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Thirty-Two-Channel Coil 3T Magnetic Resonance-Guided Biopsies of Prostate Tumor Suspicious Regions Identified on Multimodality 3T Magnetic Resonance Imaging: Technique and Feasibility

Thomas Hambrock, MBChB,* Jurgen J. Füttener, MD, PhD,* Henkjan J. Huisman, MSEE, PhD,* Christina Hulsbergen-vandeKaa, MD, PhD,† Jean-Paul van Basten, MD, PhD,‡ Inge van Oort, MD,§ J. Alfred Witjes, MD, PhD,§ and Jelle O. Barentsz, MD, PhD*

Objectives: To test the technique and feasibility of translating tumor suspicious region maps in the prostate, obtained by multimodality, anatomic, and functional 3T magnetic resonance imaging (MRI) data to 32-channel coil, T2-weighted (T2-w), 3T MR images, for directing MR-guided biopsies. Furthermore, to evaluate the practicability of MR-guided biopsy on a 3T MR scanner using a 32-channel coil and a MR-compatible biopsy device.

Materials and Methods: Twenty-one patients with a high prostate-specific antigen (>4.0 ng/mL) and at least 2 prior negative transrectal ultrasound-guided biopsies of the prostate underwent an endorectal coil 3T MRI, which included T2-w, diffusion weighted and dynamic contrast enhanced MRI. From these multimodality images, tumor suspicious regions (TSR) were determined. The 3D localization of these TSRs within the prostatic gland was translated to the T2-w MR images of a subsequent 32-channel coil 3T MRI. These were then biopsied under 3T MR guidance.

Results: In all patients, TSRs could be identified and accurately translated to subsequent 3T MR images and biopsied under MR guidance. Median MR biopsy procedure time was 35 minutes. Of the 21 patients, 8 (38%) were diagnosed with prostate cancer, 6 (29%) had evidence of prostatitis, 6 (29%) had combined inflammatory and atrophic changes, and only 1 (5%) patient had no identifiable pathology.

Conclusions: Multimodality, 3T MRI determined TSRs could effectively be translated to T2-weighted images, to be used for MR biopsies. 3T MR-guided biopsy based on these translated TSRs was feasible, performed in a clinical useful time, and resulted in a high number of positive results.

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From the Departments of *Radiology and †Pathology, University Medical Centre Nijmegen, Nijmegen, Netherlands; ‡Department of Urology, Canisius Wilhelmina Hospital, Nijmegen, Netherlands; and §Department of Urology, University Medical Centre Nijmegen, Nijmegen, Netherlands. Supported by the Dutch Cancer Society Grant KUN 2004-3141.

Reprints: Thomas Hambrock, MD, Department of Radiology, Route 667, University Medical Centre Nijmegen, P.O. 9101, 6500HB, Nijmegen, Netherlands. E-mail: t.hambrock@rad.umcn.nl.

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Like many cancers, prostate cancer is treated most effectively when detected early.¹ Two of the most important tests for the early diagnosis of prostate cancer are the digital rectal examination (DRE) and the prostate-specific antigen (PSA) blood test.² Currently, prostate cancer is most often confirmed after biopsy of the prostate,³ and the histopathologic examination of tissue obtained from these biopsies remains the reference standard for diagnosis of prostate cancer.

Standard sextant transrectal ultrasound (TRUS)-guided biopsy of the prostate up till few years ago was the most common method used to detect prostate cancer in patients after an abnormal DRE or high serum PSA levels.⁴ Recently, it was shown that extended schemes incorporating laterally directed biopsies significantly increase the detection rate.⁵ ⁶ Biopsy techniques consisting of 12 cores including laterally directed cores seem a current compromise between maximizing the cancer detection rate and minimizing adverse events.⁶ Tumor detection rates at initial biopsy sessions vary according to the extent and site of biopsies. Schemes involving sextant and octant cores reported cancer detection rates of 22% to 29%,⁷,⁸ whereas 10 to 12 core schemes reported initial detection rates of between 33% and 36%.⁹,¹⁰ If patients with initial negative biopsies were subjected to subsequent sextant or octant biopsies, the tumor detection rates were between 10% and 19%,⁷,¹¹,¹² whereas, by using extended 10 to 12 core schemes, tumor detection rates at second biopsy were reported to range between 17% and 35%.⁹,¹⁰,¹²,¹³ Unfortunately, the literature is still very heterogeneous on the biopsy schemes performed and no clear consensus is reached yet by urologists.⁵,⁶,¹⁴–¹⁹

