Fast Fluid Suppressed DTI

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Introduction

Diffusion tensor imaging (DTI) (1,2) often suffers from fluid and flow contaminations from CSF and vasculature, especially at the ventral brain regions, within the periventricular space or close to the cortical surface, because of the hyper-intensity of fluid in the T2 weighted baseline image. Early methods for removing these confounds have relied on inversion recovery technique (3) which could result in a large reduction in signal-to-noise ratio and temporal resolution. Here we propose an efficient and effective method that applies flow-sensitive diffusion weighting to the conventional DTI acquisition. In evaluating its impact on the delineation of white matter anisotropy, it was found that such a strategy can help achieve much improved characterization of white matters, further separate the white matter from the gray matter based on the diffusion anisotropy, and help set more objective criteria for fiber tractography.

Methods

It has been shown previously that moderate diffusion weighting can be used to suppress fluid and flow contributions to MRI signal (4). In this study, we incorporate diffusion weighting baseline scans and evaluate its impact on delineating white matter anisotropy in DTI scans. Images were acquired with a SENSE DTI sequence (5) from eight RF channels (R=2), with an isotropic spatial resolution of 2 × 2 × 2 mm within a FOV of 25.6 cm. In addition to the normal baseline scan at b = 0 (denoted b0), six additional baseline scans (denoted b1 – b6) at b factors of 50, 100, 150, 200, 250, 300 s/mm^2 were inserted (all three gradient axes were turned on for these baseline scans). Finally, another 15 scans (denoted b7 - b21) for diffusion weighting along 15 directions at a b factor of 800 s/mm^2 were acquired. As the result, a total of 22 volumes constituted the DTI data set for each run. Six runs were carried out on a GE 3T EXCITE scanner. Fig. 1 illustrates the acquisition procedure.

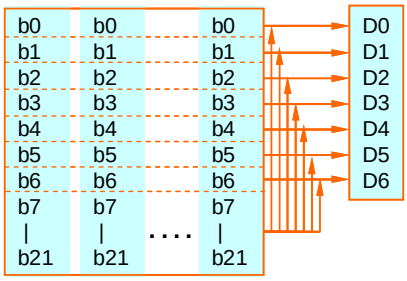

Fig. 1 Acquisition and processing procedures.

Seven sets of diffusion tensors (D0 – D6 in Fig. 1) were derived, using the respective baseline scans from b0 to b6 and the additional diffusion weighted scans along fifteen different directions. The individual baseline b factors were accounted for in the tensor analysis procedure. To investigate the impact of various baseline scans on the white matter anisotropy, fractional anisotropy (FA) maps were generated as a function of the b factors. In addition, to assess the SNR dependence, FA maps were also generated based on the number of averages.

Results and Discussion

Fig. 2 shows the FA maps as a function of the baseline b factor and the number of averages. A clear enhancement of the white matter anisotropy is observed with increasing b factors. Based on the averaged FA maps, regions with significant increases in anisotropy (0.1 < FA < 0.5) are shown in Fig. 3a near ventral brain areas, periventricular space, and cortical surfaces, where the fluid signal are significant. As a result, these areas demonstrate much improved white matter delineation. Regions that experience insignificant or small increases (<0.1 in FA) are identified and shown in Fig. 3b. Most of these regions fall into the gray matter and CSF space, which is mostly isotropic.

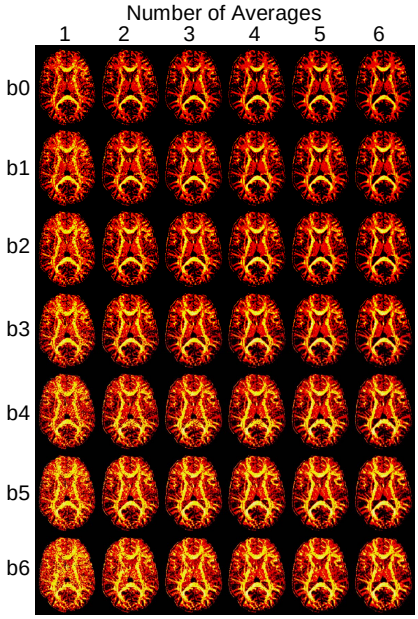

Fig. 2 FA maps as a function of the baseline b factors (vertical) and numbers of averages (horizontal).

Using these two maps as regions of interest, the FA values were averaged and plotted as a function of the baseline b factors (Fig. 3c). While the FA values in the white matter experienced large increase, those in the gray matter saw relative small changes. After reaching an asymptotic plateau with b > 250 s/mm^2, the absolute difference between the gray and white matters is significantly increased from 0.17 to 0.38. This clearer separation between the white and gray matters will facilitate improved fiber tractography with better white matter characterizations and a more objective FA criterion.

We demonstrate here that the use of diffusion weighted baseline scan can be an effective and efficient solution to achieve much improved characterization of white matter anisotropy. The much increased separation between the white matter and gray matter can offer more robust FA criterion to initiate fiber tracking procedure.

References:

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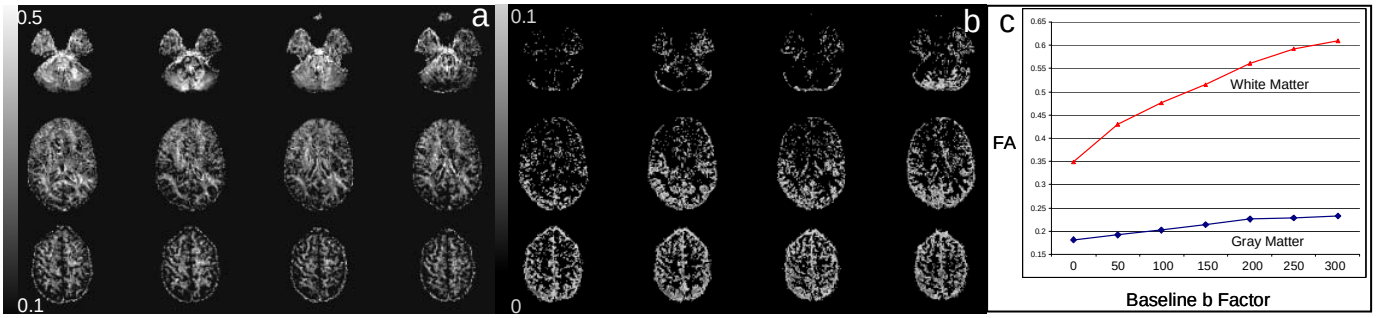

Fig. 3 (a) Regions show large FA increase (0.1 – 0.5) after moderate baseline diffusion weighting, illustrating improvements in white matter delineation, especially in the ventral (top row), peri-ventricular (middle row) and superior (bottom row) brain regions; (b) Regions show no or little increase in FA (< 0.1), which fall mostly within the gray matter regions adjacent to CSF space; (c) Averaged FA value dependence on the baseline b factors, showing increased separation of gray/white matter and improved white matter characterization with increasing b factors, while reaching asymptotic response when b > 250 s/mm^2.