Combining SENSE with HAR-DTI in the C-Spine: Toward an Optimal Imaging Combination

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Introduction: The combination of high field and parallel imaging reconstructions has been particularly useful for diffusion tensor imaging (DTI). Single-shot studies of the brainstem and cervical cord are now possible [1]. A number of possible strategies exist to maximize image resolution and provide accurate fiber information such as anisotropy and direction. This will be especially useful in assessing white matter (WM) injury in clinical settings such as evaluation of post-traumatic hemiplegia or anterior horn cell disease. We have exploited the relative lack of longitudinal variation in spinal cord anatomy to explore DTI acquisition strategies that might optimize information recovery. In this article we explore the tradeoff of high angular resolution (HAR) with high signal averaging (NEX) factors given that, a priori, fiber direction in structures below the pons may be estimated [2] from scout images before DTI scanning.

Methods: All images were acquired on a 3T GE scanner equipped with 8-channel Excite/ASSET (SENSE) and the vendors DTI sequence, which incorporates a twice-refocussed single-shot EPI spin echo [3] readout. Following scanning, the individual DW images were exported to a workstation where the tensors were calculated, anisotropy (FA) extracted and directional color-coded (DEC) images [4] generated with in-house software.

Results: Figure 1 shows three slices obtained from a volunteer with the following MRI parameters: TR/TE/NEX/ASSET=4200/73/8/2. FOV/RO/PE=190/140/128. 15 diffusion directions were acquired at b=1000, plus 3 at b=0. The locations of the DEC slices shown in (b) are indicated on the scout in (a). Top tow: DTI reconstruction at each level using 3 of the 15 directions most closely matching the X, Y and Z axes. Middle row: reconstruction obtained with the full set of directions but setting Dxy=Dxz=Dyz=0 before tensor calculation; Bottom row: full reconstruction. Left: Slice from approx C1 level shows similar structural pattern on all rows. Middle: Pyramidal decussation (green) visualized on all rows, but lower-order solutions make transition from A-P (green) to I-S (blue) more abrupt. Right: Pyramidal tracts, medial lemniscus (blue) and olivocerebellar fibers (red) are well visualized, but transition from R-L (red) to I-S (blue) is more abrupt with lower-order solutions.

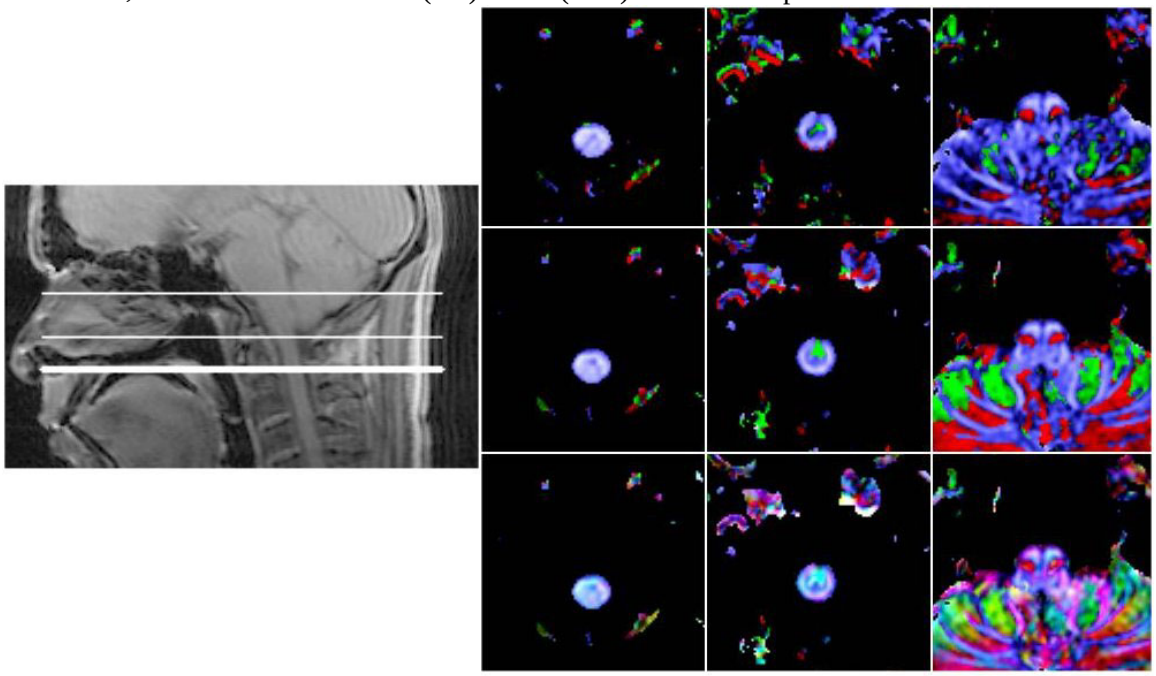

Figure 1. (a) Scout, (b) DTI DEC maps.

Discussion: Although progress has been made in evaluating WM fiber tracts in the brain, technical obstacles such as small anatomical sutructures have hindered progress in the spinal cord. However, the relatively slow longitudinal variation in cord anatomy suggests a priori estimation of fiber orientation. A minimum set of diffusion-encoding directions may then be used, together with a large NEX and SENSE acceleration, to obtain meaningful measures of WM direction and anisotropy from single-shot DTI acquisitions, as demonstrated here.

References: 1) Nagae-Poetscher et al. AJNR 2004:25;1325-1330. 2) Lee, Alexander. ISMRM 2004:444.3) Reese et al. MRM 2003:49;177-182. 4) Pajevic, Pierpaoli. MRI 1999:17;1121-1133.