Because PSA is a nonspecific marker for prostate cancer, urologists are often faced with the dilemma of managing a patient with a high index of suspicion for prostate cancer.
after an initial set of negative prostate biopsies. Hence, the possibility remains that these patients may still have tumor, as prostate cancer is often multifocal and heterogeneous in nature and the volume of prostatic tissue sampled relatively small.7 Patient anxiety about the possibility of cancer is particularly high when there is a high index of tumor suspicion.20 Therefore, more accurate methods need to be found to detect or rule out significant disease.

Magnetic resonance imaging (MRI) of the prostate has established itself as a very useful modality to accurately localize prostate cancer within the gland.21,22 On a T2-weighted (T2-w) MR image, the characteristic pattern of prostate cancer is a low signal-intensity lesion. Despite high-resolution imaging (eg, when using an endorectal coil for MRI at 3T), the diagnostic localization accuracy of T2-w imaging remains quite low.23,24 Therefore, functional MRI modalities have been used to increase this accuracy. Dynamic contrast-enhanced MRI (DCE-MRI), diffusion weighted imaging (DWI), and proton spectroscopic MRI (H-MRS) have all been established as reliable techniques for this purpose: localization accuracies of DCE-MRI being between 80% and 90%,21,25 DWI-MRI between 82% and 89%,26–28 and H-MRS around 85%.21,29,30 Because the sensitivity of grayscale ultrasound to localize prostate cancer is quite low (38%–44%),21 MRI, with its higher tumor localization ability, can potentially be used as a modality for directing biopsies of tumor lesions. Despite the fact that most current data on MR of the prostate is for 1.5T imaging, recent publications on functional imaging at 3T show a tendency of increased accuracy.26,32,33

Recent publications on the use of MR spectroscopic imaging to guide TRUS biopsies have shown an improved detection yield.34,35 Because translation of MR images to ultrasound images is technically challenging, prostate tissue sampling techniques under direct MR guidance have been developed. Initial experience of using such MR-guided devices at 1.5T, to biopsy tumor suspicious regions on T2-w imaging, have shown promising results.36,37

MR-guided biopsies directed by functional imaging modalities (DCE-MRI, DWI, or H-MRS) added to anatomic images (to increase tumor localization accuracies) requires a robust and accurate technique to exchange positional information from the localization MRI to the biopsy MR images. The accuracy of this exchange is crucial to improve tumor detection yield, especially if this is to be done with a low number of cores and performed in a clinically acceptable time.

The principal aim of our study was to test the technique and feasibility of translating tumor-suspicious region maps obtained by multimodality, anatomic and functional 3T MRI data to 32 channel coil, T2-w, 3T MR images for directing MR-guided biopsies. Furthermore, we evaluated the practicability of MR-guided biopsy on a 3T MR scanner using a 32-channel coil and a MR-compatible biopsy device.

PATIENTS AND METHODS

Patients

Between August 2006 and March 2007, 21 consecutive patients were referred for tumor localization, from the departments of urology at the Radboud University Nijmegen Medical Centre and the Canisius Wilhelmina Hospital in Nijmegen, Netherlands, for MRI of the prostate. In 20 of these patients, there was a suspicion for prostate cancer based on an elevated PSA of >4.0 ng/mL and/or abnormal DRE. One patient had a PSA of 1 ng/mL with an abnormal DRE and previous high-grade prostate intraepithelial neoplasia on biopsy. All patients had received at least 2 prior negative TRUS-guided biopsy sessions of the prostate. In all patients, prior biopsies had been at least 6 weeks before referral. Eight patients have received more than 2 prior TRUS biopsies because of continuous concern for the presence of prostate cancer, based on excessive high PSA >10 ng/mL or continuous rising PSA. In 8 of 21 patients, at least 1 extended biopsy session was performed, which included a 9-core sampling technique (6 lateral peripheral zone, 2 transition zone, 1 apically directed), whereas the remaining 13 had at least one 10-core biopsy (8 peripheral zone cores and 2 transition zone cores). Median age was 62 years (range, 54–71) and the median PSA value was 15 ng/mL (range, 1–123). This study was approved by the Institutional Review Board, and the requirement for signed informed consent were waived.

