3T Multiparametric MRI and MR-Guided In-Bore Biopsy to Detect Prostate Cancer

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Introduction

Multiparametric magnetic resonance imaging (mp-MRI) of the prostate gains increasing influence in prostate cancer detection, especially in patients with prior negative transrectal ultrasound (TRUS) biopsy and continuous suspicion of prostate cancer [1]. Prostate MRI can also be useful in active surveillance of low-grade tumors [2]. The European Society of Urogenital Radiology (ESUR) released in 2012 guidelines for prostate MRI in order to standardize evaluation and reporting [3]. As a consequence of defining suspect areas in the mp-MRI subsequent targeted biopsies (MR-GB) to verify these lesions should be performed. Currently three techniques are available that incorporate MRI information to define target structures for biopsy: Cognitive ultrasound biopsy (c-GB), MRI/ultrasound fusion biopsy (FUS-GB), and MR-guided in-bore biopsy (IB-GB) [1, 4].

Patient history

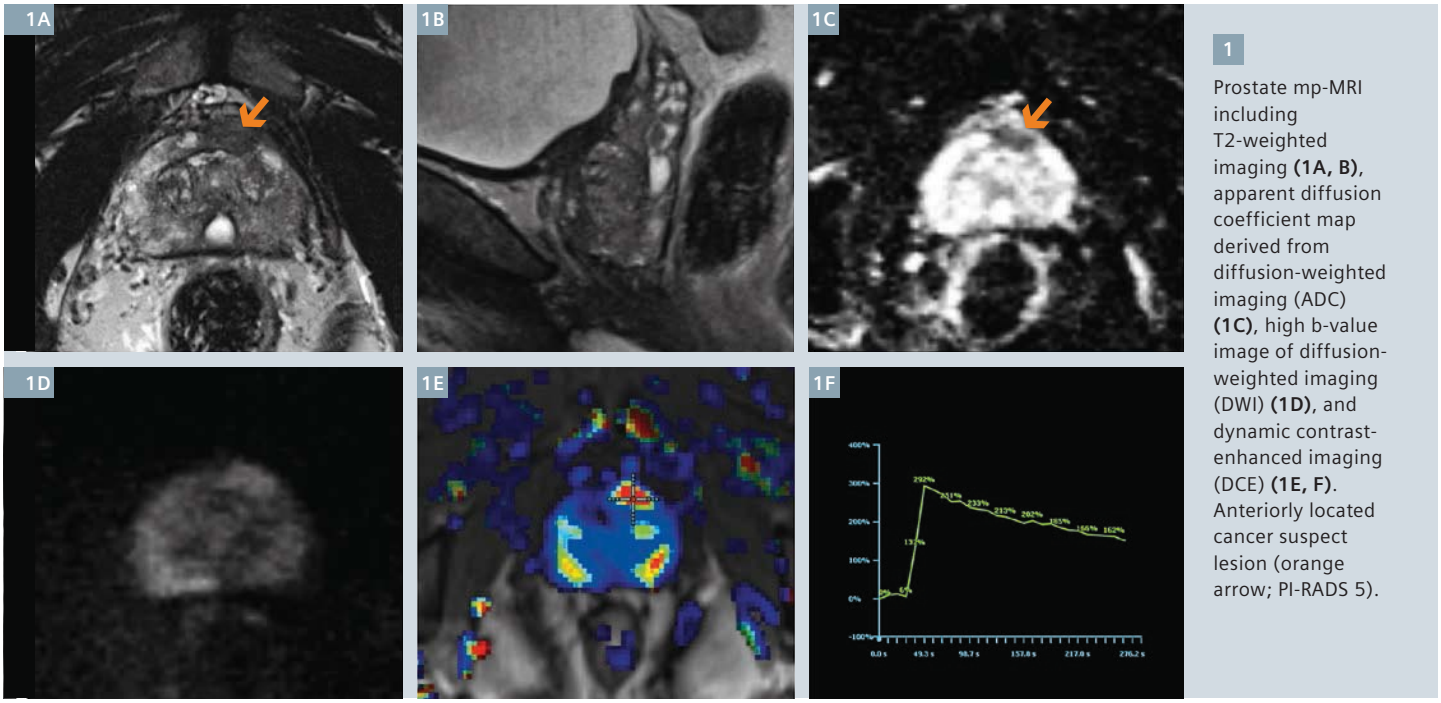
A 62-year-old man was referred to our Institute of Diagnostic and Interventional Radiology with two negative TRUS-guided biopsies and remaining suspicion of prostate cancer due to continuously increasing prostate-specific antigen (PSA) values. The ultimate PSA value was 9.9 ng/ml. The prostate volume was only slightly enlarged (42 ml).

