Comparison of Image-Based Retrospective and Optical Prospective Motion Correction for Diffusion Tensor Imaging

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INTRODUCTION Correction of rigid head motion correction is important in diffusion tensor imaging because of the long acquisition times. Rigid head correction can be carried out either retrospectively prospectively. In this study, we compared the effectiveness of these two approaches in correcting motion artifacts in DTI. Retrospective correction was based on MR-based navigator data (1-3), whilst prospective correction used an external tracking system (4,6).

MATERIALS and METHODS

(a) Retrospective Correction: In this study, we used a self-navigated single-shot spiral-in & variable density multi-shot spiral out trajectory to perform retrospective in-plane correction. The spiral-in part sampled the center of k-space and was used to get a low-resolution 2D navigator image for each TR interval. The spiral out readout made up one interleaf of the final high-resolution image. After the scan was completed, the low-resolution images were used to find motion between interleaves. The motion parameters were then integrated into an augmented sense reconstruction (5).

(b) Prospective Correction: For prospective optical motion correction, we used a system consisting of a single camera and a self-encoded marker (6). The camera was mounted on the head coil to track the motion of a checkerboard marker attached to the subject's forehead. The marker contained black and white squares, and each black square had a unique pattern on it that identified its position within the marker. This allowed the camera to track the marker even if part of the marker was outside the field of view.

(c) Experiments: Spiral DTI data was acquired four times on a healthy volunteer. For the first scan, the subject was asked to perform a left-right (in-plane) head motion, and for the second acquisition, a nodding motion throughout the scan. These motion patterns were then repeated for scan 3 and 4 with the motion correction system turned on. Thereafter, each acquired data was reconstructed with and without retrospective motion correction.

RESULTS Figure 1 and 2 show the results in the presence of in-plane and nodding motion, respectively. In the presence of in-plane motion, retrospective correction eliminated most of the artifacts. However, due to the existence of some through plane motion, residual motion artifacts remained. These were removed when the prospective motion correction was turned on. Performing additional correction on prospectively corrected data did not improve image quality. For the case with nodding motion, retrospective correction did not improve image quality, as expected. However, prospective correction eliminated most of the artifacts. Again, no improvement in image quality was observed after retrospective correction was applied. For both types of motion, mean diffusivity maps obtained with retrospective correction had increased blurriness compared to the ones obtained with prospective correction. Fig. 3 shows the standard deviation of each pixel on the b=0 navigator images (8 interleaves x 2NEX = 16 images). This figure also emphasizes that in the presence of nodding motion or through-plane motion, prospective correction performs superior to retrospective correction. This is due mostly to the 3D correction capability of the optical approach and a considerable limitation of the 2D navigator techniques.

DISCUSSION In this study, we compared an image-based 2D retrospective motion correction and an optical prospective motion correction system for DTI. Since most DTI sequences are currently 2D slice interleaved sequences, through plane motion is very difficult to correct for in retrospect. Since retrospective correction can only correct for in-plane component of motion, the difference between prospectively and retrospectively corrected data was more evident in the presence of nodding motion. Thus, it was shown in this study that especially in the presence of through-plane motion, prospective correction must be the method of choice.

References [1] Skare et al, MRM, 55:1298–1307 (2006) [2] Holdsworth et al, EJR, 65:36-46 (2008) [3] Aksoy et al, MRM, 59:1138–1150 (2008) [4] Aksoy et al, ISMRM, 2009, #4624.[5] Bammer et al, MRM, 57:90-102 (2007). [6] Aksoy et al, ISMRM, 2008 #3120.**Acknowledgements** This work was supported in part by the NIH (1R01EB008706, 5R01EB002711, 1R01EB006526, 1R21EB006860, P41RR09784), Lucas Foundation, Oak Foundation, and GE Healthcare.

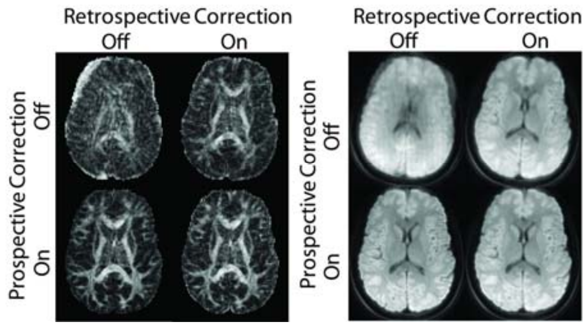

Figure 1. Experiments with in-plane motion. FA maps (left) and mean diffusivity images (right) are shown. It can be seen in FA images that prospective correction works superior to retrospective correction. Performing additional retrospective correction on prospectively corrected data did not improve image quality.

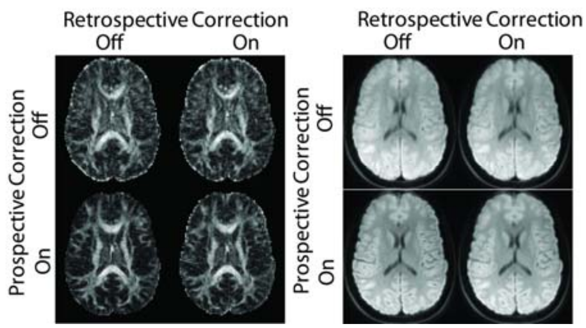

Figure 2. Experiments with nodding motion. FA maps (left) and mean diffusivity images (right) are shown. Retrospective method was ineffective in correcting for through plane motion whereas prospective optical correction significantly removed most of the motion artifacts.

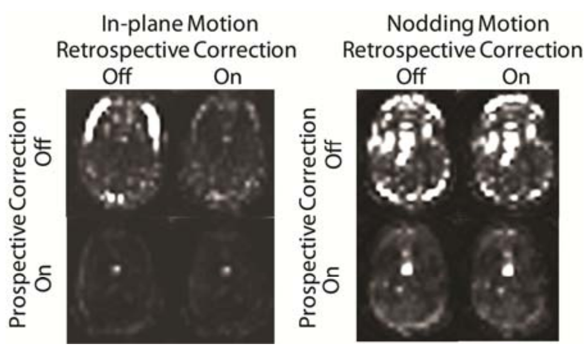

Figure 3. Variance of pixel intensity values throughout the b=0 navigator images (16 images, 32x32 resolution). For both in-plane and nodding motion experiments, prospective correction was superior to retrospective correction, as implied by the low standard deviation. Especially in the presence of nodding motion, retrospective correction provided no improvement, whereas prospective correction lowered the standard deviation significantly.