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Original article

Effect of targeted biopsy guided by elastic image fusion of MRI with 3D-TRUS on diagnosis of anterior prostate cancer

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Abstract

Purpose: To evaluate the effect of targeted biopsy (TB) with elastic fused magnetic resonance imaging (MRI) and 3-dimensional transrectal ultrasound (3D-TRUS) guidance in the diagnosis of anterior prostate cancer (APCa).

Material and method: A retrospective study was performed on patients who underwent TB with elastic fused MRI/3D-TRUS guidance using a 1.5-T MRI with T2- and diffusion-weighted images. APCa was defined as TB-proven cancer whose MR-imaged center was located anteriorly according to standardized MRI reporting schema. Prostate Imaging Reporting and Data System was used to quantify MRI suspicion. Maximum cancer core length (MCCL), cancer core involvement, primary Gleason grade pattern, and Gleason score (GS) on TB were assessed. A clinically significant cancer on TB was MCCL $\geq$ 5 mm of GS 6 or any cancer with GS $\geq$ 7. Agreement between TB and radical prostatectomy step sections was assessed for all subjects when possible.

Results: A total of 211 consecutive subjects were included. APCa was found in 81% (170/211). Median (range) of TB per patient, MCCL, and cancer core involvement were 2 (1–5), 10 mm (4–23), and 57% (10%–100%), respectively.

According to the level of MRI suspicion, positive rate for any cancer vs. clinically significant cancer was 96% (114/119) vs. 86% (102/119) for highly suspicious, 80% (46/57) vs. 68% (39/57) for likely, and 29% (10/35) vs. 20% (7/35) for equivocal, respectively ($P = 0.016$ and <0.001).

Step-section analysis was possible for 70 patients. Concordance of primary Gleason grade pattern and GS between TB and radical prostatectomy was 90% ($\kappa = 0.7$) and 77% ($\kappa = 0.64$), respectively.

Conclusion: TB with elastic fused MRI/3D-TRUS guidance significantly enhanced accuracy in diagnosing clinically significant APCa.

Keywords: Clinically significant prostate cancer; Magnetic resonance imaging; Transrectal ultrasound; Elastic image fusion; Targeted prostate biopsy

1. Introduction

Analyses of step-sectioned radical prostatectomy (RP) specimens show that anterior prostate cancer (APCa) often has a greater volume and a higher positive margin probability than posterior tumors [1–3]. APCa is generally not palpable and is difficult to differentiate from the nodule of benign prostate hypertrophy using conventional gray-scale transrectal ultrasound (TRUS) alone. Limited biopsy-needle core length combined with a transrectal approach is also thought to result in APCa undersampling [4].

Magnetic resonance imaging (MRI) is a promising modality for detecting clinically significant anterior and transitional zone prostate cancer [5]. The foundation of PCa

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diagnosis remains histological, and suspicious MRI findings require biopsy confirmation. Targeted biopsy (TB) using elastic fusion of MRI and 3-dimensional (3D) TRUS guidance is an innovative diagnostic method that improves the diagnostic accuracy of prostate biopsy [6–9]. To our knowledge, no studies have reported the accuracy of TB using elastic fused MRI/3D-TRUS guidance for diagnosing APCa using standard Prostate Imaging Reporting and Data System [10,11].

This study aimed to assess the clinically significant cancer (CSCa) yield of TB using elastic fused MRI/3D-TRUS guidance in patients with suspicion of APCa on MRI. The secondary aim was to evaluate the agreement between Gleason score (GS) and primary Gleason grade (GG) for TB and RP step-sectioned specimen.

2. Materials and methods

2.1. Patients

This retrospective quality control study received ethical committee approval from Oslo University Hospital. Between January 2010 and August 2013, 211 consecutive patients who underwent TB with elastic fused MRI/3D-TRUS guidance and had at least one suspicious anterior lesion on MRI that was targeted were included. Subjects who had undergone previous in vivo PCa therapy such as external beam radiation therapy and high-intensity focused ultrasound were included. A total of 70 patients had undergone RP.