MR imaging

In the apical anterior prostate gland mp-MRI detected a highly suspicious area, located in region 13as/14as on a 27-region localization scheme [5] (Fig. 1). This lesion was rated according to the PI-RADS scoring system for each MR-sequence. The overall PI-RADS classification for this lesion was 5 (clinically significant disease is highly likely to be present) [6]. In addition, the MRI showed post-inflammatory transformations in the peripheral zone and considerable changes due to benign prostate enlargement (BPE) in the transition zone. The seminal vesicles were inconspicuous and no enlarged lymph nodes were found in the area under investigation.

Sequence details

Prostate mp-MRI was performed at a 3T MRI system (MAGNETOM Trio; Siemens Healthcare, Erlangen, Germany) with a 6-channel phased-array body coil. The imaging protocol



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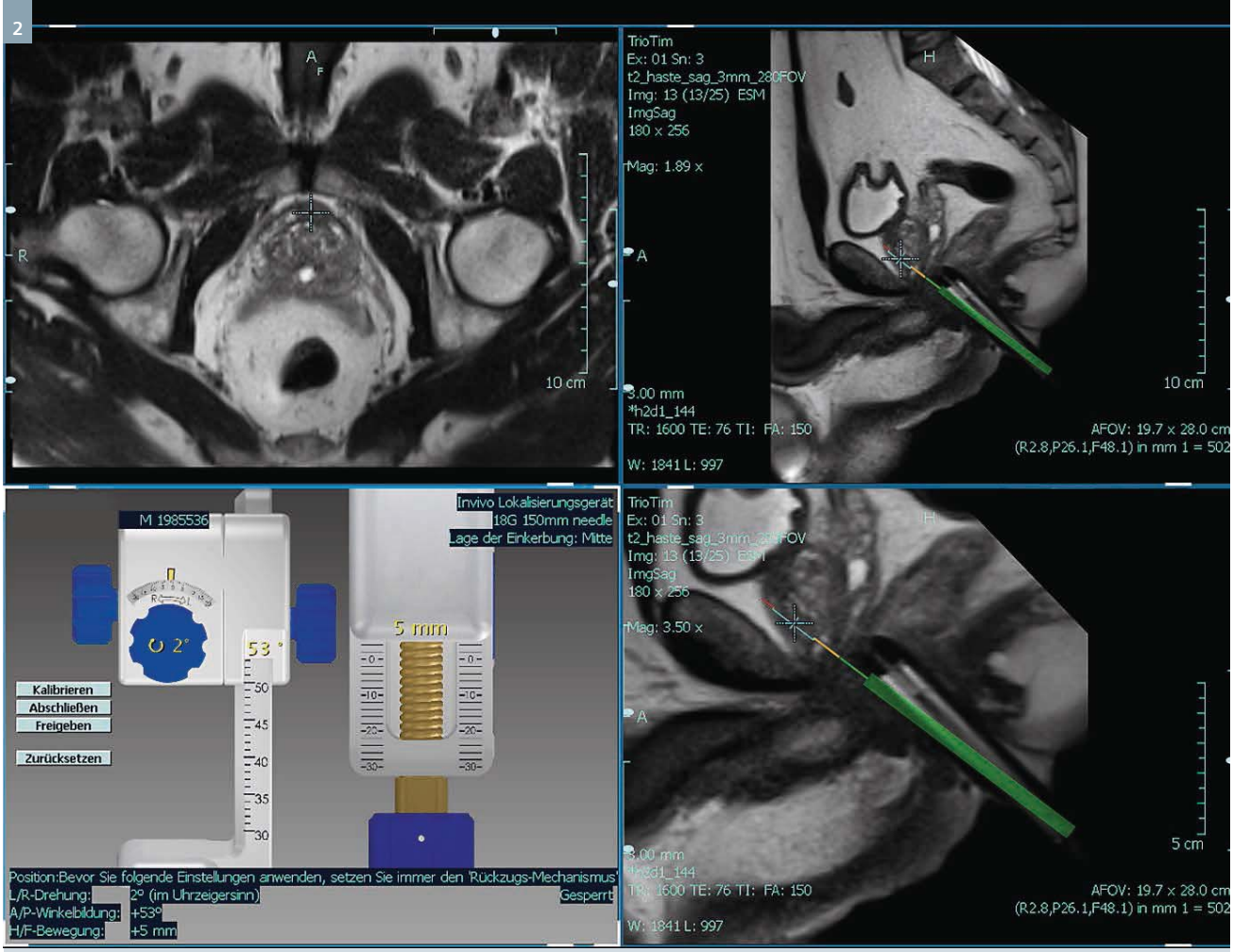
Prostate mp-MRI including T2-weighted imaging **(1A, B)**, apparent diffusion coefficient map derived from diffusion-weighted imaging (ADC) **(1C)**, high b-value image of diffusion-weighted imaging (DWI) **(1D)**, and dynamic contrast-enhanced imaging (DCE) **(1E, F)**. Anteriorly located cancer suspect lesion (orange arrow; PI-RADS 5).



