

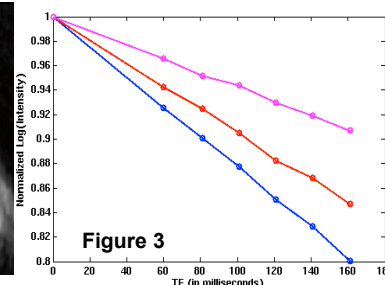
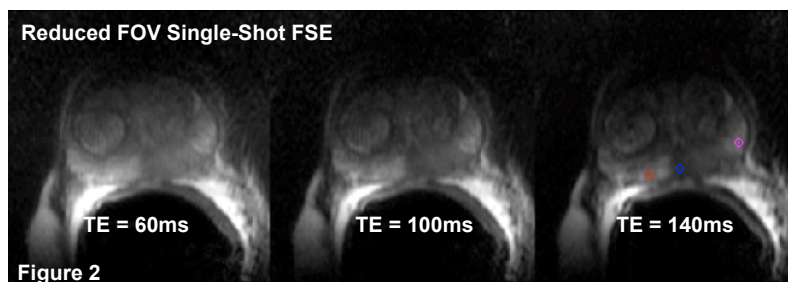
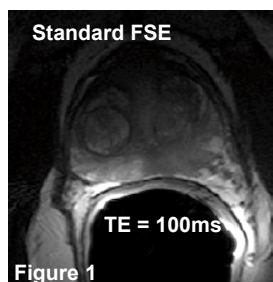
# Rapid Quantitative T2 imaging of prostate cancer using a reduced FOV single-shot fast-spin-echo sequence

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## Introduction

The standard MR-based signature of prostate cancer tumors is a hypo-intense signal on T2-weighted spin-echo scans that derives from lower T2 values in prostate tumor tissue as compared to healthy tissue. Signal hypo-intensity is relative and non-quantitative in that one is visually comparing the suspect region with the intensities in surrounding ones. A more quantitative approach whereby T2 is actually measured, rather than just inferred from a comparison of intensities, would be desirable, especially when automated or semi-automated multi-parametric approaches are applied for tumor discrimination. T2 is independent of signal level, therefore, no special calibration based on signal scaling is needed to discriminate tumor from healthy tissue, assuming that the tissues can be separated based on their measured T2 values. Here we introduce an approach using a modified single-shot fast-spin-echo method that enables whole-gland T2 quantification in about one minute from image sets acquired at a range of TE values.



## Methods

**Imaging sequence:** A single-shot fast-spin-echo (SSFSE) sequence was modified to enable reduced FOV imaging in the phase-encode direction without aliasing. To enable multi-slice imaging, the method was implemented using a shallow angle between the 90-degree and refocusing pulses. For slice selection in the z direction, the RF pulses have their selection profiles along z. However, the 90-degree pulse is given a small tilt in the y-z plane so that not all spins in the y direction are refocused. The selective FOV in the y direction is a function of the selected slice thickness and the tilt angle of the 90-degree pulse. With this approach, adjacent slices can be excited without causing saturation, although slices must be interleaved to avoid crosstalk.

**Prostate imaging and data processing:** Six patients with biopsy-proven prostate cancer were imaged with informed consent obtained according to an approved IRB protocol. Images were acquired using the reduced (in phase-encode direction) FOV SSFSE sequence on a 3T GE MRI system. Scans were repeated multiple times with six different effective TE settings (from 60 to 160 msec in steps of 20). Other parameters of the acquisitions were: FOV = 160x80mm, acquisition matrix = 256x160, slice thickness=3mm, bandwidth = 50kHz. T2 values were estimated for a selection of ROIs using the mean signal in the ROI for all six TEs (see Fig.3). A total of 44 ROIs were chosen within the peripheral zone of the six patients; 20 in areas deemed to be 'suspected cancer' and 24 in areas deemed to be 'suspected healthy'. The areas were selected in consultation with a radiologist based on examination of results from T1 and T2 weighted, diffusion and DCE scans.

## Results

One slice from the standard FSE acquisition from one of the patients is shown in Fig.1 with a region of darkening due to the likely presence of a tumor in the peripheral zone. Three of the SSFSE images with TEs of 60, 100 and 140 msec are displayed in Fig.2 along with a plot in Fig.3 of the log of the signal from three ROIs for all six TE datasets. In Fig.4 the estimated T2 values for the suspected healthy ('SH') and suspected cancer ('SC') ROIs are plotted. Estimated T2 in the SH ROIs is 224.3 +/- 67 msec and for the SC ROIs is 129.2 +/- 25 msec. There is a clear separation of the two tissue types, however, there is also an overlap. An ROC curve, which displays true positive versus false positive fractions, is shown in Fig.5. Note that, according to this data, for a 100% detection rate, a 40% false-positive rate would result.

## Discussion

A multi-slice SSFSE sequence for reduced FOV imaging in the prostate was implemented. Images are suitable for estimation of T2 using acquisitions at different TEs with total acquisition time on the order of 1 minute. It should be noted that full FOV SSFSE acquisitions would require very long echo-trains resulting in image blurring and significantly longer TRs. Results show that the estimated T2 value with the reduced FOV sequence can be used to discriminate between suspected healthy and cancerous tissue, for example, with sensitivity and specificity of 82% and 80% respectively (see Fig. 5). Estimated mean T2 values of 224 and 129 msec for the healthy and cancer ROIs respectively are in the range of values found in a previous study (193 and 100 msec) with a larger group of patients using a CPMG sequence requiring a 10-minute acquisition [1]. Other studies have reported a wide range of T2 values for healthy and cancerous regions [2]. As with the CPMG sequence, it is to be expected that T2 measured using SSFSE will suffer from inaccuracies due to the use of slice-selective refocusing pulses, thus, it would be more accurate here to use the term 'apparent T2'. However, as this and previous CPMG work demonstrate, these apparent T2 values can be used to separate healthy and cancerous tissue with reasonably high sensitivity and specificity, although, other MR modalities such as diffusion are required to insure diagnostic accuracy.

**References:** [1] Roebuck et al. Magn Reson Imag. (2009) 27:497-502. [2] Folz et al. Magn Reson Med (2010) 64:1155-1161

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