Parallel imaging of the upper airway with a novel 16-channel tongue coil

Y.-C. Kim[1], C. E. Hayes[2], S. S. Narayanan[1], and K. S. Nayak[1]

[1]Ming Hsieh Department of Electrical Engineering, University of Southern California, Los Angeles, CA, United States, [2]Department of Radiology, University of Washington, Seattle, WA, United States

Introduction: Recently, Hayes et al. proposed novel designs for 12- and 16-channel tongue coil arrays and demonstrated their ability to improve tongue SNR [1]. The coil array provides highly localized sensitivity that includes the tongue and upper airway. In this work, we measure and analyze the SNR and g-factor of the 16-channel tongue coil for several tissues of interest, in a mid-sagittal scan plane. We examine the feasibility of parallel imaging using undersampled 2DFT and 2DPR with a range of acceleration factors.

Methods: Experiments were performed on a GE Signa HDx 3.0T MRI scanner. Three coils were compared: single-channel birdcage transmit/receive coil, 8-channel neurovascular (NV) array receive-only, and 16-channel tongue array receive-only. Imaging parameters were: 3DFT gradient echo, TE=2.1 ms, TR=3.9 ms, $1.88 \times 1.88 \times 2.50$ mm^3 spatial resolution, $24 \times 24 \times 18$ cm^3 FOV. The subject held their mouth closed without swallowing during each 30 second scan. The noise covariance matrix was calculated from data acquired with the RF turned off. Coil sensitivity maps for each coil element were calculated by dividing each coil image by a body coil image. Nine ROIs (see Table 1) were selected and their SNR/g-factors were evaluated separately with respect to different reduction factors R=1 to 6. For Cartesian SENSE, the phase encode direction was anterior-posterior (A-P), SNR was calculated using the B1 weighted combining method [2,3], and g-factors were calculated pixel-by-pixel [4]. For radial SENSE, g-factor maps were determined via Monte-Carlo simulation [5]. A k-space dataset with white Gaussian noise was generated for each coil element and image was reconstructed based on an iterative conjugate-gradient algorithm [6]. The iterative reconstruction was terminated at the 50th iteration. This process was repeated 200 times. The g-factor map was taken as the standard deviation of the pixel values of the images resulting from all 200 realizations [5].

Results: Table 1 shows SNR values for 9 different ROIs with 3 different coil arrays. The 16-ch tongue coil produced an 8.8-fold and 19-fold increase in the SNR of the lower lip ROI over the 8-ch NV and birdcage coil, respectively. A 9.3-fold SNR drop-off was observed from lower lip to pharyngeal wall (i.e., the A-P direction) in the 16-ch tongue coil. Figure 1 shows g-factor values for 2DFT and 2DPR trajectories with 8-ch NV array and 16-ch tongue array. The g-factor values for 2DFT were substantially lower for the 16-ch tongue array compared to the 8-ch NV array (e.g., the average g-factor was 40% lower for reduction factor 4). The g-factor values for 2DPR were lower than those for 2DFT for both the 8-ch NV and 16-ch tongue coils. Figure 2 contains images reconstructed via SENSE (R=4) from the Cartesian sampled data. Compared to the 8-ch NV image the 16-ch tongue array image exhibits substantially higher SNR and overall image quality.

Discussion: The 16-ch tongue coil has provided substantial improvement in SNR compared to existing coils and produced acceptable image quality with a SENSE reduction factor 4 when using 2DFT trajectories. The use of this coil will significantly improve MRI for speech production research and other investigations of the upper airway. The use of 2DPR or other non-Cartesian trajectories with parallel imaging may be useful for improving the spatio-temporal resolution of real-time MRI of speech [7].

References: [1] Hayes et al., ISMRM, p449, 2007, [2] Kellman et al., MRM:54:1439-1447, 2005, [3] Roemer et al., MRM:16:192-225, 1990, [4] Pruessmann et al., MRM:42:952-962, 1999, [5] Eggers et al., ISMRM, p2429, 2005, [6] Pruessmann et al., MRM:46:638-651, 2001, [7] Narayanan et al., J.Acoust.Soc.Am.:115(4):1771-1776, 2004.
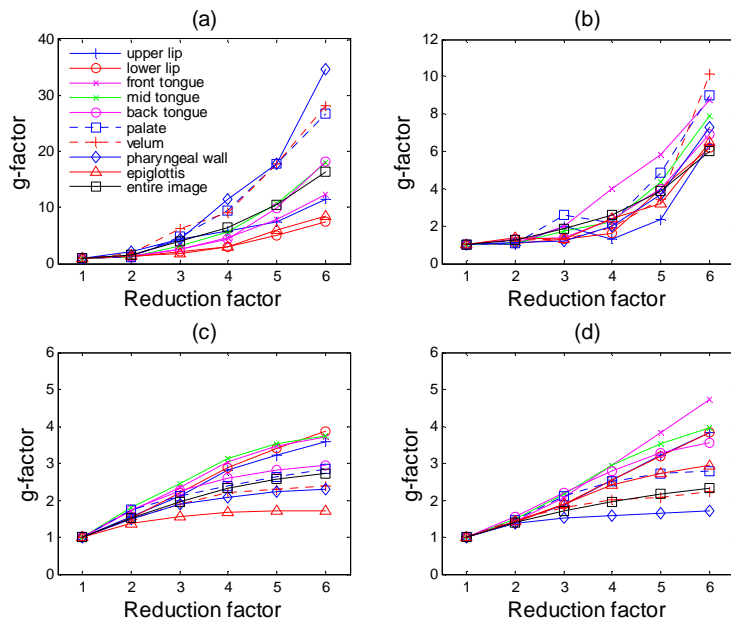
Figure 1. g-factor values for (a) 2DFT with 8-ch NV array, (b) 2DFT with 16-ch tongue array, (c) 2DPR with 8-ch NV array, (d) 2DPR with 16-ch tongue array.

	Birdcage	8-ch NV	16-ch tongue
Upper lip	20.92	46.64	242.11
Lower lip	20.66	44.74	391.65
Front tongue	19.65	35.98	196.26
Mid tongue	22.19	34.09	119.21
Back tongue	20.53	32.47	83.37
Palate	30.85	50.30	97.22
Velum	29.12	42.20	83.22
Pharyngeal wall	20.94	28.27	42.22
Epiglottis	12.92	20.20	65.41

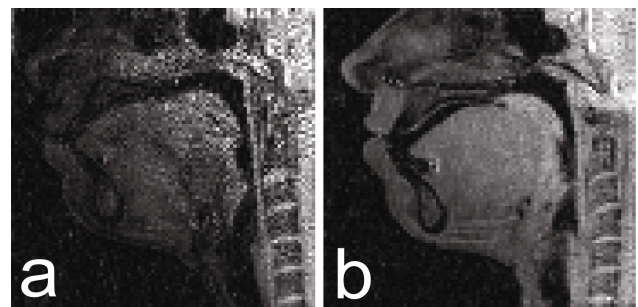**Table 1.** SNR for birdcage head coil, 8-ch NV array, and 16-ch tongue coil for R=1.

Figure 2. Reconstructed images using SENSE with a reduction factor 4. (a) 8-ch NV array and (b) 16-ch tongue array.