Track Density Imaging for High Resolution Diffusion Tractography in the Prostate With and Without Tumor

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Introduction Prostate cancer is the most common cancer in men and the second-most common cause of cancer-related death. Multiparametric MRI of the prostate, which combines multiple MRI contrast mechanisms, has evolved into a powerful tool for localizing tumor within the prostate gland and monitoring treatment. Detection of central gland tumors, extracapsular extension and neurovascular bundle involvement remain important challenges in prostate cancer imaging. Recently, nerves running within the prostate neurovascular bundles have been visualized using MR diffusion tractography. Track density imaging (TDI) further exploits fiber tractography to construct images with novel tissue contrast and spatial resolution exceeding the native resolution of the diffusion weighted acquisition. This technique has been evaluated in the brain and applied to characterization of white matter infiltration in glioblastoma. In this study, we investigate TDI as a complement to multiparametric 3T prostate MRI.

Methods Study was approved by the local institutional review board with informed consent. 19 patients who were referred for multiparametric prostate MRI underwent diffusion imaging sequences in addition to a standard clinical MRI examination. The distribution of Gleason grading was: G3+3 (12), G3+4 (4), and G4+4 (1) (one patient had no tumor on recent biopsy). 14 patients were being managed by active surveillance, 4 had received radiation therapy, and 1 hormonal therapy. Patients were imaged using a 3T MRI scanner (GE Healthcare) and endorectal coil (MedRad). Standard clinical examination included high resolution T2 fast spin echo, large field of view T1 gradient echo, diffusion imaging with low (b=600 s/cm²) and high (b=1350 s/cm²) diffusion sensitization, and MR spectroscopy. Dynamic contrast enhancement images were performed in a portion of patients. For tractography, diffusion weighted EPI was acquired (TR/TE=5000/500, BW 250 kHz, matrix 128x128, FOV 24 cm, slices 21 x 3 mm). One image with b = 0 was acquired followed by b = 600 images along 25 non-collinear directions. Scan time was approximately 2.5 minutes. Note that the scan time was nearly identical to our standard clinical diffusion weighted scan (which is performed with 6 directions x 4 averages versus 25 directions x 1 average). Two tractography algorithms were compared as a basis for track density imaging: tractography based on diffusion tensor tractography (DTI) and high-angular-resolution diffusion imaging (HARDI) tractography.

Results TDI was technically successful in all subjects except four subjects where diffusion weighted images were degraded by brachytherapy seeds. There was visually precise alignment with high-resolution T2 images.

Discussion TDI was shown to be technically feasible in the prostate with scan time nearly identical to clinical standard diffusion weighted images. At least two patients show tracks within the central gland that are interrupted by tumor. Current efforts are focused on optimizing imaging and reconstruction parameters. Further work aims to validate the physical basis of the tracks that are observed and determine the utility of this technique for detecting central gland tumors, extracapsular extension, and neurovascular involvement.

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References