**Effects of Eddy Current Induced Distortion on In Vivo Measurement of the Diffusion Tensor with EPI**

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**Introduction:** *In vivo* measurement of diffusion tensor by diffusion tensor imaging (DTI) requires multiple image acquisitions with diffusion sensitivities in at least six non-collinear directions. These diffusion-weighted (DW) images, which are frequently acquired using echo-planar imaging (EPI), are highly sensitive to eddy current induced geometric distortions that vary with the magnitude and direction of the diffusion sensitising gradients. Such distortions cause misalignment of images acquired with different diffusion strengths and orientations. This in turn can result in errors when calculating the diffusion tensor, which is characterized at each pixel by eigenvalues and eigenvectors. Errors of the eigenvalues give rise to errors in calculated diffusion anisotropy maps. Errors of the eigenvectors lead to errors when tracking the orientations of tissue fibre tracts. In this study, we have explored the effect on diffusion tensor parameters of correcting eddy current distortion errors by method that can accommodate non-linear distortions[1].

**Materials and methods:** Paired images with diffusion sensitising gradients reversed were acquired for each of six non-collinear directions[2] from normal human volunteers on a 1.5T Eclipse Scanner (Philips Medical Systems, Cleveland OHIO). Five axial slices with image matrix of 100x100 were acquired with TR = 6000ms, TE = 100ms, FOV = 24x24cm, slice thickness = 5mm, and b = 710s/mm$^2$. Image acquisition was repeated four times for each diffusion weighting direction. The zero and first order distortions were corrected for each image in each pair by affine transformation using a cross-correlation method[1]. Higher order spatial distortions were then corrected by linear combination of the affine corrected data from the pairs of images with reversed gradients[1]. Since the full data correction combined two images, four measurements were averaged for the raw uncorrected data and only two measurements were averaged when the full correction was applied. Diffusion tensor maps of Fractional Anisotropy (FA) and of the direction of the principle eigenvector were calculated from the uncorrected data and fully corrected data.

**Results:** Figure 1 shows an example from a normal volunteer of the distribution of directions of the principle eigenvector in a region of the brain centred on the anterior corpus callosum (CC). The through slice component of the eigenvector is colour coded and each pixel is shaded according to the local FA. Note that in the raw data (Fig 1 (left)) the fibre orientation is disrupted in parts of the CC, but after correction a more coherent pattern was found. We have observed this widely throughout the brain and particularly in regions of lower anisotropy the corrected data tends to have more consistent streamline structures. This is likely to be of significance for fibre tracking since eddy current induced errors may be a significant factor in producing erratic results in this application. Figure 2 shows FA maps before and after correction, again showing more consistent structure.

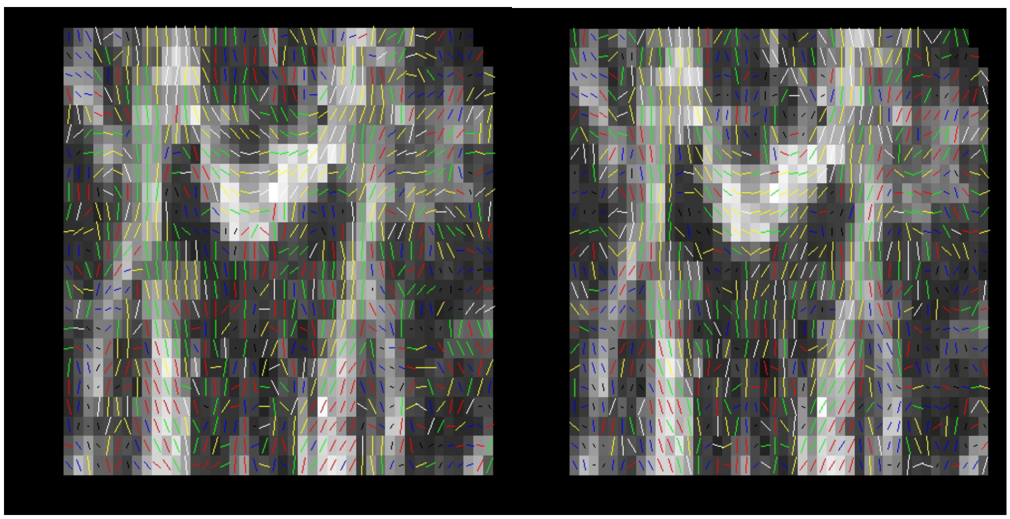

**Figure 1.** Directions of principle eigenvector in a region of anterior corpus callosum (CC) from uncorrected data (left) and fully corrected data (right).

**Conclusion:** Distortions caused by eddy currents on diffusion-weighted images can give rise to errors in diffusion tensor measurements. Correction of these distortions yields more coherent patterns of direction of the principle eigenvector and more consistent FA values. This is likely to lead to improved fibre tracking consistency.

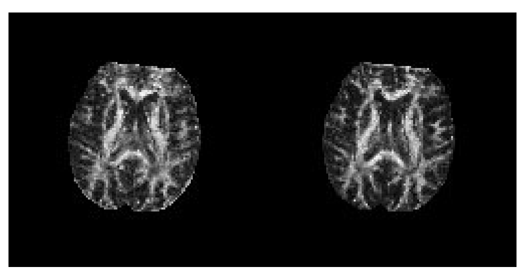

**Figure 2.** FA maps. (left) raw data and (right) full correction data.

**References:** [1]Shen Y et al . Proc ISMRM 2003; 1035. [2]Basser PJ, Pierpaoli C. Magn Reson Med 1998; 39:928-934.

**Acknowledgement:** Thanks to Philips Medical Systems for research grant support.