A Comparison of White Matter Fiber-Tracking Results Using PROPELLER and SE-EPI Datasets.

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Introduction: Diffusion tensor imaging (DTI) can be used to visualize, non-invasively, the white mater fiber bundles by means of fiber tractography [1]. In contrast to conventional EPI-based DTI, PROPELLER-DTI offers images that are free from susceptibility artifacts. Therefore, white matter fiber tracking using PROPELLER-DTI may provide images of fibers that better match real anatomy. We have adopted the PROPELLER and SE-EPI sequences and compared different fiber tracking results. Fiber tracts on PROPELLER acquisitions were coherent and undistorted even in regions with field inhomogeneities.

Methods: In this study, all scans were performed on a GE 3.0T MRI scanner. The scanning parameters for the SE-EPI-DTI acquisition were TR = 5400ms, TE = 71.8ms, FOV = 24cmx24cm, 256x128 image matrix reconstructed to 256 x 256. High-order shimming was applied to reduce susceptibility artifacts. For PROPELLER-DTI, the parameters were TR = 8700ms, FOV = 24cmx24cm, 16 lines/blade, 190 samples/line reconstructed to a 256 x 256 image matrix[1]. In both scans, the same 18 axial slices were prescribed, slice thickness was 3mm, b=1000s/mm², NEX=5, and 6 diffusion directions were used based on the icosahedral scheme [2]. All datasets were interpolated to cubic voxels (0.9375mmx0.9375mmx0.9375mm). In SE-EPI-DTI, eddy current distortions were corrected by registering all DW images to the mean DW image using a 6-parameter 2-D registration algorithm [3]. Raw PROPELLER DTI images were low-pass filtered. SE-EPI-DTI images contained less noise and were not filtered. Diffusion tensors, primary eigenvectors and eigenvalues, and fractional anisotropy (FA) values were estimated in every voxel. White matter tracking was performed using the FACT (fiber assignment by continuous tracking) algorithm [4]. Seed voxels were placed in similar regions in both PROPELLER and SE-EPI datasets. Tracking results from the cortico-spinal tract, U-fibers of the frontal lobe and temporal lobe fibers were compared between PROPELLER-DTI and SE-EPI-DTI.

Results: In regions distant from severe magnetic field inhomogeneities, fiber tracking results based on SE-EPI and PROPELLER were similar (Fig.1). In regions suffering severe distortions and signal loss, such as the frontal and temporal lobes, fiber tracts based on SE-EPI-DTI acquisitions were distorted and oftentimes not detected. In contrast, fiber tracking based on PROPELLER datasets, provided additional fibers in the frontal and temporal lobes that were not traced using SE-EPI. Also, fibers obtained using PROPELLER were undistorted and appeared to match the anatomy (Fig.2). In the temporal lobes, SE-EPI fiber tracking data resulted in fibers that appeared somewhat random. The same fibers using PROPELLER data were more coherent (Fig.3).

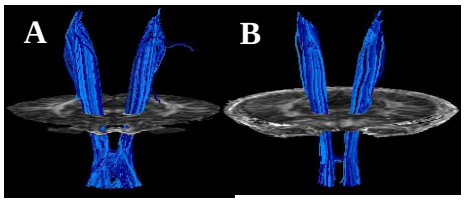


Fig.1. Fiber tracking based on SE-EPI (A) and PROPELLER (B) data shows similar results in the cortico-spinal tracts. (Note: only the inferior part of the brain was imaged.)

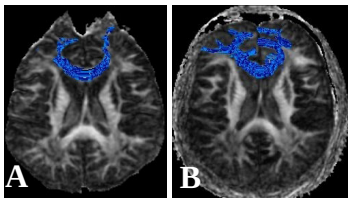
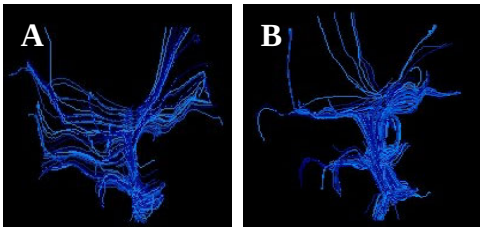


Fig.2. U-fibers of the frontal lobe traced using SE-EPI (A) and PROPELLER (B) data. More fibers were traced in (B). Fibers in (B) appeared undistorted and matched the anatomy.

Discussion: PROPELLER-DTI datasets allow more anatomically accurate tracking of the white matter fibers in regions with field inhomogeneities than data acquired with SE-EPI. This may be of significant importance for pre-surgical planning and other clinical applications. The only drawback of PROPELLER-DTI is the fact that the total acquisition time is longer than SE-EPI-DTI. However, acquisition times can be reduced using advanced MR imaging techniques such as sensitivity encoding [5].



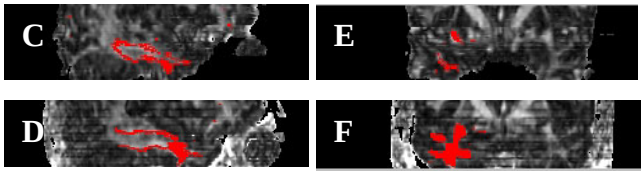


Fig.3.Fibers of the left temporal lobe traced using SE-EPI (A) and PROPELLER (B) data. In (A) fibers are distorted and somewhat random while in (B) they are more coherent. Sagittal (C, D) and coronal (E, F) slices of the fiber tracts shown in (A) and (B) demonstrate the different fiber tracking results obtained using SE-EPI and PROPELLER data respectively.

References:

1. Pipe JG, Farthing VG, Forbes KP, Magn Reson Med, 47: 42-52 (2002)
2. Hasan KM, Parker DL, Alexander AL, J Magn Reson Imag 13: 769-780 (2001)
3. Woods RP, Grafton ST, Holmes Cj, Cherry SR, Mazziotta JC, J Comp Assist Tomogr, 22: 141-154 (1998)
4. Mori S, Crain B, Ann Neurol, 45: 265-269 (1999)
5. Pipe JG, Proceedings of the 11th Annual Meeting of ISMRM, Toronto, Canada, 2003, p.66