MR-Guided Biopsies of the Prostate in Supine Patient Position

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Introduction
Prompted by elevated PSA levels, more than a million men in the United States alone have to undergo transrectal ultrasound (TRUS)-guided prostate biopsy to clarify suspicion for prostate cancer per year [1]. Unlike pathways for other malignancies, biopsy of the prostate is performed by standardized, systematic but essentially random sampling [2]. The major limitation of this approach is that clinically insignificant cancers are often identified by chance while, even more important, clinically significant cancers may remain undetected [3, 4]. As a result of this uncertainty, more than one-third of men whose first biopsy was negative are rebiopsied within 5 years [1].

Over recent years, multiparametric magnetic resonance imaging (mpMRI), combining the morphological assessment of T2-weighted (T2w) imaging with different functional imaging techniques such as diffusion-weighted imaging (DWI) and dynamic contrast enhanced imaging (DCE) has become a mature tool for localizing and visualizing suspicious foci in the prostate.

Consequently, advances are being made in the way that biopsies are performed, with the aim to integrate the additional information into the biopsy workflow: Cognitive registration, in-bore MR guided biopsy and MR/US fusion biopsies are the most commonly used techniques to improve prostate cancer detection with targeted biopsy.

While both cognitive integration and MR/US fusion biopsies have been shown to improve the cancer detection rate [5], prostate biopsies performed under direct MR guidance are indicated in patients where MR imaging identified lesions that are either very small or located in areas difficult to reach with standard TRUS-guided biopsy. Another indication might be in patients showing a clear discrepancy between the histopathological findings of TRUS-biopsy and imaging results.

In the following, we report on our clinical experience with a customized approach and a simplified biopsy workflow for MR-guided prostate biopsies where the patient lies in supine position.

Case 1
Due to a contraindication for digital rectal examination and transrectal ultrasound because of rectal stenosis, a 72-year-old, biopsy-naive patient with continuously rising PSA levels (last: 12 ng/ml) was referred to our institution for diagnostic prostate MRI. Scans were performed with high-channel surface coils only using a MAGNETOM Skrya 3T system.

The protocol consisted of axial, coronal and sagittal T2-weighed TSE scans (TR 8300 ms, TE 107 ms, slice thickness 3.0 mm, FOV 160 mm, matrix 320, TA 3:11 min); axial diffusion-weighted imaging with RESOLVE (TR 4190 ms, TE 69 ms, slice thickness 3.0 mm, FOV 160 mm, matrix 114, TA 4:42 min) and axial DCE scans (TR 5.08 ms, TE 1.77 ms, slice thickness 3.5 mm, FOV 260 mm, matrix 192, TA 8:1 s, 35 repetitions).

Transversal T2w TSE images (1A) demonstrating a suspicious lesion within the left peripheral zone with correspondingly increased signal in the b = 800 s/mm² image (1B), diffusion restriction in the ADC map (1C). The lesion can be confirmed in the coronal T2w images (1D). The parametric map (1E, Ktrans) shows a clear focal lesion with a highly suspicious curve (1F).
Dynamic contrast-enhanced images were post-processed using syngo.via Tissue 4D.

As illustrated in Figure 1, a lesion in the apical third of the prostate was visible in T2-weighted images as a hypointense, lenticular shaped structure extending more than 1.5 cm with corresponding diffusion-restriction and suspect, focal contrast uptake as well as wash-out in the DCE series. Consequently, the patient was referred to MRI-guided prostate biopsy of the highly suspicious areal in the gland.

Biopsy was performed in a wide-bore MAGNETOM Aera 1.5T system with the patient in supine lithotomy position using a tailored positioning device (Fig. 2, Invivo Germany, Schwerin, Germany). Intra-procedural imaging was undertaken using a combination of a flexible 4-channel coil underneath the patients back and a standard 18-channel body coil positioned on the pelvis of the patient. First, a small, contrast-filled tube was inserted to the patient’s rectum and fixated with a highly flexible MR-compatible arm. To define the target for biopsy, fast T2-weighted scans (TR 5000 ms, TE 100 ms, slice thickness 3.5 mm, FOV 200 mm, matrix 256, TA 1:45 min) were performed, while the position and orientation of the contrast-filled needle guide was imaged using a 3D fat suppressed TrueFISP sequence and visualized with a 3D maximum intensity projection (MIP) technique. By simply positioning the center mark of a slice block (Fig. 3, yellow circle) in the center of the lesion, the orientation of the needle guide with respect to the target was checked and the trajectory of the needle guide was iteratively corrected to point to the target. In the given case, only one iteration (repositioning of the needle guide, control scan) was necessary. After contentedly positioning the needle guide, the actual fully-automated biopsy device was inserted and two samples from slightly different positions were taken (Fig. 4). Histopathology revealed a $3 + 3 = 6$ acinar adenocarcinoma.
Case 2

Patient presented at our department with constantly high PSA values (03/2015: 10.8 ng/ml; 04/2015: 13.0 ng/ml) with a referral for prostate MRI. Diagnostic multiparametric prostate MRI was performed on our 1.5T MAGNETOM Aera and revealed two relatively small lesions in the right and left peripheral zone (Fig. 5). The lesion in the right peripheral zone was selected for MR target biopsy due to better accessibility. During the MR-guided biopsy session, two samples were taken from different positions (Fig. 6). The one taken from the periphery revealed an acinar adenocarcinoma with a Gleason Score of 6 (3 + 3) while the other sample even showed a more aggressive pattern (Gleason Score 3 + 4 = 7).

Summary

Targeted biopsies of the prostate under direct MRI-guidance are a reasonable complement to ultrasound biopsy techniques. As shown in the second case presented here, exact targeting of the most suspicious portion of a tumor is crucial for correct classification and consequently best therapy decisions. Especially in case of relatively small lesions, direct MR-guidance has clear advantages over fusion techniques which are always susceptible to intrinsic sources of registration errors.

The targeting procedure presented here, does not require any additional software equipment or extra planning PCs, since it is solely based on standard sequences and planning tools provided with the scanner. Biopsies in a supine position, as performed in Nuremberg, may further improve the acceptance and applicability of MR guided biopsies of the prostate especially in obese, dyspneic or elderly individuals.

References


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