Magnetic resonance imaging-guided biopsies may improve diagnosis in biopsy-naive men with suspicion of prostate cancer

Winther, Mads Dochedahl; Balslev, Ingegerd; Boesen, Lars; Logager, Vibeke; Noergaard, Nis; Thestrup, Karen-Cecilie Duus; Thomsen, Henrik S

Published in:
Danish Medical Journal

Publication date:
2017

Document version
Publisher's PDF, also known as Version of record

Magnetic resonance imaging-guided biopsies may improve diagnosis in biopsy-naive men with suspicion of prostate cancer

Mads Dochedahl Winther[1], Ingegerd Balslev[2], Lars Boesen[3], Vibeke Logager[1], Nis Noergaard[3], Karen-Cecilie Duus Thestrup[1] & Henrik S. Thomsen[1]

ABSTRACT

INTRODUCTION: The purpose of this pilot study was to investigate whether a short prostate biparametric magnetic resonance imaging (bp-MRI) protocol provides a valuable diagnostic addition for biopsy guidance in biopsy-naive men with a suspicion of prostate cancer (PCa).

METHODS: A total of 62 biopsy-naive patients referred to a systematic transrectal ultrasound biopsy (TRUS-bx) due to suspicion of PCa were prospectively enrolled. Bp-MRI was performed before biopsy. All lesions were scored according to the modified Prostate Imaging Reporting and Data System (PI-RADS) version 2. All patients underwent TRUS-bx followed by bp-MRI-guided biopsies (bp-MRI-bx) under MRI/TRUS image fusion from any bp-MRI suspicious lesions not obviously targeted by TRUS-bx.

RESULTS: PCa was found in 42 (68%) and 32 (52%) patients by TRUS-bx and bp-MRI-bx, respectively. Bp-MRI-bx detected PCa in one patient who had been missed by TRUS-bx, and found the highest Gleason score (GS) in 13 (30%) patients leading to an overall GS upgrade in six (14%) patients. Bp-MRI missed nine patients with GS = 6 and two with a GS = 7 (3 + 4), all of whom were diagnosed by TRUS-bx.

CONCLUSIONS: Addition of bp-MRI-bx to routine TRUS-bx seems feasible in biopsy-naive patients and may improve the detection of aggressive PCa in first-round biopsies. This pilot study thus provides an incentive for a larger investigation.

FUNDING: Costs were covered by the Department of Radiology, Herlev Hospital, Denmark.

TRIAL REGISTRATION: This study was registered with the Danish Data Protection Agency (HEH-2015-054, I-Suite no: 03775) and with the Committee for Health Research Ethics (no. H-15009341).

Early detection and risk evaluation of patients with prostate cancer (PCa) is the key to providing the right treatment at the right time. Approx. 4,400 men are diagnosed annually with PCa in Denmark and the incidence is expected to rise in coming years [1]. Transrectal ultrasound (TRUS) guidance of biopsies (bx) has been the primary diagnostic examination for many years. However, TRUS-bx suffers from a high biopsy burden, frequent false negative results and an erroneous estimation of the final pathology [2-4]. Since TRUS poorly visualises both any pathological changes and the anterior components, the systematic biopsies based on TRUS may benefit from supporting image diagnostics. PCa typically presents with varying degrees of aggressiveness and Gleason scores (GS) and it is important to detect severe pathological changes early.

Multiparametric magnetic resonance imaging (mp-MRI) has been shown to be a valuable addition to TRUS-bx [5-7]. However, mp-MRI of the prostate is time-consuming. An examination time of one hour and the usage of intravenous contrast medium make it a less attractive option in a large patient population. Conceivably, it is feasible to shorten the examination time in patients with no prior biopsies and still offer an adequate examination. Therefore, we undertook a pilot study to investigate whether a biparametric MRI (bp-MRI) scanning protocol may serve as a valuable diagnostic addition to guide TRUS biopsies in biopsy-naive men with a suspicion of PCa.