Localization MRI

To identify possible tumor location(s), MRI was performed on these patients using a 3T MR scanner (Siemens Trio Tim, Erlangen, Germany) with the use of an endorectal coil (Medrad, Pittsburgh). The endorectal coil was inserted and filled with a 40-mL perfluorocarbon preparation (Fomblin; Solvay-Solexis, Milan, Italy). Peristalsis was suppressed with an intramuscular administration of 20-mg butylscopolaminebromide (Buscopan; Boehringer-Ingelheim, Ingelheim, Germany) and 1 mg of glucagon (Glucagen; Nordisk, Gentofte, Denmark). After this, all patients were examined using a 3T MRI.

The imaging protocol, after fast evaluation of correct endorectal coil position with fast gradient echo imaging, included the following sequences: first, T2-w turbo spin echo sequences were performed with an in-plane resolution of 0.4 × 0.4 mm [repetition time (TR) 3250 ms/echo time (TE) 116 ms; flip angle 120 degree; 15–19 slices; 3-mm slice thickness; echo train length 15; 180 × 180 mm field of view and 448 × 448 matrix] in axial, coronal, and sagittal planes, covering the prostate and seminal vesicles. Second, a single-shot-echo-planar imaging sequence with diffusion modulation and fat suppression pulses was implemented. Water diffusion in 3 directions was measured using b-values of 0, 50, 500, and 800 s/mm2 and a TR of 2500 ms, TE of 91 ms, slices 15–19, 3-mm slice thickness and an in-plane resolution of 1.5 × 1.5 mm. ADC-maps were automatically calculated by the scanner software. Third, 3D T1-weighted spoiled gradient-echo images (TR/TE 34/1.6 ms, 14-degree flip angle, 10 transverse partitions on a 3D slab, 4-mm section thickness, 192-mm field of view, 128 × 128 matrix, Grappa parallel imaging, factor 2) were acquired during an intravenous bolus injection of a paramagnetic gadolinium chelate—0.1 mmol of gadopentetate dimeglumine (Dotarem; Guerbet, Paris, France) per kilogram of body weight—which was administered with a power injector (Spectris; Medrad) at 2.5
mL/s and followed by a 15-mL saline flush. With this sequence, a 3D volume with 10 partitions was acquired every 2.5 seconds during 210 seconds, with the same positioning angle and center as the transverse T2-w sequence, covering the entire prostate. Before contrast material injection, the same transverse 3D T1-weighted gradient echo sequence (with the exception of TR/TE of 800/1.6 and an 8-degree flip angle) was used to obtain proton-density images, with identical positioning to allow calculation of the relative gadolinium chelate concentration curves.

