Comparison of conventional histology and diffusion weighted microimaging for estimation of epithelial, stromal, and acinar volumes in prostate tissue

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Target audience Researchers and clinicians interested in the biophysical basis of diffusivity variations in normal and pathological glandular tissue.

Purpose Diffusion weighted (DW) microimaging of fixed prostate tissue reveals distinct diffusivity differences between epithelium, stroma, and acinar spaces1. In normal glandular tissue changes in the relative volumes of epithelium and stroma explain ~60% of the variation in signal fraction of a biexponential model of diffusion signal decay2. We hypothesise that microscopic tissue volume changes may also explain the observed strong correlation between cancer Gleason grade and apparent diffusion coefficient measured in vivo. In this pilot study we used semi-automated morphometry methods to quantify partial volumes of epithelium, stroma and acinar space in H&E-stained histological images of benign and cancerous prostate tissue and compared these results with segmentation and statistical analysis of diffusion weighted microimages of normal tissue.

Methods DW images were obtained from a previous study in which six normal glandular tissue samples from five patients were formalin fixed and imaged with 40 µm isotropic voxels at 16.4 T1. In the previous work partial volumes were estimated by fitting three Gaussian curves to voxel diffusivity histograms1. Five diffusion-weighted images per specimen were manually segmented into epithelium, stroma and acinar space (Fig. 1.). For light microscopy 63 20× images (14 normal, 17 Gleason-3, 32 Gleason-4) from two patients were manually segmented into epithelium, stroma and lumen components. For cancer samples the field of view was cropped to ensure the presence of a single Gleason grade only. Segmentation of the light microscopy images was based on separate selection of epithelial tissue or acinar space with the magic wand tool in Adobe Photoshop followed by manual correction of obvious errors.

Results Fig. 2. compares partial volumes of epithelium, stroma and acinar space estimated by DWI and histology in our study and two earlier histology studies. Normal tissue volumes estimated by segmentation of DW images are similar to those obtained by voxel diffusivity statistics of the same samples. When compared with histology images DWI appears to underestimate the volume of acinar space. Normal tissue volumes estimated by segmentation of our histology samples show more variability than previous studies based on morphometry of histology samples3,4.

Our histology-based segmentation demonstrated significant differences in the volumes of epithelium, stroma and acinar space between normal, Gleason 3, and Gleason 4 samples (p<0.05, one-way ANOVA).

Conclusion There is broad agreement between estimated partial volumes of epithelium and stroma obtained from diffusion-weighted microimages and histology. The relatively low estimate of acinar space obtained from DWI may be the result of partial volume effects as the thickness of the epithelial layer of most glands (15 – 20 µm) is typically smaller than the 40 µm voxel dimension in our DWI data. The increasing volume of low diffusivity epithelial tissue and decreasing volume of high diffusivity stroma that occurs with increasing Gleason grade may explain the clinically observed decrease in ADC with increasing Gleason grade2. This pilot study is the first step towards a validated measurement of microscopic tissue compartment volumes that can be used for development of models for diffusion of water in prostate tissue.


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