METHODS

Invited to participate in the study were all patients referred for a TRUS-bx to the Department of Urology, Herlev Hospital, University of Copenhagen, Denmark, on Mondays, Tuesdays and Thursdays within a two-month period on suspicion of PCa due to either 1) a prostate-specific antigen (PSA) > 4 ng/ml, 2) suspicious digital rectal exploration (DRE), 3) earlier suspicious TRUS without biopsies or 4) other predisposition (e.g. family history of PCa).

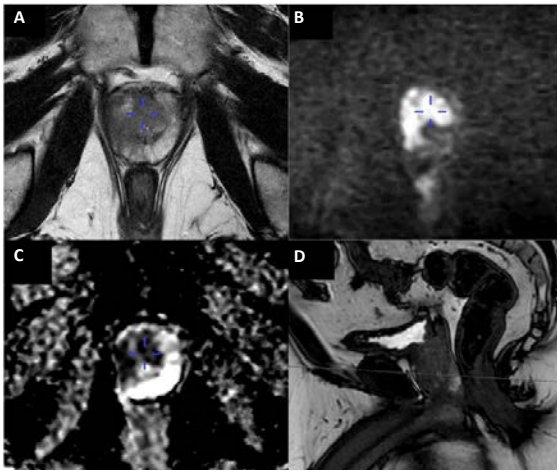
The exclusion criteria were: 1) previous PCa diagnosis, 2) previous biopsies of the prostate, 3) certain types of implants incompatible with MRI (e.g. pacemaker), 4) any metal implants in the pelvis (e.g. hip replacement) and 5) claustrophobia.

Permission for this study was granted by the Danish Data Protection Agency (HEH-2015-054, I-Suite no: 03775) and by the Committee for Health Research Ethics (no. H-15009341).

ORIGINAL ARTICLE

1) Department of Radiology, Herlev Hospital
2) Department of Pathology, Herlev Hospital
3) Department of Urology, Herlev Hospital, Denmark

Dan Med J 2017;64(5):A5355



Example of a biparametric magnetic resonance imaging (bp-MRI) showing axial sequences of T2-weighted (T2W) (**A**), diffusion-weighted images with b = 2,000 (**B**) and the apparent diffusion coefficient map (**C**) in addition to the sagittal T2W scout (**D**). Routine transrectal ultrasound biopsy found Gleason score (GS) = 3 + 4 in two biopsy cores while a bp-MRI-guided biopsy from the indicated anterior prostate cancer component found GS = 5 + 3 leading to an overall GS upgrade.

Biparametric magnetic resonance imaging

Patients were scanned in a 3.0-T clinical MRI system (Ingenia, Philips Healthcare, Best, the Netherlands) to acquire: 1) an axial T2-weighted (T2W) sequence, 2) axial diffusion-weighted images (DWI) with b-values of 0, 100, 800 and 2,000. An apparent diffusion coefficient (ADC) map was calculated based on all acquired b-values. A sagittal T2W scout supported the axial sequences. The combined examination time was 30 minutes.

Magnetic resonance image analysis

Suspicious malignant lesions in the transitional and peripheral zone of the prostate were marked on the bp-MRI and retrospectively classified in accordance with the European Society of Urogenital Radiology's (ESUR) recommended Prostate Imaging Reporting and Data System (PI-RADS) guidelines [8, 9]. All lesions were scored on a scale ranging 1-5 indicating the likelihood of malignancy (1 = highly unlikely; 2 = unlikely; 3 = equivocal; 4 = likely; 5 = highly likely). However, asbp-MRI does not include dynamic contrast enhanced (DCE) T1W sequences, the scoring criteria of lesions in the peripheral zone were determined by the DWI and ADC map in accordance with PI-RADS version 2 guidelines [9].

Transrectal ultrasound biopsy procedure with biparametric magnetic resonance imaging guidance

All patients had a DRE prior to TRUS. During TRUS, the prostate volume was measured (width × length × height) and the parenchyma was evaluated for suspicious malignant areas. A Hitachi Ascendus ultrasound scanner (Kashiwa, Japan) and a Hitachi EUP-533 biplane transducer (Kashiwa, Japan) were used.