2.2. Magnetic resonance imaging

Prebiopsy MRI was performed on a 1.5-T Avanto MR scanner (Siemens, Erlangen, Germany) using a 6-channel Body MATRIX coil (Siemens). The sequences were as follows: axial 3D T2-weighted (T2w) and axial diffusion-weighted imaging with apparent diffusion coefficient map calculated from b50 and b1000. Additional b2000 sequences were acquired [7]. APCa on MRI was defined as TB-proven cancer whose MR-imaged center was located anteriorly according to the standardized MRI prostate reporting scheme [10]. Suspicion level for performing TB was rated as highly suspicious, likely, and equivocal based on signal quality on T2w and signal intensity on T2-corrected b1000, apparent diffusion coefficient, and b2000 images [7]. These levels correspond to the highest 3 levels of 5 levels of suspicion in Prostate Imaging Reporting and Data System [12]. All MRI sequences were used for tumor detection. Estimated MRI tumor volume (MTV) was calculated on T2w images using the simplified volume formula for an ellipsoid model: height $\times$ width $\times$ length $\times$ 0.5 [13]. All MR images were interpreted by one radiologist (E.R.) who was not blinded to the clinical provenance. The time lapse between previous negative biopsy and MRI was at least 6 weeks.

2.3. Biopsy procedure

The 3D-TRUS prostate and prostate volume acquisition was performed using the Accuvix V10 Medison-Samsung (Korea) ultrasound machine. Suspected MRI findings were segmented on T2w images [7]. TB was guided by MRI/3D-TRUS elastic image fusion with Urostation (Koelis, La Tronche, France) using real-time 3D-TRUS organ-tracking technology [14]. Simulation of the biopsy trajectory using the virtual biopsy technique of Urostation was used to plan and achieve the ideal direction of end-fire probe 3D5-9EK Medison. To adequately sample from the anterior lesion, the biopsy needle was first (before firing) placed at a suitable depth based on the target lesion distance from the rectal wall. Biopsy trajectory and simulated tissue capture volume (TCV) were displayed on the 3D fused image while positioning the biopsy needle. Once the simulated TCV was located within the targeted lesion to the operator's satisfaction, the biopsy needle was fired and held still for 3 seconds for acquisition of actual TCV and digital registration in the live 3D prostate volume. This allowed for confirmation that the TCV was indeed from the center of MRI target. In cases of imprecise needle placement, additional cores were taken until the MRI target was sampled centrally. All TB were performed by one urologist (E.B.) under local anesthesia in an outpatient clinic using a biopsy needle of 18 gauge $\times$ 25 cm with a 20-mm sampling length (Tru-Core II; Angiotech, Vancouver, Canada). Standard random 12 core TRUS biopsies were performed in men who were biopsy naïve but not in those who had previous biopsy.

2.4. Histological analysis

Biopsy cores were labeled individually according to biopsy location. The same team of uropathologists performed histopathological analyses of all biopsy and RP specimens according to standard procedures [15]. Biopsy results were classified as positive or negative for any cancer as well as CSCa. Maximum cancer core length (MCCL), cancer core involvement, GS, and primary GG pattern were recorded for each TB. A CSCa on TB was defined as MCCL $\geq$ 5 mm of GS 6 or any MCCL of GS $\geq$ 7 [11,16]. A CSCa on step-sectional analysis of RP was defined as cancer volume $\geq$0.5 ml of GS 6 or any cancer volume of GS $\geq$ 7.

Histological findings on negative biopsy as fibrosis, inflammation, and atypical small acinar cell proliferation were documented.

2.5. Statistical analysis

Descriptive statistics were used for patient characteristics. The Mann-Whitney *U* test, and Student *t* test were used to assess differences, as appropriate. Concordance between TB and RP in terms of GS and primary GG pattern