Early experiences in Ultra High Field Prostate MR-imaging: Prostate Cancer Detection at 7T

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Target Audience: Prostate radiologists, pelvic radiologists, ultra high field physicists

Purpose

Ultra high field (≥7T) MR imaging may have future clinical advantages for imaging prostate cancer (PCa) by its increased signal-to-noise ratio (SNR), which can be traded for a higher spatial resolution or a faster imaging procedure. Unfortunately, imaging at these field strengths is challenging because of the strong B1-inhomogeneity and increased specific absorption rates (SAR). Previous reports have shown that *in vivo* imaging of the prostate is feasible, albeit after adaptation of pulse durations and echo times [1,2]. In order to find out whether the anatomical contrast at 7T is useful in patients with prostate cancer, we have compared the visibility of PCa lesions between 7T and 3T on an individual patient level.

Methods

Thirteen patients with biopsy-proven PCa that had undergone a 3T staging-MR examination with an endorectal coil were enrolled in this study. Written informed consent was obtained from all patients. Imaging was performed in supine position on a 7T whole-body MR-system (Magnetom, Siemens Healthcare, Erlangen, Germany) using an 8-channel multi Tx/Rx external body array coil [3]. After B0-shimming, B1-shimming and localized calibration of flip angles within the prostate, T2-weighted (T2w) fast spin-echo images were acquired in three orthogonal directions with the following parameters: TR 3000-3640 ms, TE 71 ms, 8 refocusing pulses of 7.68 ms with flip angle 150°, resolution 0.75x0.75x3 mm and acquisition time 1:30 – 1:53 min. The images were obtained using the external body array coil only. At 3T, imaging was performed on a whole-body MR scanner (Skyra, Siemens Healthcare, Erlangen, Germany) and the images were obtained with both body array coil and endorectal coil, with the following parameters: TR 4930 ms, TE 101 ms, flip angle 120°, resolution 0.4x0.4x3 mm and acquisition time 4:21 min.
One radiologist, who was aware that patients had biopsy-proven PCa, evaluated the T2w-images of both field strengths. For both 3T and 7T data, general image quality was scored as insufficient (artifacts that could interfere with detection of the lesion), sufficient (artifacts not interfering with diagnosis) or good (no artifacts). Next to that, all 3T and 7T images were independently evaluated for the presence of a cancer lesion. The location of PCa was checked with the histopathologically confirmed area, with transrectal (ultrasound-guided or MR-guided) biopsy as the reference standard. Subsequently, image-contrast and visibility of anatomical details (peripheral zone, transition zone, neurovascular bundles, seminal vesicles and peri-prostatic tissue) at 7T were directly compared with 3T.

Results

All patients completed the full MR-examination and no adverse events occurred. At 3T, image quality was scored as good in 10/13 and sufficient in 3/13 cases. Image quality at 7T was rated good (9/13), sufficient (3/13) and insufficient (1/13). No lesions were visible in two patients at either field strength, while in one patient cancer was visible on 3T images but not at 7T. The biopsy Gleason score was 3+3 in these three patients. In the remaining ten patients the detection of cancer lesions was comparable between both field strengths (fig. 1). In general, the appearance of 7T images was different from 3T images with respect to image contrast. In all patients, at 7T the peripheral zone appeared darker. Neurovascular bundles and peri-prostatic lipids were brighter at 3T compared to 7T. Transition zone and seminal vesicles looked similar on 7T as on 3T images.

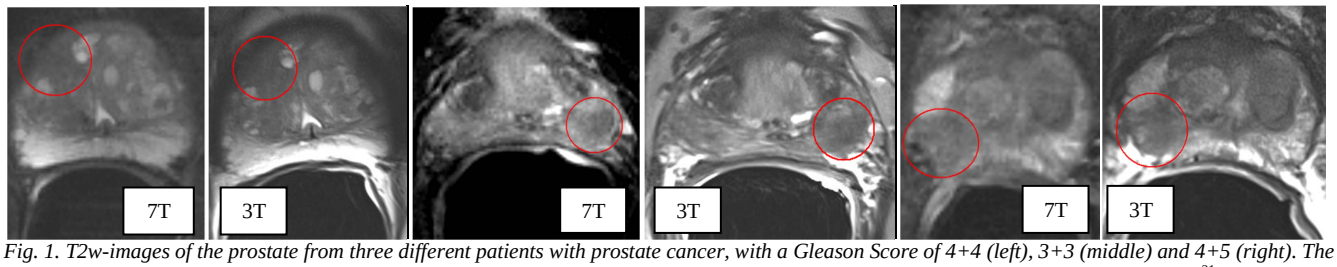

Fig. 1. T2w-images of the prostate from three different patients with prostate cancer, with a Gleason Score of 4+4 (left), 3+3 (middle) and 4+5 (right). The red circle represents the lesion in which prostate cancer was histopathologically confirmed. The endorectal coil visible in the 7T images was used for ^{31}P spectroscopic imaging performed in conjunction with these experiments (data not shown here [4,5]), and was not used for signal reception in these images.

Discussion

In the majority of patients, lesions that could be detected at 3T were detectable at 7T as well. In one patient the quality of 7T images was considered insufficient due to severe motion artifacts at the base of the prostate. This was the same patient in which the lesion was not visible at 7T while it was at 3T, so the failed detection at 7T was probably due to patient movement. The difference in appearance of the peripheral zone between both field strengths was likely due to the influence of the coil-profile at 3T (resulting in a brighter peripheral zone). The hypo-intense peri-prostatic lipid tissue at 7T resulted from the use of prolonged (i.e. narrow bandwidth) refocusing pulses. Different bandwidths of radiofrequency pulses for excitation and refocusing introduce a difference in the large chemical shift artifacts in slice selection, resulting in almost complete spatial separation of excited and refocused lipid slices, giving rise to nearly complete fat suppression. The intrinsic SNR gain compared to 3T that higher field strengths can provide, was not observed in this study because we did not use an endorectal coil for ^{1}H-signal reception at 7T. Spatial resolution was therefore lower at 7T than at 3T. Future studies using a ^{1}H-(Rx)-endorectal coil are needed to quantitatively compare the SNR gained by moving to a higher field strength. The use of an endorectal coil may enable higher spatial resolutions, which may further optimize the quality of 7T images.
In this study we only analyzed T2w-images; however, recently introduced international guidelines [6] recommend the addition of at least two functional techniques (such as diffusion weighted imaging, MR spectroscopic imaging or dynamic contrast-enhanced imaging) for prostate cancer detection. These early experiences show that the first step towards such a protocol for prostate T2w-imaging at 7T has been made. At the moment, anatomical imaging at 7T is currently being used to provide an anatomical reference for 31P-spectroscopic imaging [4,5]. The next step would be optimization of T2w-imaging and exploration of possibilities for functional MR-techniques at an ultra high field strength.

Conclusion

These early experiences show that the first step towards *in vivo* T2w-imaging of the prostate in cancer patients at 7T has been made. T2w-imaging can routinely be performed. We demonstrated that prostate cancer lesions are detectable on T2w-images at 7T, despite differences in image contrast and thus appearance of anatomical details. Therefore, T2w-imaging at 7T has future potential for the detection of PCa.

References

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