The effect of coil types and GRAPPA acceleration in HARDI and probabilistic fibertracking

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Background: The head coils for *in vivo* human brain MRI have been progressively developed with increasing number of channels with parallel imaging to achieve higher image signal-to-noise ratio (SNR) and faster acquisition time. This results in an increase of image quality with a reduction of geometrical distortions in EPI sequences. Such characteristics are particularly useful for FMRI studies where fast acquisition is desired (*1*). However, little is known about the effects of coil type and acceleration factor to the accuracy of fibertracking of the whole brain. The 12-channel (12Ch) coil has the advantage that it can produce deep brain penetration and thus produces more uniform SNR throughout the brain. The 32-channel (32Ch) coil has higher brain surface SNR, less signal penetration but can achieve faster parallel imaging acquisition (*1*).

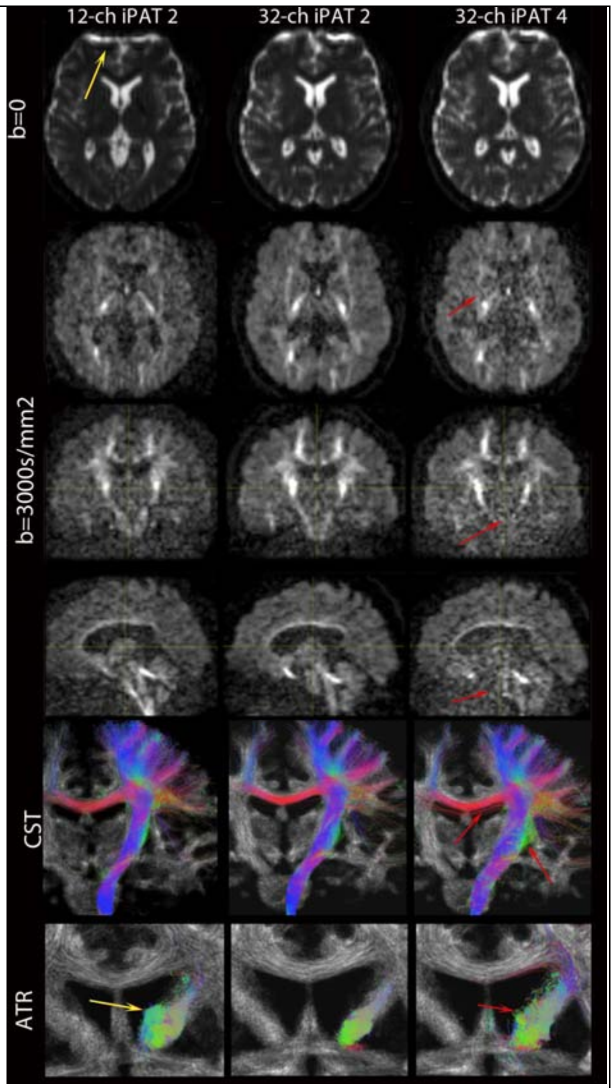

Figure 1. The effects of coil types and GRAPPA acceleration to DWI-EPI and probabilistic fibertracking.

Purpose: The aim of this study is to determine the effect of 12Ch and 32Ch coils and GRAPPA acceleration factor (iPAT2 and 4) to the data analysis of diffusion data using constrained spherical deconvolution (CSD) and probabilistic fibertracking.

Methods: Diffusion-weighted imaging data of 3 healthy adult subjects was acquired using a Siemens 3T Trio Tim MR scanner (Siemens, Erlangen, Germany), equipped with a TQ-engine of 45mT/m a slew rate of 200T/m/s.

High angular resolution diffusion-weighted images (HARDI) were acquired using a twice-refocused bipolar diffusion spin-echo sequence, with 2.5 mm isotropic resolution, TE/TR = 112/9400ms, partial FT acceleration 6/8, 64 diffusion gradients with the b= 3000 s/mm^2. The acquisition time for HARDI with GRAPPA iPAT2= 10min 41s and iPAT4=9 mins 44s.

HARDI data was processed using MRtrix 0.2.10, with CSD l_{max}=8, full-length fibertracks were generated using step size = 0.25 mm, curvature = 45 degrees, FOD cut off 0.1, min/max track length 5/250 mm (*2*). ROIs were drawn in a directionally color-encoded FA image and registered to the other datasets using FSL linear registration with ten thousand long-streamlines were produced in each ROI. For short tracks TDI (stTDI), five millions streamlines were calculated per brain, max track length = 25 mm, and grid size = 0.25 mm.

Results: Comparison of DW image datasets showed that the 32Ch iPAT2 produces superior overall image quality throughout the brain. DW images acquired with 32Ch iPAT4 produce poor SNR in the thalamic, mid/hind brain and cerebellum regions (red arrows). DW images acquired with 12Ch iPAT2 produces reasonable SNR, but suffers from strong inhomogeneity artifacts near the sinuses and prefrontal cortex.

CSD probabilistic fibertracking shows that the 32Ch iPAT2 datasets produced robust white matter streamlines throughout the brain. For example, structures such as the anterior thalamic radiation (ATR) and cortico-spinal tracts (CST) are well delineated with no erroneous streamlines outside the pathway margins. In contrast, there is an increased number of aberrant streamlines in the 32Ch iPAT 4 and 12Ch iPAT2 datasets (yellow and red arrows).

Conclusion: Coil types and acceleration factors are important factors that influence the results of quantitative diffusion fibertracking. The increasing number of false aberrant tracks offsets the shorter acquisition time and inhomogeneity artefacts when HARDI data was acquired using larger number of acceleration factors. Nonetheless, sufficient number of acceleration factor is required to achieve short echo-train-length to consequently produce higher SNR and lower inhomogeneity artifacts.

References: (1) Kaza E, Klose U, Lotze M. *Comparison of a 32-channel with a 12-channel head coil: are there relevant improvements for functional imaging?* JMRI : JMRI. 2011;34(1):173-83. (2) Calamante F, Tournier JD, Heidemann RM, Anwander A, Jackson GD, Connelly A. *Track density imaging (TDI): validation of super resolution property*. Neuroimage. 2011;56(3):1259-66.