Utility of T2 histogram analysis in active surveillance of prostate cancer

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Target Audience: Radiologists, physicists and data scientists focusing on the novel applications of the prostate cancer MRI.

Purpose Prostate cancer is most common malignancy among men (15%) with almost perfect survival rate 5 year post initial diagnosis (98.9%) [1]. Active surveillance has emerged as an important option for patients with low risk prostate cancer. However, there are limited non-invasive quantitative biomarkers, such as PSA, at present for patients on active surveillance of prostate cancer [2]. The radiologist's readings of multi-parametric prostate MRI (mpMRI) is a potential method for active surveillance, however, a consensus on its use has not yet been reached [3,4]. Further, its application for active surveillance is limited by the qualitative and subjective radiologist readings with limited reproducibility. T2w MRI is an integral part of mpMRI and is used to identify tumors by their hypo-intense appearance. Recent studies have reported that T2 values of multi-parametric MRI positive tumors (95±18msec) can be separated from normal PZ (280±65) [5,6,7] where 70-75% of the prostate cancers are found [8]. The purpose of this study is to determine if a T2 histogram of the PZ obtained from a fast multi-echo TSE T2 mapping sequence can be utilized as quantitative biomarker to assist in monitoring prostate cancer patients on active surveillance.

Methods This retrospective IRB approved study included 24 contiguous patients on active surveillance protocol with an age of 66±6.9 years, and PSA of 6.4±3.7 ng/ml at their baseline. All patients underwent multi-parametric (mpMRI) of prostate at baseline with endorectal coil (ERC) followed by a targeted TRUS/MRI fusion guided biopsy [9]. At their 1 year followup visit (406±108 days), all patients underwent mpMRI of prostate without ERC followed by a targeted TRUS/MRI fusion biopsy if there are any suspicious findings visible in the followup-MRI. Radiologist readings of the prostate mpMRI and biopsy results were used to determine if the patient was stable or progressed between baseline and followup. MRI scans were acquired at 3T using clinical MRI scanner. mpMRI of prostate included an accelerated multi-echo multi-slice TSE MRI with whole prostate coverage; number of echoes=16; TE_1=22ms; ΔTE=11ms; TR=2608ms (ERC) 2139 ms(non-ERC); spatial resolution 0.60×0.60×3.0 mm^3 (ERC) 1.12×1.12×3.0 mm^3 (non-ERC) mm^3, slice gap = 0.00mm, FOV=420×420×78 mm^3) to cover the whole prostate in 5 min 55 sec [6,7]. T2 maps were obtained on the scanner.

Histogram: Whole prostate and combined central gland (CG) and transition zone (TZ) was contoured by a radiology trainee with an experience of reading over 500 prostate MRI (1.5 years). Contours were drawn over a TE=121msec T2W echo image from the ME-TSE T2 mapping datasets using a research software. Matlab (Matlab, Natick, MA) was used for data analysis. Histogram of the T2 values was obtained over the PZ using the pixels that were part of whole prostate and not present in combined CG and TZ contours. Histograms were obtained over the range of T2 values form 0 to 300msec with bin width of 25 msec.

Training: Another radiologist with over 8 years of experience in reading prostate MRI was blinded to any patient information and graded the patients on a 4 point scale (improved, stable, suspicious and progression) using only the T2 histogram of PZ. T2 histogram of a stable and a progression patient was shown prior to the grading for training purposes (Figure 1). An increase in T2 histogram values around 75-100msec and decrease in histogram of higher T2 values is seen as sign of suspicion and progression.

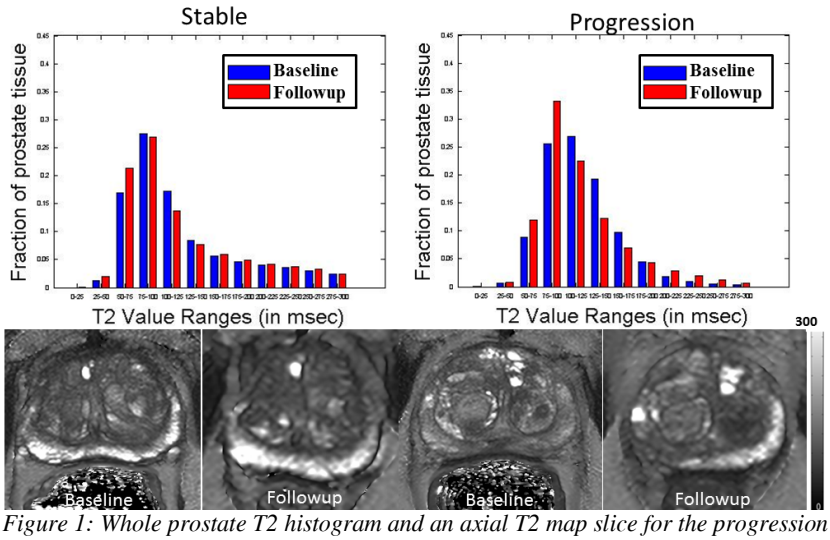

Figure 1: Whole prostate T2 histogram and an axial T2 map slice for the progression and the stable case. These two cases were used for training the radiologist.

	T2 histogram evaluation			
mpMRI evaluation	Improved	Stable	Suspicious	Progression
Improved (n=1)	1 (100%)	0 (0%)	0 (0%)	0 (0%)
Stable (n=20)	3 (15%)	7 (35%)	7(35%)	3(15%)
Progression (n=4)	0 (0%)	0 (0%)	0 (0%)	4 (100%)

Table 1: mpMRI evaluation of followup MRI and T2 histogram evaluation for active surveillance patients.

Results: For this study, all 25 patients' MRIs showed low-risk, organ confined prostate cancer at their first mpMRI. Of these patients, 20 had stable mpMRI on follow-up, 1 had an improved mpMRI, and 4 had progression in mpMRI findings. As shown in Figure 1, the histogram of a stable case remains same. On the other hand, the histogram of a progression case shows notable shift from T2>100msec to T2<100msec marking the increased lesion size visible in followup MRI (Figure 1). Similar pattern were observed for other stable and progression cases. Table 1 shows the cross tabulation of T2 histogram evaluation on four point scan against ground truth mpMRI evaluation by radiologist at followup MRI. All (100%) progression and improved patients were correctly classified. 15% of stable cases were misclassified as progression.

Discussion and Conclusion: In this preliminary study we have shown that the histogram model obtained from fast T2 mapping MRI sequences can be potentially utilized as an efficient, and quick visual method of determining status of active surveillance in case of low-risk prostate cancer. All the progression cases were correctly identified using T2 histogram analysis suggesting high predictive value of T2 histogram evaluation. However due to the limited percentage of progression cases in active surveillance population, further study with larger patient population is warranted.

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