

# Diffusion imaging for prostate cancer: A quantitative comparison of Echo Planar Imaging and Half Fourier Single Shot Turbo Spin Echo sequences

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**Purpose:** To compare Diffusion Weighted Imaging (DWI) using Echo Planar Imaging (EPI) and Half Fourier Acquisition Single shot Turbo spin Echo (HASTE) sequences for prostate cancer tumour detection. Quantitative assessment of the Apparent Diffusion Coefficient (ADC) of tumours and healthy tissue was compared for both sequences, using whole mount histology as the gold standard.

**Introduction:** Echo Planar Diffusion weighted imaging is the current method of choice for utilising the diffusion properties of water to localise cancer tumours. While it has had success in distinguishing tumours from tissue it is highly sensitive to chemical shift, magnetic susceptibility and phase error, which produce artefacts in the ADC map images. We propose to use HASTE, which is less affected by these artefacts, for prostate cancer tumour detection. In this study ADC values were investigated for tumours and healthy tissue in both sequences. For accurate detection of tumours and possible monitoring of disease, the tumour ADC value should be distinctly different, compared to healthy tissue.

**Methods and Materials:** Nineteen volunteers with biopsy confirmed prostate cancer and a mean age of 62 years, (range 45-74 years) participated in the study. Scanning was performed on a 1.5T Siemens Sonata MRI, (Erlangen, Germany). T2 weighted images and DWI, for both EPI and HASTE, were acquired for each volunteer. DWI was performed with b-values of 0, 150, 300, 450, 600, 750, 900, and 1000 s/mm<sup>2</sup>, an ADC map was then created from combined b-values. T<sub>2</sub> images were used to aid in defining regions in the DWI. The slice thickness of the histologically dissected prostate was 5mm hence MR images were matched for an accurate comparison.

A true positive result in the ADC maps was found if a hypo intense region matched the histology results. A Region of Interest (ROI) analysis was used to calculate average ADC for selected regions of the ADC Map. ROIs were chosen in identified tumours (Pca), Peripheral Zone (PZ) and Central Zone (CZ) tissues. The mean ADC value and standard deviation was calculated for the PZ, CZ, Pca for the two sequences, EPI & HASTE. The Signal to Noise Ratio (SNR) was also calculated for each DWI sequence, using ROIs in the PZ and background in the b=0 s/mm<sup>2</sup> image. The mean ADC values of the PZ, CZ, Pca and false positive results were used to create Receiver Operator Characteristic (ROC curves). ROC curves were also produced using the PZ of the prostate as the ADC value of the CZ and tumour are similar<sup>1</sup>.

**Results & Discussion:** The results show that the mean ADC values differed between the two sequences, concurring with previous work<sup>2</sup>. There was a difference in mean ADC between the PZ and Pca for both sequences, Fig 1. However there was considerable overlap between the CZ and Pca. The EPI sequence showed better differentiation of tumour and CZ tissue, however false positive results were not represented in this analysis.

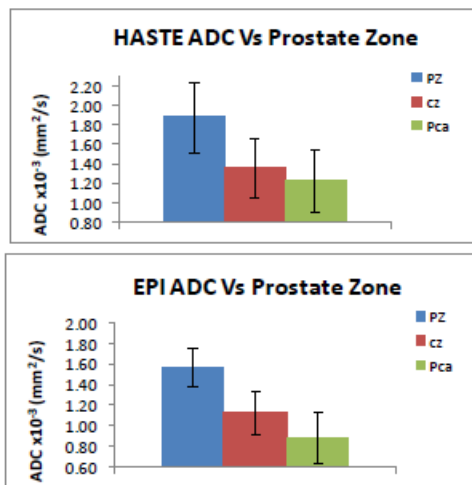


Fig 1: Mean ADC values of Pca, Pz and CZ for EPI and HASTE

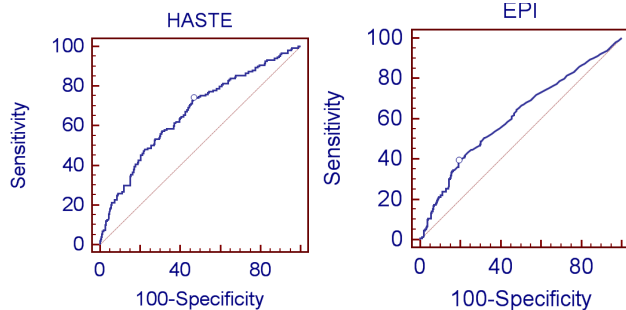


Fig 2: ROC curves of EPI and HASTE, including PZ and CZ values

The SNR of the HASTE images were greater than EPI, however the standard deviation within each zone ROI was similar for both sequences.

The ROC curve that included both the PZ and CZ healthy tissue values (Fig 2) produced an area under the curve of 0.611 and 0.666 for EPI and HASTE, respectively. The increased false positives in the EPI sequence resulted in a less accurate detection method. Observing the PZ zone only, the area under the curve for both sequences was similar, 0.873 and 0.856 with ADC thresholds of  $1.19 \times 10^{-3} \text{ mm}^2/\text{s}$  and  $1.59 \times 10^{-3} \text{ mm}^2/\text{s}$  for EPI and HASTE, respectively. Therefore different ADC value definitions of tumour and healthy tissue are required for each sequence. The area under the curve values compare well with the literature<sup>3,4,5</sup>. The sensitivity and specificity associated with the ADC threshold values were similar, 88.1/90.6% and 73.3/70.1% for EPI/HASTE, respectively.

The comparison of EPI and HASTE in this analysis showed similar detection capabilities, however HASTE detected 95/150 tumours and EPI detected 74/150 tumours. Therefore PZ only ROC curves should not have been similar. This highlights one limitation of this study, only true positive tumours were used in the ROC curves.

**Conclusion:** ADC values of HASTE and EPI were different, which resulted in unique ADC thresholds in the ROC curves for each sequence. Both sequences were able to accurately distinguish the PZ from Pca as reported by the high >0.8 area under the curve values from the PZ only curves. However direct comparison of EPI and HASTE in the PZ only ROC curves was not possible.

## References

- [1] DeSouza NM, Reinsberg SA, Scurr ED et al. British Journal of Radiology. 2007; 80: 90-95.
- [2] Babourina-Brooks B, Cowin G, Wang D. MRI. 2012;30(2):189-194
- [3] Miao H, Fukatsu H, Takeo Ishigaki T. European Journal of Radiology. 2007;61: 297-302.
- [4] Kumar V, Jagannathan NR, Kumar R et al. NMR Biomed. 2007; 20: 505-511
- [5] Pickles MD, Gibbs P, Sreenivas M et al. Journal of magnetic resonance imaging 2006;23:130-13.