Initially, all patients underwent TRUS-bx, varying the number of biopsy cores deemed necessary for diagnosis and depending on the clinical situation. Patients who were considered suitable for treatment with a curative intent had 6-10 standard biopsies (n = 60). Patients in whom PCa was highly likely based on DRE and PSA and who were not suitable for curative treatment had 1-2 standard biopsies (n = 2) to confirm their diagnosis. The TRUS-bx operator was blinded to any bp-MRI findings during the standard biopsies. Thereafter, the bp-MRI was opened, transferred to the ultrasound machine via the Hitachi RVS-software and then fused with the TRUS image. Fusion biopsies (1-2 cores) were taken from each suspicious lesion marked on the bp-MRI. If bp-MRI-suspicious lesions were placed in a region already biopsied by the standard biopsies, the area was omitted. All biopsies were taken using an end-fire technique and a Hitachi EUP-V53W transducer.

Criteria for clinically significant prostate cancer

The following preoperative criteria were used to evaluate positive TRUS-bx as clinically significant: a) a GS ≥ 7, b) ≥ 3 positive biopsy cores or c) cancer extension ≥ 50% per biopsy. Furthermore, a PSA > 10 ng/ml in combination with a GS of 6 was deemed clinically significant. On MRI target biopsies, the criteria were GS ≥ 7, cancer extension ≥ 50% per biopsy or a PSA > 10 ng/ml.

Statistical analysis

Clinical data including age, PSA, PSA density, number of bp-MRI lesions and the number of bp-MRI biopsies were compared based on biopsy findings using a nonparametric Wilcoxon rank sum test when possible and characterised using descriptive statistics. Overall, GS of TRUS-bx, bp-MRI biopsies and combined results were compared. Bp-MRI PI-RADS scores for each identified lesion were graphically compared with biopsy results. No statistical tests or calculation of sensitivity or specificity were performed due to the population size and lack of a gold

! ABBREVIATIONS

ADC = apparent diffusion coefficient
Bp-MRI = biparametric magnetic resonance imaging
Bx = biopsy
DCE = dynamic contrast enhanced
DWI = diffusion-weighted images
ESUR = European Society of Urogenital Radiology
GS = Gleason score
HG = high grade
IG = intermediary grade
LG = low grade
mp-MRI = multiparametric magnetic resonance imaging
MRI = magnetic resonance imaging
NAD = no applicable disease
PCa = prostate cancer
PI-RADS = Prostate Imaging Reporting and Data System
PSA = prostate-specific antigen
PSAD = PSA density
PZ = peripheral zone
T2W = T2-weighted
TRUS = transrectal ultrasound
TZ = transition zone

TABLE 1

Demographic data.

Clinical characteristic	Negative (N = 19)	Positive (N = 43)	p-value[a]	Total (N = 62)
Age, yrs, median (range)	63 (52-72)	68 (49-80)	< 0.02	66 (49-80)
PSA concentration, ng/ml, median (range)	6 (1.6-20)	7.3 (1.7-85)	< 0.053	6.9 (1.6-85)
Prostate volume, ml, median (range)	59 (33-99)	44 (20-105)	< 0.001	49 (20-105)
PSAD, ng/ml/cm^3, median (range)	0.11 (0.05-0.31)	0.19 (0.04-1.55)	< 0.0001	0.15 (0.04-1.55)
Clinical T category, n (%)				
T1c	14 (74)	19 (44)		33 (53)
T2a	1 (5)	7 (16)		8 (13)
T2b	0	6 (14)		6 (10)
T2c	0	2 (5)		2 (3)
T3a	0	7 (16)		7 (11)
Tx	4 (21)	2 (5)		6 (10)
Nonpalpable tumour, cT1c, n (%)	14 (74)	19 (44)		33 (53)
Palpable tumour, cT2-cT3, n (%)	1 (5)	23 (53)		29 (47)
Bp-MRI foci/patient, n, median (range)	2 (0-3)	2 (0-4)		2 (0-4)
Bp-MRI-bx/patient, n, median (range)	2 (0-3)	2 (0-4)		2 (0-4)
TRUS-bx/patient, n, median (range)	10 (10-11)	10 (2-10)		10 (2-11)
Total bx/patient, n, median (range)	12 (10-14)	12 (4-16)		12 (4-16)
Overall Gleason score, n %)				
≤ 6				13 (30)
7				22 (51)
≥ 8				8 (19)

