

High spatial-resolution DTI using 32 channel head coil at human 7 T

H.-K. JEONG^{1,2}, J. C. GORE^{1,2}, and A. W. ANDERSON^{1,2}

¹Vanderbilt University Institute of Imaging Science, Nashville, TN, United States, ²Radiology and Radiological Sciences, Vanderbilt University, Nashville, TN, United States

INTRODUCTION: Diffusion tensor imaging (DTI) is very valuable for providing information on the microscopic structure and changes in white matter based on detecting variations in water molecular diffusion. A main technical difficulty is to maintain high sensitivity to microscopic motion while reducing the effects of more macroscopic motions e.g. subject bulk movements. For this reason, diffusion-weighted (DW) single-shot (ssh)-EPI sequences combined with parallel imaging and partial Fourier acquisitions have been the most frequent choice for DTI (1). However, this method suffers significant geometric distortions because it employs low phase-encoding bandwidth, and the spatial-resolution is reduced because of T2* decay during the long echo-train used. For high spatial-resolution DTI, therefore, a multi-shot (msh) approach is required that corrects the motion-induced phase variations that occur during the application of the diffusion encoding gradients. Recently, we suggested methods for the acquisition and reconstruction of DW data using a dual spin-echo DW msh-EPI sequence with 2-D navigator and a column-by-column image reconstruction algorithm, and demonstrated the use of this with a 16 receive-channel head coil on a human 7 T scanner (2). This acquisition and reconstruction scheme is capable of high spatial-resolution DTI with accelerated acquisition (SENSE (3) for both image- and navigator-echo) and reduced memory requirement (matrix inversion of $N \times N$, rather than $N^2 \times N^2$). In this study, we evaluate the new method using a 32 receive-channel head coil and compare the ssh and proposed msh approach.

METHODS: Diffusion-weighted data were acquired using a 7 T Philips Achieva whole body scanner with 32 channel head coil. Scan parameters are; single-shot: TR/TE 9423/59 ms, voxel size (r/p/s) 2.0/2.05/2.0 mm, partial Fourier factor 0.68, echo-train 41, NSA 2; multi-shot: TR/TE 2878/73 ms, voxel size (r/p/s) 0.8/0.9/5.0 mm, echo-train 13, shots 7, NSA 3; common: FOV 240×240, SENSE factor 3. Highly aliased image-echo image data (due to msh and SENSE) are reconstructed for each image column using the new algorithm (2). All image reconstructions and calculations are performed off-line using Matlab (R 7.7, MathWorks, Natick, MA).

RESULTS: Figure 1 shows a typical diffusion-weighted brain image, FA map and a magnified ROI obtained using ssh (a,c,e) and the proposed msh (b,d,f) acquisitions, respectively. With a 32 channel head coil, the image SNR is much better for both the ssh and msh results than with the 16 channel coil (not shown). As expected, however, ssh results (a,c,e) show much larger geometric distortions and blurring artifacts than msh results (b,d,e). The magnified FA (Fig.1f) shows details within the small white matter fiber bundles using the new approach, whereas ssh FA (Fig.1e) shows significant blurring of fiber structures, even with SENSE and partial Fourier acquisition. The blurring in the ssh image cannot be reduced with more averaging unless echo-train is reduced.

DISCUSSION and CONCLUSION: High spatial-resolution DTI data may be acquired and reconstructed using the new method with a 32 channel head coil at 7 T. With increased number of coil-elements, ssh DW images and FA maps can be generated with much improved SNR than when using a 16 channel coil, albeit the blurring artifact is the same. Our approach provides high spatial-resolution DW images and FA maps with negligible distortions and blurring effects, and these results suggest that we can delineate small white matter fiber structures at sub-millimeter resolution using a 32 channel coil, even in regions of low relative B₁.

ACKNOWLEDGEMENT: This work is supported by an NIH Bioengineering Research Partnership (BRP) grant (RO1 EB000461).

REFERENCES: [1] Bammer *et al.*, MRM 2002;48:128-136. [2] Jeong *et al.*, ISMRM 2010 p1616. [3] Pruessmann *et al.*, MRM 1999;42:952-962.

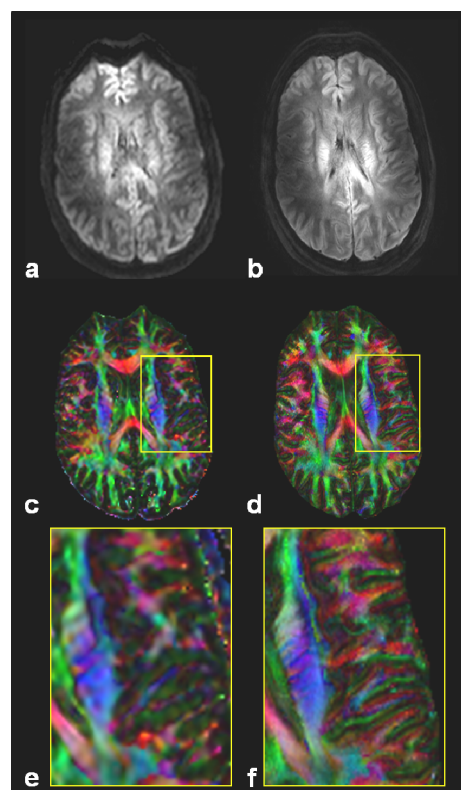


Figure 1. Diffusion-weighted images (a,b), FA maps (c,d) and magnified ROIs (e,f) drawn in the FA maps for ssh (a,c,e) and suggested msh (b,d,f) acquisitions.