**Localization MR Data Analysis**

The prostate images were viewed on an in-house developed analytical software workstation, which calculated the pharmacokinetic DCE-MRI parameters and projected these parameters as color overlay maps over the T2-w images. Additionally, ADC maps calculated from DWI were also projected as color overlays. DWI images as such were not used as part of the evaluation. If patient-related movement caused misregistration of the different modalities, these were corrected using a manual coregistration tool built into the software. Images of all patients were read in consensus by 2 readers with 1 year (T.H.) and 4 years (J.F.) experience in prostate MRI. The high-resolution, axial T2-w images were used as basis for evaluation of the prostate and all other functional imaging modalities were interpreted in relation to these. On T2-w imaging, the generally known tumor criteria were used to detect TSRs. These included (a) low signal intensity areas in the peripheral zone (PZ), (b) within the transition zone, a homogeneous low T2 signal intensity area with ill-defined margins or a lenticular shape, and (c) within the central zone, areas of homogenous low signal intensity with an ill-defined margin. After identification of tumor suspicious regions on T2-w images, the ADC maps and multiparametric pharmacokinetic (DCE-MRI derived) color maps-K<sup>trans</sup>, V<sub>e</sub>, K<sup>ep</sup>, and WashOut were analyzed in a color overlay mode on the T2-w images. The generally known features of tumor on DCE-MR imaging (high V<sub>e</sub>, K<sup>trans</sup>, K<sup>ep</sup>, and negative WashOut) and areas of restriction on ADC maps (especially in the PZ and transition zone) were used to increase the specificity of the T2-w-identified TSRs. Additionally, after the functional data from DWI and DCE images were evaluated in relation to the TSR findings on the T2-w images, the DWI and DCE images were viewed separately and in combination to determine additional TSRs not evident on T2-w images. Eventually, the information from all the imaging modalities were combined and used to determine the (up to 3) most suspicious TSRs within the prostate.

Figure 1 shows an example of how the prostate was divided into different axial and sagittal regions for 3D spatial position estimation of the TSR. This was done as follows: on the sagittal T2-w images, the prostate was divided into 5 slabs, equating to: apex, apex-mid, mid, midbasis, and basis levels. These slabs were equal in thickness and parallel to the axial T2-w images. The axial T2-w slice(s) containing the TSR were then related to the corresponding sagittal slab. On the axial T2-w images, distinction was made between peripheral zone, central zone, and transition zone, and the relationship of the TSRs to these was noted. Furthermore, each axial zone was divided into the following subzone regions: PZ, for...
each left and right half of the prostate, using the urethra as dividing point for (1) anterior horn, (2) dorsolateral region, and (3) dorsal region. The central zone was divided into 4 quadrants, whereas the transition zone was divided into left and right regions only. The apical and basal slabs, where the PZ and CG often do not clearly coexist, were divided into simple quadrants. The TSR in relation to the subzone region was then noted. Therefore, for each TSR position, the slab, zone, and subzone were recorded. This position was used as basis for re-identification of a TSR on the T2-w images during the biopsy MR session.

MR-Guided Biopsy

On average, 2 weeks (range, 1–4 weeks) after the initial tumor localization MRI, patients received a 32-channel coil (in vivo, Schwerin, Germany). 3T-MR guided biopsy (Trio Tim; Siemens, Germany). For antibiotic prophylaxis, all patients took oral ciprofloxacin 500 mg (Ciproxin, Bayer, Leverkusen, Germany) the evening before, on the morning of the biopsy, and 6 hours postbiopsy. Prostate biopsies were performed with the patient in the prone position, with the 32-channel coil elements positioned beneath and on the back of the patient. A gadolinium-filled needle guider was inserted rectally and attached to the arm of a MR-compatible biopsy device (in vivo). Figure 2 shows the MR-guided biopsy device attached to the patient, lying prone on the scanner table. The used method and adjustments made to the device during scanning were previously described.36,37 In summary, the arm onto which the needle guider was attached enabled the needle guider to be rotated, moved forward and backward, and adjusted in height. The insertion angle can be adjusted by rotating the needle guide about a point inside the rectum. The needle guide was then directed to the defined TSR within the prostate. After correct alignment, the needle guide was fixed in position for obtaining tissue samples with an 18-gauge, fully automatic, core-needle, double-shot biopsy gun (in vivo) with needle length of 150 mm and tissue core sampling length of 17 mm.