bp = biparametric; bx = biopsy; PSA = prostate-specific antigen; PSAD = PSA density; TRUS = transrectal ultrasound.
a) Wilcoxon rank sum test comparing the negative and positive prostate cancer population.

standard. Patients were divided by tumour aggressiveness into the following groups: low grade (LG; GS ≤ 6), intermediary grade (IG; GS = 7) and high grade (HG; GS ≥ 8 or any grade-5 component present).

Trial registration: Danish Data Protection Agency (HEH-2015-054, I-Suite no: 03775) and Committee for Health Research Ethics (no. H-15009341).

RESULTS

A total of 67 patients were included between November and December 2015. Five patients were excluded due to comorbidity (n = 1), transport difficulties to the hospital (n = 3) or claustrophobia (n = 1). Demographic data are summarised in **Table 1**.

Overall, PCa was detected in 43 out of the 62 patients (69%). Bp-MRI-guided biopsies were positive for at least one PCa lesion in 32 patients (52%), while standard TRUS-bx detected PCa in 42 patients (68%). Bp-MRI missed seven out of 37 (19%) patients with clinically significant PCa. Of these, two patients had GS 7 (3 + 4) and five had GS 6 (3 + 3), which were deemed clinically significant due to ≥ 3 positive biopsies. One patient had PCa detected only on bp-MRI biopsy of a PI-RADS 4 lesion showing a GS of 7 (4 + 3) in 75% of the biopsy core. No patients with severe malignancy PCa (GS ≥ 8) were missed by bp-MRI-bx.

TABLE 2

Overall Gleason scores for standard transrectal ultrasound biopsy (TRUS-bx), biparametric (bp) MRI biopsy cores and a combination of both. The values are n.

	Bp-MRI-bx	Standard TRUS-bx	Standard TRUS-bx + bp-MRI-bx
Gleason score			
3 + 3	7	14	13
3 + 4	6	16	14
4 + 3	7	6	8
≥ 8	12	6	8
Prostate cancer			
Insignificant	4	7	6
Significant	28	35	37

Bp-MRI-bx cores revealed the highest GS in 13 patients, leading to an overall GS upgrade in six (14%) patients. TRUS-bx scored the highest GS in five patients (16%). Of these, three patients were upgraded from a LG to an IG risk group, while two remained in the HG group with a GS ≥ 8. Bp-MRI diagnosed two patients with clinically significant PCa, which would have been deemed insignificant based on TRUS-bx. The distribution of GS and patient risk stratification for TRUS-bx, bp-MRI biopsies and the two combined are summarised in **Table 2** and **Table 3**.

