken in a 27 year old male subject with and without iPAT (acceleration factor 2). In 1A, no iPAT or signal averaging was applied compared to 1B and 1C that use iPAT, with 1Nex and 2Nex, respectively. Table 1 compares the SNR and CNR between the vessel wall and lumen for the images in Fig 1. For this table, the vessel wall ROI was generated for a region indicated by the green arrow which corresponding to the region of the lowest overall contrast as in Fig. 1B (iPAT and Nex=1) to demonstrate the signal gain or loss emphatically. The ROI for the lumen was placed within the center of the lumen, and the noise the ROI was placed entirely in the air filled region of the trachea where there is no signal. Clearly seen from the images, the trend in SNR and CNR is that they drop considerably with iPAT and no signal averaging even though the imaging time is reduced by nearly one-half. On the other hand signal averaging in the iPAT acquisition not only boosts the SNR in the vessel wall to almost the same extent of the image with no iPAT, it also further suppresses the lumen signal thereby boosting wall-lumen contrast. The vessel wall boundaries are more well-defined in the case of iPAT with 2 Nex when compared to no iPAT. The reason is the amount of motion in the acquisition of each Nex is considerably reduced in the iPAT case as opposed to the motion in the full acquisition. The signal averaging boosts both the SNR and CNR which was realized in application of automated segmentation. The lumen was reasonably well segmented in all cases, however the algorithm failed in all cases except for the image data acquired with iPAT and signal averaging.

Conclusion

We conclude from this preliminary analysis that iPAT has an important potential application for motion compensation in high resolution applications.

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