SENSE Factor Optimization for Diffusion Tensor Imaging of the Human Brain at 7T

S. Sammet[1], R. Koch[1], O. M. Irfanoglu[1], P. Schmalbrock[1], R. Machiraju[2], and M. V. Knopp[1]

[1]Department of Radiology, The Ohio State University, Columbus, OH, United States, [2]Computer Science and Engineering, The Ohio State University, Columbus, Ohio, United States

Introduction

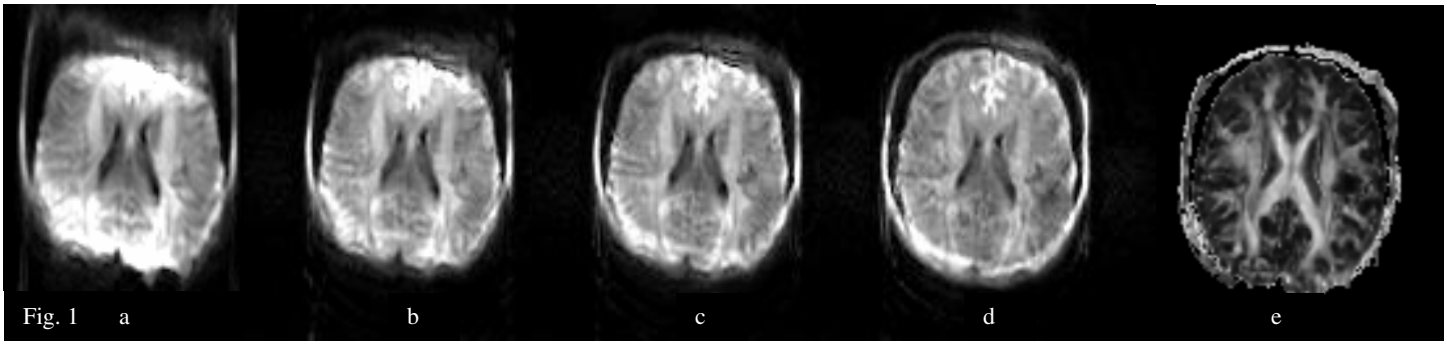
Diffusion Tensor Imaging (DTI) allows the observation of molecular diffusion in tissues in vivo and therefore assessment of the structural organization. While holding vast potential, DTI with single-excitation protocols still faces serious challenges: limited spatial resolution, susceptibility to magnetic field inhomogeneity, and low signal-to-noise ratio (SNR) are the most prominent limitations. These shortcomings can be effectively mitigated by the transition to parallel imaging technology and high magnetic field strength [1]. DTI using the parallel imaging technique SENSitivity Encoding (SENSE) improves image quality at ultra-high magnetic fields [2, 3]. The aim of this study was to optimize the SENSE factor for in-vivo DTI and fibertracking of the human brain at 7T.

Material and Methods

DTI of the human brain was performed on 6 volunteers on a 7T whole body MR-scanner (Achieva, Philips Medical Systems, Cleveland, OH) using a prototype 8 channel SENSE head coil. DTI was performed with different SENSE factors: 1, 1.5, 2 and 3 with the following acquisition parameters: TR=3600; TE=74; FOV=230; matrix size=128x128; b=0, 250, 500, 750, 1000; slice thickness=3mm and NSA=2. To reduce motion artifacts in the DTI images the datasets were post-processed with Diffusion Registration Rel-0.4 of Philips' Research Imaging Development Environment (PRIDE). From the processed DTI datasets, tracts representing fibers were reconstructed using FiberTracking V4.1 (PRIDE).

Results

DTI at 7T provides high quality diffusion weighted images when using SENSE. To reduce possible susceptibility artifacts a second order shim before the data acquisition is necessary. SENSE was shown to improve the acquisition speed and to reduce susceptibility and distortion artifacts in 7T DTI (Fig. 1a-d). A SENSE factor of 3 provided images with the least distortions (Fig. 1d) and allowed to create high quality Fractional Anisotropy maps (Fig. 1e) and to create fibertracks of the human brain in-vivo at 7T (Fig. 2 and Fig. 3).



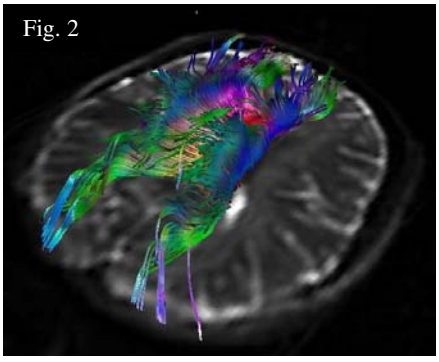
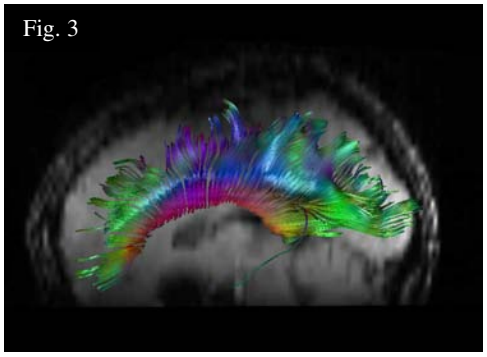


Fig. 1 DT Images of the brain of a human volunteer with increasing SENSE factors: a) SENSE=1; b) SENSE=1.5; c) SENSE=2; d) SENSE=3; e) Fractional Anisotropy map with SENSE=3.

Fig. 2 7T fibertracking of the brain of a human volunteer on a transverse slice.

Fig. 3 7T fibertracking of the brain of a human volunteer on a reconstructed sagittal slice.



Discussion

Diffusion tensor imaging is an emerging and promising tool to provide information about the course of white matter fiber tracts in the human brain. Fiber tractography using high-quality SENSE-DTI data from ultra high fields provides a promising method for exploring the neuronal connectivity of the brain. DTI at ultra high fields can be applied to study white matter diseases (MS, PML, leukodystrophies) and other diseases like brain tumors that affect the integrity of white matter structures.

Literature

[1] Jaermann T, Crelier G, Pruessmann KP, Golay X, Netsch T, van Muiswinkel AM, Mori S, van Zijl PC, Valavanis A, Kollias S, Boesiger P.: SENSE-DTI at 3 T. Magn Reson Med. 51(2):230-6 (2004).

[2] Sammet S, Koch RM, Schmalbrock P, Duraj J, Thompson MR, Knopp MV: Diffusion Tensor Imaging and Fiber Tracking of the Human Brain using SENSE at 7T. Society of Molecular Imaging, 5th Annual Meeting. Hawaii, USA: SMI (2006).

[3] Sammet S, Koch RM, Schmalbrock P, Duraj J, Thompson MR, Knopp MV: Diffusion Tensor Imaging and Fiber Tracking of the Human Brain using SENSE at 7-T RSNA (2006).