T2-w turbo spin-echo images in the axial and sagittal direction (TR 3500 ms/TE 116 ms, flip angle 180, slice thickness 3 mm, in-plane resolution 0.7 × 0.7 mm, number of slice 15) were obtained for anatomic visualization of the prostate. The axial T2-w slices had a similar angulation relative to the dorsal surface of the prostate as during the localization MR session. The MR images of the previous localization MRI were projected on a monitor positioned next to the MR console. Re-identification of the TSRs on the new T2-w images was done first by using the relative 3D position, which incorporated the 5 slabs, the zones, and different subzonal regions. For this purpose, on the sagittal T2-w images, the prostate was divided into the 5 slabs from apex to base. The axial T2-w slices corresponding to the TSR slab were then identified. These were visually divided into the different zones and subzone regions (see localization for details). When the desired subzone region was re-identified, the positioning was a fine-tuned. This was done by noting heterogeneous features within the gland, eg, features relating to nodular and stromal appearances, position of urethra, and other prominent characteristics within the zones. These were established on the T2-w images of the initial MRI, which were projected on the computer screen next to the console and then compared with the features visible on the biopsy MR images. If a low-signal intensity lesion was evident on the original T2-w images and re-identified on the current T2-w images within the desired zone-region, a certain TSR re-identification was evident. Otherwise 1 or 2 slices were scrolled up or down (axial T2-w slices) for identification of the T2-w-evident lesion.

After re-identification of the desired TSR, adjustments were made to the biopsy device to aim the gadolinium-filled needle guider exactly towards this area. In-between adjustments, fast T2-w True-Fisp images (TR 4.48 ms/TE 2.24/flip angle 70-degree, field of view 228 × 228 mm, matrix 228 × 228, slice thickness 3 mm) were made in the axial and sagittal direction (imaging time 11 seconds for each direction) to visualize correct guider position and used to plan further adjustments. Biopsies were obtained and to verify correct needle position within the TSR, fast T2-w TRUE-FISP images were again obtained with the needle left in situ. This was done for each TSR that was biopsied. One to 3 biopsies were taken per TSR, depending on the certainty of correct needle position within a TSR and the size of the TSR. A maximum of 3 different TSRs were biopsied per patient. All biopsies were performed by 1 radiologist (T.H.).

Samples were subsequently processed by a routine fixation in formaldehyde, embedded in paraffin, stained with hematoxylin-eosin, before being evaluated by a histopathologist for the presence of tumor or other benign pathologies.
RESULTS

The tumor localization MRI had an average scanning duration of 22 minutes. In all 21 patients referred for a tumor localization MRI, 1 or more TSRs could be identified. On average 2 TSRs were identified per patient (range, 1–3). Using the described translation technique, all TSR regions could be confidently re-identified during the biopsy MR session. Patients tolerated the MR-guided biopsies well and apart from 1 transient transurethral hemorrhage immediately after the procedure; only minor pain after tissue sampling was reported as a side effect by some patients. By imaging with the needle left in situ, identification of needle position confirmed correct sampling of all the TSRs. In total, 84 prostate cores were obtained from 40 different TSRs in 21 patients. The average number of biopsies per patient was 4 (range, 1–7). Of the 40 different TSRs sampled, 23% (9 of 40) contained tumor, whereas 77% (26 of 40) were normal, containing benign pathologic changes in 65% (26 of 40) and no changes in 13% (5 of 40). Histopathologic analysis of the prostate samples revealed adenocarcinoma in 31% of cores (26 of 84) and in 38% of patients (8 of 21). Of all core samples, 27% revealed prostatitis (23 of 84), whereas 21% (18 of 84) showed combined atrophic and inflammatory changes, 1 core (1%) showed atypia and 1 (1%) core revealed necrosis. No identifiable pathology was found in 18% (15 of 84) of cores and in only 1 patient. Of the 8 patients identified with adenocarcinoma, 1 patient had a tumor with Gleason score 5, 4 had a tumor with Gleason score 6, 1 with 2 TSRs positive for tumor, each with a Gleason score 7 and 2 patients with a Gleason score of 8. Of the 9 TSRs positive for tumor, 67% (6 of 9) were in the ventral aspect of the transition zone, 22% (2 of 9) in the peripheral zone, and 11% (1 of 9) in the central zone. The median duration of MRI guided biopsies was 35 minutes (range, 21–75 minutes). A learning curve was evident in manipulating the biopsy device and performing biopsies, quickly and effectively. This was also reflected in the median imaging time of 41 minutes for the first 10 patients, which subsequently decreased to 32 minutes for the following 11 patients. Table 1 reveals a summary of the patient and biopsy findings. The imaging features of the TSRs, positive for tumor, are summarized in Table 2. Figure 3 shows the multimodality MR images of a patient, which include: T2-w, DWI, and DCE-MRI, used for identifying the TSRs. In this patient, the tumor was situated in the right ventral aspect of the prostate, on the border between the transition and central zone. Figure 4 shows this TSR, which was subsequently re-identified on the T2-w images during the MR-guided biopsy session.