2 Setting of MR-guided in-bore biopsy (IB-GB) with a DynaTRIM biopsy device (Invivo, Gainesville, FL, USA) and DynaCAD workstation (Invivo).

was adapted according to the ESUR guidelines [3]. To suppress peristalsis the patient received 20 mg butylscopolamine (Buscopan; Boehringer, Ingelheim, Germany). Mp-MRI included T2-weighted (T2w) imaging, T1-weighted (T1w) imaging, diffusion-weighted imaging (DWI), and dynamic contrast-enhanced imaging (DCE-MRI).

T2-weighted turbo spin echo sequences were acquired in three standard orthogonal planes

axial: TR 10630 ms, TE 117 ms, FOV 12.8 cm, voxel size 0.5 × 0.5 × 3.0 mm, image matrix 256 × 256, turbo factor 23; **sagittal/coronal:** TR 11330 ms, TE 103 ms, FOV 17 cm, voxel size 0.7 × 0.7 × 3.0 mm, image matrix 256 × 256, turbo factor 25.

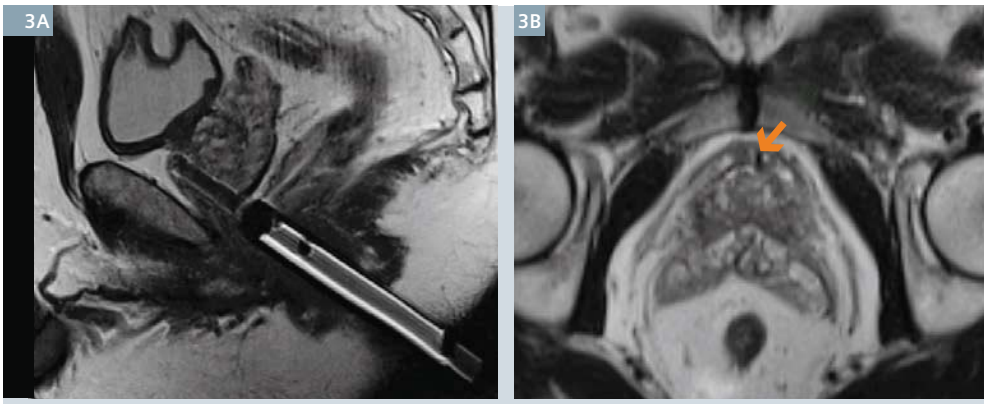
For T1w axial turbo-spin echo images (TR 650 ms, TE 13 ms, FOV 30 cm, voxel size 1.3 × 0.9 × 5.0 mm, gap 10%, image matrix 240 × 320, turbo factor 3), and for DWI single-shot spin-echo echo-planar sequence (TR 4600 ms, TE 90 ms, FOV 20.4 cm, voxel size 1.5 × 1.5 × 3.0 mm, image matrix 136 × 136, GRAPPA parallel imaging scheme with acceleration factor 2) using 3 b-values (0, 500, 1000 s/mm^2) with eight averages, were performed. Apparent diffusion coefficient (ADC) parameter maps were calculated by the scanner software using the standard monoexponential model. For the DCE-MRI volume-interpolated gradient echo sequence (TR 5.26 ms, TE 1.76 ms, FOV 19.2 cm, voxel size 1.5 × 1.5 × 3.0 mm, image matrix 128 × 128, GRAPPA parallel imaging scheme with acceleration factor 2, 31 scans, scan time 5:05 min, temporal resolution 10 sec) were applied. Contrast media injection started after the second measurement using gadoteric acid (Dotarem®, Guerbet, Aulnay-sous-Bois, France) in a weight-adapted standard dose (0.2 mmol/kg body weight) with an injection rate of 3 ml/s. Total scan time was approximately 33 minutes.