PI-RADS scores of suspicious bp-MRI lesions showed

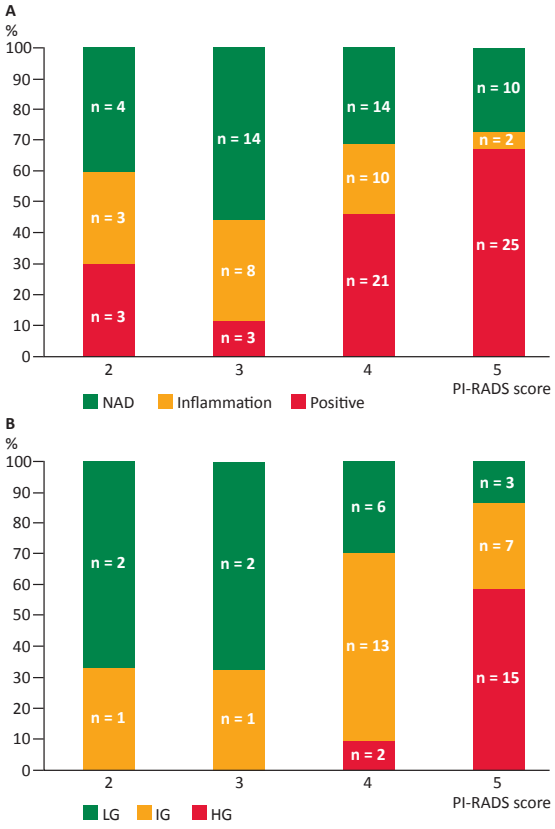
TABLE 3

A cross-table of Gleason scores (GS) of standard transrectal ultrasound biopsy and biparametric (bp) MRI-guided biopsies. The values are n.

	Standard transrectal ultrasound biopsy				
bp-MRI-guided biopsies	**negative**	**GS = 3 + 3**	**GS = 3 + 4**	**GS = 4 + 3**	**GS ≥ 8**
Negative	0	9	2	0	0
GS = 3 + 3	0	4	3	0	0
GS = 3 + 4	0	1	5	0	0
GS = 4 + 3	1	0	5	1	0
GS ≥ 8	0	0	1	5	6

FIGURE 1

Percentage of positive, inflammation and no appreciable disease for Prostate Imaging Reporting and Data System scores of magnetic resonance imaging lesions (**A**) and distribution of Gleason score risk groups for Prostate Imaging Reporting and Data System scores of lesions (**B**).



HG = high grade; IG = intermediary grade; LG = low grade; MRI = magnetic resonance imaging; NAD = no applicable disease; PI-RADS = Prostate Imaging Reporting and Data System.

a good correlation with both the number of positive biopsies and their GS. Higher PI-RADS risk group was associated with a higher likelihood of positive biopsies. Distribution of positive and negative biopsies and LG, IG and HG PCa in relation to PI-RADS scores for both zones is presented in **Figure 1**A and B, respectively. The rate of positive biopsies from PI-RADS 4 and 5 lesions was in the transition zone (TZ); 20% and 47% and for the peripheral zone (PZ) 68% and 82%, respectively.

DISCUSSION

Our results confirm that bp-MRI-guided biopsies can detect clinically significant PCa and may improve the diagnosis of biopsy-naive men. Addition of bp-MRI-guided biopsies to the standard TRUS-bx upgraded more patients to a higher PCa risk group with potential consequences for the choice of treatment. However, bp-MRI-bx missed clinically significant PCa in 19% according to the criteria. These missed PCa lesions were either GS = 7 (3 + 4) cancers (n = 2) or high-volume (≥ 3 positive core) GS 6 lesions (n = 5). GS 6 lesions are harder to detect on MRI and are therefore more often missed [10]. However, all patients with a high-grade (GS ≥ 8) PCa lesion were detected and a bp-MRI led to an overall GS upgrade in six patients. Thus, combining bp-MRI-bx with TRUS-bx in the examination of biopsy-naive men seems to decrease the risk of missing severe malignancy in the first round of biopsies.

Our findings are in line with other studies showing that the use of MRI-guided biopsies in combination with TRUS-bx leads to an improved detection of intermediary and high-risk PCa [5-7]. Especially lesions located anteriorly are more frequently missed by standard TRUS-bx, but subsequently detected by MRI-guided biopsies both in patients with prior negative TRUS-bx and biopsy-naive patients [11-13]. Although these studies used mp-MRI, we expected similar results using bp-MRI-guided biopsies as a recent retrospective study concluded that bp-MRI is comparable with mp-MRI in detection of PCa [14]. If these anterior lesions were detected by bp-MRI-bx during the first round of biopsies, an early and more effective treatment from day one would be ensured, while lowering the biopsy burden by possibly avoiding several negative rounds of TRUS-bx. However, we had no such cases and a larger study is warranted to answer this question.