DISCUSSION

Our principal aim was to test the technique and feasibility of translating multimodality, anatomic and functional 3T MRI data of tumor suspicious regions, to subsequent 32-channel coil, T2-w, 3T MR images. We have shown this to be feasible and can be performed without much difficulty. We further demonstrated that such a technique could be used to direct and perform MR-guided biopsies in a clinically acceptable manner on a 3T MR scanner using a 32-channel coil and an MR-compatible biopsy device.

To achieve accurate tumor localization, we performed an endorectal coil, 3T MRI, using validated, multimodality MR sequences with high diagnostic accuracies for tumor localization. Additionally, because reading of these images was performed using a high sensitivity approach, TSRs could

| TABLE 1. Patient and Biopsy Characteristics of the 21 Patients Biopsied |
|---|---|---|---|---|---|
| Patient | Age | PSA | No. TSRs | No. Biopsies | Diagnosis | Tumor Gleason Score |
| 1 | 69 | 20 | 2 | 3 | Tumor | 6 (3 + 3) |
| 2 | 63 | 1 | 1 | 1 | Prostatitis | — |
| 3 | 65 | 17 | 2 | 3 | Tumor | 6 (3 + 3) |
| 4 | 66 | 20 | 2 | 3 | Prostatitis/atrophy | — |
| 5 | 68 | 58 | 1 | 6 | Prostatitis/atrophy | — |
| 6 | 62 | 7 | 1 | 3 | Prostatitis/atrophy | — |
| 7 | 60 | 4 | 1 | 3 | Prostatitis | — |
| 8 | 59 | 8 | 3 | 3 | Prostatitis | — |
| 9 | 59 | 20 | 3 | 4 | Prostatitis | — |
| 10 | 54 | 12 | 1 | 1 | Prostatitis | — |
| 11 | 57 | 8 | 2 | 6 | N.A.D | — |
| 12 | 62 | 32 | 3 | 7 | Prostatitis/atrophy | — |
| 13 | 58 | 123 | 2 | 5 | Tumor | 6 (3 + 3) |
| 14 | 63 | 14 | 3 | 6 | Tumor | 7 (4 + 3) |
| 15 | 70 | 21 | 3 | 4 | Prostatitis/atrophy | — |
| 16 | 63 | 9 | 2 | 5 | Prostatitis | — |
| 17 | 70 | 34 | 1 | 4 | Tumor | 8 (4 + 4) |
| 18 | 61 | 16 | 3 | 3 | Prostatitis | — |
| 19 | 62 | 5 | 1 | 6 | Tumor | 5 (3 + 2) |
| 20 | 71 | 17 | 1 | 3 | Tumor | 6 (3 + 3) |
| 21 | 70 | 15 | 1 | 4 | Tumor | 8 (5 + 3) |
be identified in all patients. To use multimodality 3T MRI for
directing 3T MR-guided biopsies is unique and contrasts to
prior studies in which only T2-w imaging at low-field sys-
tems was used.36,37,41

We established that using high-resolution T2-w im-
ages as basis for image interpretation of functional modal-
ities, followed by a “crude” translation technique with
subsequent visual fine-tuning, resulted in an accurate 3D
translation of TSRs between the MR sessions. In all 21
patients, we were confident that every TSR could be
adequately re-identified during the biopsy MR session.
Apart from the translation technique, this can also be
related to using high-resolution images, obtained with a 3T
32-channel coil for biopsy guidance.