MRI/US fusion guided biopsy (FUS-GB)

Subsequently to the suspect mp-MRI a targeted FUS-GB was performed using the Urostation® 3-dimensional ultrasound system (Koelis, La Tranche, France) to ensure biopsy cores were taken of the described suspicious area. The histological result revealed minor chronic prostatitis and no cancer verification.

MR-guided in-bore biopsy (IB-GB)

Owing to the highly suspicious mp-MRI we decided in consent with the patient to perform another targeted biopsy. An IB-GB was performed on the same 3T MRI system (MAGNETOM Trio). The patient was placed in a prone position and a needle guide fixed to a portable biopsy device (DynaTRIM, Invivo, Gainesville, FL, USA) was introduced rectally. Image data were transferred to a DynaCAD workstation



3 Biopsy needle* verification of the direct lesion hit in our patient (orange arrow).

(Invivo) for biopsy planning (Fig. 2). Two cores were taken of the anterior lesion in region 14as with an MR-compatible, 18-gauge, fully automatic biopsy gun (Invivo). Due to the negative results of the prior MRI/US fusion prostate biopsy we decided to perform a needle control scan. The needle control scan confirmed the correct positioning of the biopsy needle (Fig. 3). The histopathology resulted in a malignant gland forming prostate tumor (Gleason score 4 + 3 = 7), described as an acinar adenocarcinoma with high percentage of cancer involvement (80% per core).

Discussion

The current gold standard for prostate diagnostics is the digital rectal examination, the PSA value, and TRUS followed by a systematic TRUS-guided biopsy. Mp-MRI is a promising complementary technique that allows in uncertain or problematic cases a good differentiation between tumor and benign lesions [1, 7]. It furthermore enables targeted MR-guided biopsy (MR-GB) procedures, as a logical consequence of describing suspicious lesions. MRI/US fusion-guided biopsy (FUS-GB) shows good results, however, 2D/3D models are only overlaid, and an exact peer-to-peer verification is still missing, especially if the suspicious lesion described in the MRI is not visible in ultrasound [8]. MR-guided in-bore biopsy (IB-GB) offers some advantages in comparison. Lesions are presented and biopsied in the same modality, a direct control of taken biopsy cores is feasible, and an individual management of BPE or patient movement is possible. In our patient we could detect and histologically verify a significant prostate cancer by IB-GB alone.

References

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*Metal: The MRI restrictions (if any) of the metal implant must be considered prior to patient undergoing MRI exam. MR imaging of patients with metallic implants brings specific risks. However, certain implants are approved by the governing regulatory bodies to be MR conditionally safe. For such implants, the previously mentioned warning may not be applicable. Please contact the implant manufacturer for the specific conditional information. The conditions for MR safety are the responsibility of the implant manufacturer, not of Siemens.