Advantages of parallel imaging for DTI-based fiber tracking at 3T

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Introduction

Diffusion Tensor Imaging is a technique that can be used to visualize nerve fiber bundles and to quantify their structural integrity. It has been shown that DTI-based fiber tracking (FT) is extremely dependent on reconstruction- and imaging parameters among others the signal to noise (SNR) of the data (1). High field strength has the potential of increasing SNR but it also increases B_0 inhomogeneities. Such distortions in the B_0 field homogeneity are evident at the skull base, but more subtle distortions may result in aberrant fiber representation. Using parallel imaging techniques, this distortion can be strongly reduced. Moreover, at higher field strengths, potentially higher parallel imaging factors can be used (2). Here, we evaluated the effect of parallel imaging on FT and quantification of fiber integrity using a previously introduced automated ROI-analysis (3)

Methods

We included 20 healthy volunteers in this study. All were scanned using a 3T scanner (Tim Trio, Siemens Erlangen) and a standard 12 channel head coil, gradient strength 40 mT/m. Imaging was performed using no parallel imaging and accelerations factors of 2, 3 and 4 with GRAPPA reconstruction. We used a SSEPI: TR/TE (nopat, 2/3/4 pat): 9200/127; 6600/95; 6000/89; 5600/84, FOV 320 mm, matrix of 128x128, 50 axial slices, thickness 2.5 mm, 12 gradient directions and two b-values (0 and 1000 s/mm^2). Additional axial FLAIR imaging was performed for anatomical overlay. All data was processed using NeuroQlab (MeVis, Bremen). Quantification of fiber integrity in the corpus callosum (CC) was performed as previously described (3). All individual exams were aligned and identical ROIs were placed at different anatomical locations for the reconstruction of the corona radiata, the superior cerebellar peduncle and the optic radiation. Identical tracking parameters were used for all fiber representation: FA threshold 0.05, inner product 0.3.

Results

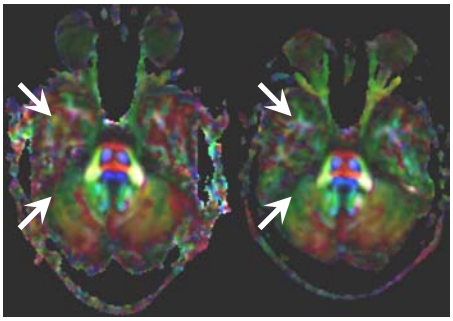

Fig. 1: Reduced distortion using PI 3x (R) compared to no PI (L). Note the improved fiber delineation in the temporal lobes and the reduced distortion at the skull base.

Visual inspection of the data revealed a large reduction of gross distotion artifacts at the skull base and the frontal lobes using PI (Fig. 1) Moreover up to acceleration factors of 3, the image quality was excellent but at higher accelerations, distortion was unacceptable. The datasets with PI up to 3 showed a marked increase in fiber deliniation on the 2D colormaps (Fig 1). In all subjects, fiber tracking showed an increased number of fibers and better delineation of the full fiber structure when comparing PI (2 and 3) with no PI (Fig. 2). We also noted that structures at the skull base, for instance the superior cerebellar peduncle showed a markedely improved delineation (Fig 3). Fiber integrity measurements of the CC did not differ significantly for PI and non PI up to a factor of 3, at a factor of 4 the fractional anisotropy decreased substantially due to marked loss of signal.

Discussion

The potential value of PI for DTI has been reported several times and has been evaluated on 2D colormaps. Here we show the marked improvement of PI on fiber tracking. Also, due to the higher actual resolution (2), 2D color maps gained visual detail when using PI (Fig 2). Quantification of the fiber integrity within the CC was not affected by PI. Thus, both for FT and DTI-derived quantification, PI is appropriate.

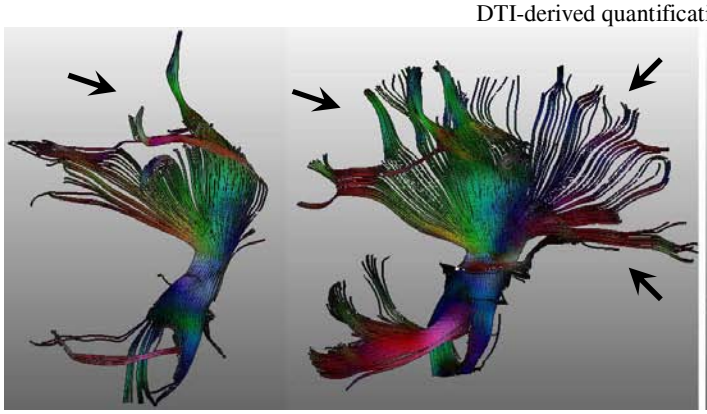

Fig. 2: Reconstruction of the corona radiata without (L) and with PI 3x (R). Note the markedly improved delineation of the full tract, especially at the more distant parts of the tract close to the cortex and in the cerebellum.

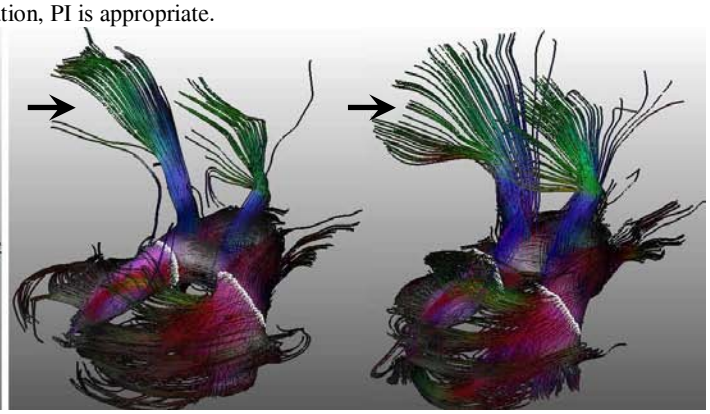

Fig. 3: Reconstruction of the superior cerebellar peduncle without (L) and with PI 3x (R). Note the increased detail in the cerebellum and also the marked improvement of delineation of distant projections close to the thalamic nuclei.

Discussion continued

Using a standard PI head coil, acceleration factors of up to 3 can be achieved with improved overall data quality. By using PI in combination with high field strength, high quality DTI-datasets can be acquired in less than 5 minutes, simplifying its application both in research and in clinical settings.

References

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