The SNR Advantage of Radial GROWL vs. Cartesian Parallel Imaging

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Introduction

When compared with conventional Cartesian acquisitions, non-Cartesian (e.g. radial and spiral) MRI methods provide advantages in ability to achieve higher temporal-resolution [1], ultra-short echo time [2] and reduction of motion artifacts [3]. Non-Cartesian parallel imaging methods provide the additional benefits of shorter scan time. Recently, a rapid self-calibrated non-Cartesian parallel imaging method, generalized GRAPPA Operator for Wider readout Lines (GROWL), has been developed and applied to both radial and spiral acquisitions [4,5]. In this work, it is demonstrated that parallel imaging with radial GROWL provides a SNR advantage vs. Cartesian SENSE, due to the ability to use coil sensitivity profiles along orthogonal directions and easy noise regularization.

Methods

The principle of radial GROWL is shown in Fig. 1. For an undersampled radial dataset, a set of GROWL operators are calibrated using fully sampled central k-space circle (Fig. 1a), allowing estimating data on lines parallel to acquired radial line (Fig. 1b) and therefore filling up the entire k-space (Fig. 1c). A k-space adaptive Tikhonov regularization strategy can be used to achieve an optimal balance between accurate data estimation and noise amplification [4,5].

The G-factor maps for SENSE and GROWL reconstruction were evaluated in a Monte Carlo simulation [6]. A noise-free T₁-weighted brain MR image (Fig.2a) was downloaded from a database (http://www.bic.mni.mcgill.ca/brainweb/). The complex sensitivity of a head coil with eight cylindrically spaced elements was computed using an analytic Biot-Savart integration (Fig.2b). The k-space data was generated with Fourier Transform and inverse regridding. In each of 100 iterations of the Monte Carlo simulation, Gaussian distributed random noise was added to each channel, resulting in a noise standard deviation in the range of 0.1% - 10.0% of the white matter signal intensity with a sum-of-square reconstruction for a fully sampled k-space. The g-factor map and root-mean square error (RMSE) were computed for SENSE and GROWL reconstruction.

The performance of GROWL with k-space adaptive regularization [5] was further examined with an in vivo brain study. A healthy volunteer was scanned on (Achieva, Philips, the Netherlands) using an 8-channel standard deviation in the range of R=8 (32 views) radial acquisition by removing slice-encoding gradients, while rotating different directions. A GROWL operator is calibrated for each radial direction, using a fixed regularization factor throughout k-space [4] (Fig. 3b). The GROWL principle of radial GROWL. (a) Undersampled radial data with a fully sampled central k-space circle that can be used for calibration. (b) A GROWL operator is calibrated for each radial direction, allowing estimating data on lines parallel to the acquired radial line. (c) The k-space coverage after applying GROWL operators.