We found that 32-channel coil 3T MRI guided biopsy,
with the patient in the prone position, is well tolerated and
feasible to perform within a clinically acceptable time. The
practicability of using the current biopsy technique and
equipment is in agreement with 2 prior 1.5T studies,36,37
which describe a similar setup. In comparison to these prior
studies, our imaging time was remarkably reduced with an
average duration of 35 minutes, compared with 55 minutes
and 2 hours, respectively. It should however be mentioned that
the latter reported imaging times were also particularly high
because of an initial learning curve in performing MR biopsies
and additionally a higher number of cores were obtained. We
found that using the fast (11 seconds) T2-w TRUE-FISP se-
quencies at 3T resulted in adequate visibility of anatomic details
to orientate the needle guider effectively. Faster imaging and
higher anatomic detail is probably the biggest advantage of 3T
MR biopsy over 1.5T, especially with the use of a 32-channel
surface coil and parallel imaging.

Despite the fact that re-identification of the translated
TSRs remains somewhat subjective; the high tumor detection
rate directed towards these regions (31% of samples and 38% of
patients) and the high prevalence of benign pathologic diagnoses
(67%—27 of 40 of TSRs) is a good indirect validation of
satisfactory re-identification. The preliminary results also show a
higher tumor detection percentage (38%) compared with sextant
and octant TRUS-guided biopsies after 2 prior negative biopsies
reported in the literature (8%–14%).7,11,12 It has to be empha-
sized that the detection of prostate cancer in subsequent biopsy
sessions is strongly dependent on the biopsy scheme used during
the initial and subsequent sessions13 and patient-related factors
like PSA value, prostate volume, and the population prevalence
of prostate cancer.18,42 In an attempt to increase the detection
rate during rebiopsy, saturation biopsy techniques with greatly
increased number of samples (>20 cores) have been advocated
by some researchers. These saturation biopsy strategies were
shown to increase detection rates (25%–41%),43–45 but at the

**TABLE 2.** MRI Features of TSRs Positive for Tumor on Biopsy

<table>
<thead>
<tr>
<th>TSR</th>
<th>T2-w</th>
<th>DWI</th>
<th>DCE-MRI</th>
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<tr>
<td>1</td>
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+ indicates that a lesion is visible, whereas − indicates no lesion visibility. Features indicated with 0 denote nonspecific heterogeneous low-signal intensity lesions on T2-w, within the central gland.

**FIGURE 3.** A case example with images from the endorectal coil, multimodality 3T MRI. The axial T2-w image (A) shows a low signal intensity area in the transitions zone, right (arrow). The ADC map (B) from the DWI shows the same area with restriction in diffusion ability, whereas the WashOut pharmacokinetic map (C), calculated from the DCE-MRI data, shows an enhanced removal rate of gadolinium. Images (D) and (E) show the TSR identified by the readers. The subsequent “crude” estimation of the 3D location within the gland shows the TSR to be predominantly within the right aspect of the transition zone (F) and in the midbase (MB) slab (G).
expense of pain and complications, and the unduly high cost of processing the large amount of pathologic material. The preliminary results of our current research may not show an increased detection performance to such saturation schemes but at a similar performance, our technique will be a more appealing alternative. Furthermore, saturation biopsies are not yet advocated by the European Guidelines for Prostate Cancer and only performed by few urologists in our country.

All our patients have received at least 1 prior TRUS session with tissue sampling of the transition zone. Despite this, 67% of our tumor-containing TSRs were situated in the transition zone. Although our results are too preliminary to make definite conclusions, it does seem as if the lack of extended transition zone sampling in rebiopsy session could account for the large number of tumors missed. It is known that 25% of prostate cancers arise in the transition zone\(^\text{46}\); yet, most studies on extended biopsy techniques conclude that laterally directed cores, apical sampling, or sampling of the anterior horns increases the detection yield, whereas additional sampling of the transition zone does not.\(^\text{6,47–49}\)

