Diffusion Tensor Imaging of the Prostate Following Therapy

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Synopsis: A single-shot diffusion tensor imaging sequence was applied in 33 post-therapy prostate cancer patients and compared with a prior study of pretherapy patients (1). Following hormone/radiation therapy, when cancer is typically poorly delineated on T2 MRI, the DTI data demonstrated significant differences between cancer and benign prostatic-tissues. In 18 post-therapy patients with residual/recurrent cancer, ADC values were significantly reduced (p=0.00003) in areas of residual/recurrent cancer compared to benign prostate peripheral zone. In 13 post-therapy patients with complete metabolic atrophy on MRSI, the ADC values were significantly higher (p=0.003) than regions of residual/recurrent cancer in the 18 post therapy patients.

Purpose: The purpose of this study was to determine whether diffusion tensor imaging could be used to detect residual/recurrent prostate cancers following hormone/radiation therapy.

Introduction: Prostate cancer is currently a major clinical problem requiring improved imaging assessment of location and extent of the tumor before and after therapy. Combined 3D MR spectroscopic imaging and high resolution MRI have demonstrated great improvement in both sensitivity and specificity (2,3) over prior methods. However, additional assessment based on tissue structure and water micro-environment could be extremely important in improving non-invasive characterization of cancer in individual patients. In particular, for post hormone/radiation therapy patients, residual/recurrent cancer is often poorly delineated on anatomic MRI. Previous studies have demonstrated the ability of diffusion MRI to detect difference in cell structure and organization between cancer and normal prostatic tissue (1, 4-6). Our initial findings using DTI-SFSE showed significantly reduced ADC and a small yet significant increase in anisotropy in regions of cancer as compared to normal peripheral zone in patients with histologically confirmed cancer prior to therapy. In this study, we evaluated the use of DTI in post-therapy prostate cancer patients.

Methods: All studies were performed on a 1.5 Tesla MR scanner (Signa; GE Medical System) using the body coil for RF transmission and a disposable endorectal coil (Medrad, Pittsburgh, PA) in combination with a pelvic phased array coil for signal reception. A diffusion tensor imaging sequence with six gradient directions based on the single-shot fast-spin-echo method described by Alsop (7) was used. The DTI SFSE imaging was acquired in 2.5 minutes in the axial plane with a FOV=24cm, 128x256 matrix, 1.8x0.9mm in-plane resolution, 4mm slices, rbw=62.5KHz, b-value=600, TE=67ms, with typically 7-9 slices covering the prostate. The DTI SFSE was added to 33 MRI/MRSI exams of post-therapy prostate cancer patients. The total MR protocol consisted of FSE sagittal scouts, T1 axial SE images covering to the aortic bifurcation, fast spin echo T2 axial and coronal high resolution images, and 3D MRSI data acquired with a spatial resolution of 0.3cc (7mm per side). All data was analyzed off-line using software developed at our institution. ADC and fractional anisotropy images were calculated and compared to the MRI/MRSI data. In 18 post hormone (n=12) and radiation-therapy patients (n=6), DTI parameters were calculated for regions where MRSI data were positive for recurrent/residual cancer and for benign prostatic tissues. In 13 post radiation-therapy patients with metabolic atrophy throughout the gland, DTI parameters were also calculated to investigate diffusion values in atrophic tissues post-therapy.

Results: Following hormone ablation or radiation therapy, it often becomes difficult on MRI to differentiate cancer from benign prostatic tissues. However, in this study, significant decreases in cancer ADC values were observed (Figure 1, 2). In 18 post-therapy patients with histology and/or MRSI data indicating recurrent/residual cancer in the peripheral zone, the mean ADC’s in the regions of cancer were 1.26±0.22 (x10-3mm2/s), (range=0.81-1.73), and in benign regions were 1.49±0.21 (range=0.91-1.83). They were significantly different (p=0.00003). These ADC values were both substantially higher than were measured in a prior study of cancer and benign prostatic regions in untreated patients (1). The mean fractional anisotropy values were 0.26±0.08 in cancer region and 0.18±0.05 in non-cancer region and were significantly different (p=0.0001). However, these anisotropy measurements are very low and near the noise threshold and thus may not truly reflect differences in the orientation of restricted water diffusion. In 13 post-therapy patients with metabolic atrophy throughout the prostate gland, the mean ADC in these atrophic regions was 1.48±0.22 which was significantly higher (p=0.003) than the ADC’s in the regions of cancer in the 18 post-therapy patients with recurrent/residual cancer.

Conclusion: Significant differences were observed in both ADC and fractional anisotropy between regions of residual/recurrent cancer and benign prostate peripheral zone in patients following hormone and/or radiation therapy. Also, ADC values in 13 patients with metabolic atrophy were significantly higher than cancer values for the 18 patients with recurrent/residual disease. This study demonstrated that diffusion tensor imaging is valuable in post-therapy patients where the cancers are typically clearly observable on ADC images but not well delineated on T2 images. It is important to note that while MRSI has demonstrated a high specificity, the DTI offers much higher spatial resolution in characterization of cancer and thus a combined approach may be clinically beneficial to provide post-treatment follow-up in prostate cancer patients.

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