Correlation Between Endorectal MRI and Diffusion Weighted Imaging (DWI) in Cancerous and Normal Prostate

Synopsis:
This study determined the relationship of DWI and ADC values between normal and cancer tissue in patients with prostate cancer. 11 patients with biopsy proven cancer were studied by endorectal MRI and DWI. Using a grid system, regions in the prostate gland were denoted as “cancer” and “normal” on T2 images and corresponding ADC values calculated. Results: The difference in mean ADC values for cancer and normal tissue were statistically significant. Conclusion: DWI demonstrates a complimentary role in tumor detection in prostate cancer.

Introduction:
Currently, magnetic resonance imaging (MRI) with an endorectal coil is the best available technique for tumor localization and staging in patients with prostate cancer. However, MRI is limited in specificity and new imaging modalities are being investigated to improve tumor localization and clinical staging. One method studied is diffusion-weighted imaging (DWI). DWI uses the apparent diffusion coefficient (ADC) to analyze the diffusive properties of tissue. This method of analysis has been successful in differentiating benign from malignant tissues such as in the brain1 and breast2. DWI has demonstrated accurate estimation of tumor size and shape on transgenic mice models of prostate cancer cells3. Bashar4 used a pelvic phased array coil in MR imaging of the prostate gland reported a statistical difference in the mean ADC values between normal and cancer tissue. The aim of this project is to determine whether or not DWI and measured ADC values can differentiate cancer from normal prostate tissue in patients following endorectal MRI.

Method:
Endorectal MR Imaging of 11 patients with biopsy confirmed prostate cancer was studied. Axial, coronal, and sagittal FSE T2-weighted images (TR/TE=3,000,81msec; section thickness=3mm; gap=0mm), and axial T1-weighted images were performed. The field of view (FOV) for all images were 20cm x 20cm. A rectangular grid was placed on the axial T2-weighted image creating voxels of tissue that measure 7.5 x 7.5 x 3mm (volume of 0.169cc). Voxels consisting of at least 75% peripheral zone (PZ) tissue were then graded on a scale of 1-4 (1=definitely cancer, 2=probably cancer, 3=probably normal, 4=definitely normal) without knowledge of the biopsy proven location. Cancer was defined as focal regions of hypointensity occupying at least 75% of the voxel in question. DWI was performed using single-shot echo planar imaging (EPI) to coincide with the slice locations as the axial T2-weighted FSE images using a diffusion sensitivity of b=1000sec/mm2. ADC values were calculated in the peripheral zone for all slices on a voxel-by-voxel basis by taking the average of the ADC computed from each of the three orthogonal DWI. voxels with grades of 1 and 2 were classified as “cancer” and voxels with grades of 3 and 4 were classified as “normal”. With the radiologist blind to biopsy location, the mean ADC values for “cancer” and “normal” prostate were plotted for each patient individually and for the group as a whole. This analysis was repeated allowing the radiologist to access the biopsy data. Any previously assigned voxel grade that was found to be inconsistent with biopsy data was regrouped as a “normal” or “cancer” voxel. An unpaired, one-tail t-test was performed between data for “cancer” and “normal” prostate in both experiments for the entire patient set.

Results:
With the radiologist blind to biopsy data location, 11 patients were studied representing a total of 820 voxels. Of these, 157 (19%) voxels were grouped as “cancer” voxels, while 663 (81%) were classified as “normal” voxels. In the second experiment, with the radiologist able to access the biopsy location data, 10 patients were studied representing a total of 787 voxels. Of these, 130 (17%) were grouped as “cancer” voxels, while 657 (83%) were classified as “normal” voxels. One patient was excluded from the second experiment because biopsy location of cancer was unavailable. 6/10 patients had no change in data since the images were graded appropriately. In the remaining 4 patients, a total of only 13 “cancer” voxels were reclassified as “normal”, while no “normal” voxels were reclassified as “cancer”. The mean ADC values for the entire patient set with and without knowledge of biopsy locations for cancerous prostate were 1091 ± 370 x 10 -3 and 1167 ± 385 x 10-3 (mean +/- SD) mm2/s respectively, while the mean ADC values with and without knowledge of biopsy locations for normal prostate were 1608 ± 262 x 10 -3 and 1612 ± 266 x 10 -3 (mean +/- SD) mm2/s respectively, P<< 0.0005.

Conclusion:
Diffusion-weighted images of the human prostate have been successfully demonstrated using an endorectal coil. These findings demonstrate that there is a statistically significant difference between mean ADC values for cancer and normal prostate tissue with or without knowledge of biopsy results. This may be explained by the replacement of the orderly arranged water-filled acinar structures and ductal system by cancer tissue that inhibits the movement of water throughout the gland. There is a significant amount of overlap between ADC values for areas of cancer and those of normal prostate tissue. A recent study5 using a pelvic phased array coil reported similar findings, although signal to noise and resolution limitations compromised image quality. Therefore, at this point in time, a diagnosis of prostate cancer cannot be made based solely upon a quantitative ADC threshold value. However, the data represents some of the first steps toward harnessing the potential impact of DWI as it relates to prostate cancer.

References:
2. Guo Y, et al. J MRI 2002; 16(2) 172-178