The transrectal sampling approach has the advantage of being the least invasive and requiring no anesthesia, compared with other described MR biopsy approaches, of which transperineal\(^\text{50}\) and transgluteal\(^\text{41,51}\) are the best known techniques. However, infection risk is increased when an endorectal approach to tissue sampling is used.\(^\text{52}\) Djavan et al\(^\text{52}\) has shown that complications due to prostatic biopsies are not trivial. Of all their patients who underwent biopsies, 11% developed infectious complications, 63% had bleeding related problems, whereas up to 8% had significant

**FIGURE 4.** The TSR (yellow interrupted circle) identified from the multimodality, endorectal coil, 3T MR images is translated to the 32-channel coil T2-w images using the 3D localization method. The midbase (MB) level containing the TSR is first identified (A). On the axial T2-w images (B) within this level, the right transition zone area with TSR is found. The gadolinium-filled needle guider is directed on sagittal (C) and axial (D) images towards this re-identified region. Correct needle positioning and tissue sampling from the TSR is verified by imaging with the needle left in situ (E).
pain or discomfort. We have demonstrated that by limiting the biopsy cores to MR-determined tumor suspicious regions only a lower number of cores can be obtained, with an average of 4 in our study. This has the advantageous potential to reduce bleeding risk, infection risk, and patient discomfort and pain. Other authors have shown that using T2-w imaging alone for tumor localization can be valuable in guiding biopsies performed in a closed-bore MRI scanner. It is known that T2-w imaging on its own has a quite poor sensitivity for localizing prostate cancer, reported in the literature to range between 58% and 65%.

Only 1 study has looked at a possible advantage of adding DCE-MRI to T2-w imaging for guidance of MR biopsies. Unfortunately, a too small patients group was evaluated to assess the possible benefit. Because of the currently available data on tumor localization accuracies by MRI, we decided to maximize the possibility of tumor detection likelihood, by using high-spatial resolution imaging with an endorectal coil at 3T and obtaining DCE and DWI imaging in addition to T2-w imaging. This approach, however, has the drawback that performing a localization MRI and biopsy MRI in the same imaging session is deemed impractical. Changing the endorectal coil, awaiting software postprocessing of the DCE data, and the time consuming evaluation of images were all considered practical reasons to postpone the MR-guided biopsy to another session. Additionally, because recent evidence by Heijmink et al. has shown that the localization accuracy of endorectal coil, T2-w 3T MRI is significantly improved compared with using a surface coil for T2-w, 3T imaging (Az 0.68 vs. 0.62), we decided to use the endorectal coil for localization.

The preliminary data on the 9 TSRs positive for tumor (Table 2) indicated that for 2 TSRs, functional imaging modalities directed the biopsies towards tumor, whereas T2-w images showed no lesion visible. Additionally, for another 2 TSRs, the heterogeneous nature of the central gland with diffuse low signal intensities on T2-w imaging was found unhelpful for clear localization of the TSRs, something that was only possible with the addition of functional data.

One of the limitations of this study is the small number of patients used. However, this study was designed as a pilot to assess the technique of translating multimodality MR data and the feasibility of MRI guided biopsies at 3T. Additionally, an arbitrarily defined maximum of 3 TSRS was chosen, as increasing this number further would have resulted in prolonged, clinically unacceptable imaging time and discomfort to the patient. Interpreting anatomic and functional MR images of the prostate requires a degree of experience, which might make routine clinical application of this technique somewhat difficult. However, recently Vos et al. showed that by using computer-aided diagnostic software support for DCE-MRI, a method can be found to aid radiologists to improve the accuracy of tumor localization.

Our conclusions are that TSR maps identified on multimodality, anatomic and functional, 3T MRI can effectively be translated to T2-w images during a MR biopsy session by using simple visual criteria. Furthermore, MR-guided biopsy of these TSRs, with the MR-compatible biopsy device using a 32-channel coil, 3T MRI, is a feasible technique, which can be performed in a clinically acceptable time and needs only a low number of biopsy cores. This shows great potential for improving tumor detection in patients with previous negative biopsies and tumor suspicious PSA levels. Assessing the true overall tumor detection capabilities, the benefit of MR-guided biopsies over extended biopsy techniques in rebiopsy sessions, and the need for using an endorectal coil is part of an ongoing study.

REFERENCES


