R2* imaging of the prostate at 7 tesla, feasibility and initial observations compared to 3 tesla

Mariska P. Luttje[1], Catalina S. Arteaga de Castro[1], Marco van Vulpen[1], Alie Borren[1], Jan J.W. Lagendijk[1], Peter R. Luijten[1], Dennis W.J. Klomp[1], and Uulke A. van der Heide[2]

[1]*Imaging Division, University Medical Center, Utrecht, Utrecht, Netherlands,* [2]*The Netherlands Cancer Institute, Amsterdam, Noord-Holland, Netherlands*

Introduction

Hypoxia is an important marker for the resistance of cancerous tissue to both radiotherapy and chemotherapy (1). Unfortunately, hypoxia measurements are highly invasive and therefore not applicable in standard clinical practice. By using MRI however, R2* (1/T2*) can be measured, correlated with the pO_2 in prostate tissue as shown by Hoskin *et al.* at 1.5T (1,2). Unfortunately, T_2 shine through degrades the correlation between pO_2 and R2* mapping. Therefore, we investigated the use of R2* mapping for diagnosing hypoxia in prostate cancer at higher field strength of 3T. In addition, even feasibility of R2* mapping has been investigated at 7T, while taking care of significant susceptibility effects.

Materials and Methods

Measurements were performed on a 3T whole body system (Philips Healthcare Best, The Netherlands) using a 16-element phased array coil (torso cardiac) as receive coil. Six patients, mean age 65 (range: 57-73) diagnosed with prostate cancer (Gleason 6-7) and scheduled for brachytherapy were included. Informed consent was obtained after the nature of the study had been fully explained. For standard clinical practice for all patients a T2 weighted (T2w), DWI and DCE-MRI exam were carried out. For R2* mapping, an MGE-sequence (TR/TE=73/5ms, ΔTE=6ms, 10 echoes, reconstructed voxel size=1x1x3mm^3, FOV=280x400x75mm^3) was used.

In one of these patients, R2* mapping was also performed at 7T (Philips Healthcare Best, The Netherlands) using a two elements endorectal coil (3) tuned and matched at 298 MHz and filled with fluorinated fluid (GALDEN; Solvay Solexis, Milan, Italy). An R2* map was acquired using an MGE with parameters TR/TE=78/2ms, ΔTE=4ms, 10 echoes, reconstructed voxel size=0.94x0.94x1mm^3, FOV=120x120x88mm^3. R2* maps were calculated by fitting ln(S(t)) of which the gradient represents –R2* (s^{-1}) using a least squares approach in Matlab (Version 2009b, The MathWorks, Natick, MA).

The delineation of volumes suspected of holding tumor at 3T was based on hypointense values on the T2w, low ADC and high K^{trans} values. In these tumor volumes the median R2* value was calculated for each patient, next to this the median value was calculated of the healthy prostate tissue in these slices.

Results and Discussion

In all patients tumor regions had lower R2* values than the surrounding healthy prostate tissue, averaged 27.7s^{-1} vs. 33.1s^{-1} at 3 tesla. However the posterior part of the prostate (close to air-tissue boundaries) suffers from a lack of stability due to susceptibility and motion artifacts (see for example Figure 1 and 2B). Therefore higher R2* values were calculated in the posterior zone compared to the more anterior areas of the prostate.

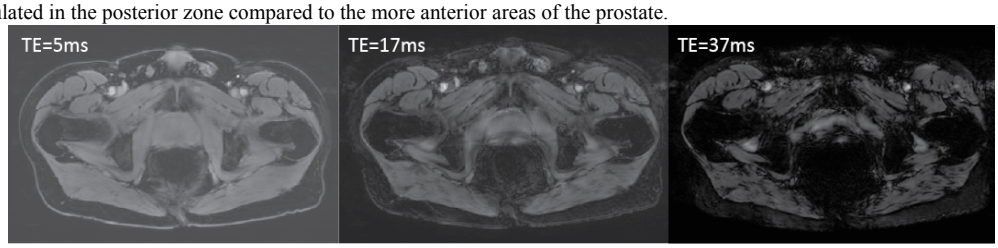

Figure 1: Original MGE images at 3 tesla using TE=5, 17 and 37 ms. Noticable is that the peripheral zone of the prostate darkens faster than the other tissue of the prostate gland, resulting in higher R2 values.*

At 7T an endorectal RF coil was used to fixate the prostate. As the susceptibility induced artifacts would become at least twice as stronger at 7T, the endorectal coil was filled with perfluocarbon for susceptibility matching. Using R2* mapping at 7T, the tumor can be recognized, Figure 2C. A median R2* value of 39.7s^{-1} was measured in prostate tissue, which including field correction is significantly lower than observed at 3T. Apart from relatively reduced susceptibility artifacts at 7T, the higher spatial resolution may have led to less dephasing within the voxel. Therefore higher fields strengths with susceptibility matching are expected to bring the R2* values closer to the intrinsic tissue R2*, which may improve correlation to pO_2.

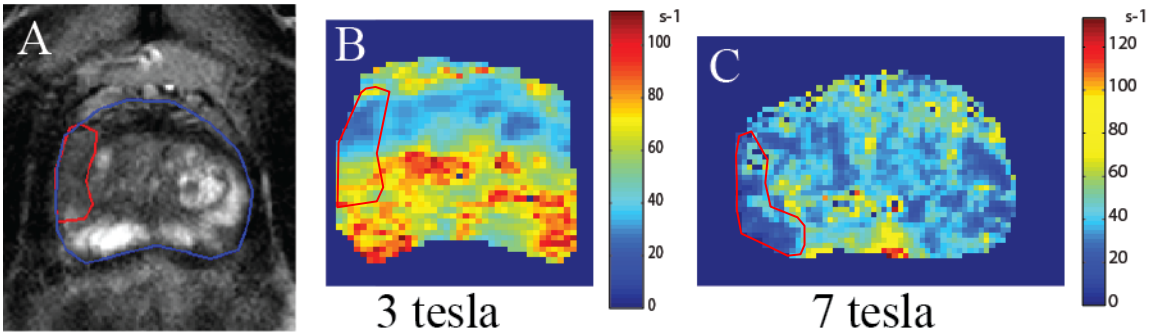

Figure 2: A) T2w image at 3T showing the delination of tumor tissue (red). B) R2 map of the same slice as A, noticable are the high R2* values in the anterior part of the prostate. C) R2* map of a tumor slice at 7 tesla, the lower R2* values in the tumor region are observable. However due to the use of an endorectal coil the prostate is deformed compared to the 3 tesla scans.*

References

1)Hoskin, P. J., et al. (2007). IJROBP 68(4): 1065-1071.
2) Alonzi, R. et al. (2010). JMRI 32(1): 155-164.
3)Arteaga et al. Proc. Intl. Soc. Mag. Reson. Med. 17 (2009), p.4744