The ESUR recommends an mp-MRI as state of the art in the work-up of PCa. Mp-MRI includes additional coronal and sagittal T2W sequences and an axial T1W fat-saturated DCE sequence with a total examination time of 60 minutes compared with bp-MRI. A T1W fat-saturated sequence is useful in detection of blood products after TRUS-bx that might otherwise hinder correct MRI diagnosis. In a biopsy-naive population, however, the usefulness is limited. DCE is recommended in the evaluation of the peripheral zone when distinguishing between PI-RADS 3 and 4 lesions, where it has been shown to improve diagnostics [15]. However, PI-RADS 3 lesions were also biopsied at our institution. Thus, the

distinction between PI-RADS lesion 3 and 4 was of limited importance. Bp-MRI also has the obvious disadvantage of including the axial plane only. Evaluation of extraprostatic extension, vesiculae seminales and the urethra is therefore insufficient, and a bp-MRI cannot be used for staging. A regular staging mp-MRI examination should be performed subsequently if needed. However, a mp-MRI would be an expensive and time-consuming examination if used in all newly referred patients with suspicion of PCa. A bp-MRI seems to be sufficient to guide biopsies in combination with TRUS-bx in biopsy-naive men and halves total examination time.

PI-RADS scores of lesion areas were associated with both the number of positive bp-MRI-bx and with histological GS in the present study. There was a direct correlation with higher PI-RADS scores and the likelihood of a positive biopsy with a greater risk of severe malignancy (Figure 1). Despite the fact that bp-MRI does not include DCE T1W and coronal and sagittal T2W sequences, we found this correlation to be largely consistent with other studies using mp-MRI [11, 16, 17] and PI-RADS version 1 scoring. However, the detection rate of PCa in high-risk PI-RADS lesions was lower than would be expected from the literature, especially in the TZ [11, 16, 17]. Our relatively high rate of false positive evaluations in the TZ may be explained by the lack of coronal and sagittal T2W images, which makes it difficult to identify a lesion capsule. Several imaging planes allow an easier for differentiation of PCa lesions from benign prostate hyperplasia. Lack of experience interpreting bp-MRI and apprehension of missing significant PCa may also play a part. However, our study demonstrates the feasibility of the PI-RADS version 2 scoring system in the PZ adjusted to a bp-MRI protocol, while the TZ remains an obstacle. As part of the evaluation of a biopsy-naive population, a number of PI-RADS score 2 lesions (n = 10) were biopsied to confirm the absence of PCa. Even though targeting these lesions was inconsistent with the PI-RADS guidelines, it was necessary to evaluate the possibility of false negative lesions on bp-MRI.

Our study has some limitations; primarily the small population size may might explain the unusually high detection rate (69%) on first-time biopsy compared with other studies [13, 18, 19]. Furthermore, the population has a selection bias due to the pilot project format that changes the usual working procedure and does not recruit patients consecutively. In addition, no inter- or intraobserver variation of PI-RADS scoring was performed. We also experienced a few cases of MRI motion artefacts that complicated evaluation; we did not use spasmolytica as is recommended for mp-MRI [8].

It is important to emphasise that out results are preliminary and indicative. However, implementing bp-MRI-guided biopsies in combination with standard TRUS-bx as part of the routine examination in patients with suspicion of PCa has the potential to improve detection of more aggressive PCa. In a population where the burden of PCa and the need for early diagnosis seems to increase, bp-MRI could be an important addition to risk stratification. Larger studies are needed to evaluate its potential as a screening tool to exclude aggressive disease and possibly avoid biopsies.

CONCLUSIONS

Bp-MRI-guided biopsies in combination with TRUS-bx upgrade more PCa patients to a higher risk group with potential consequences for the choice and effectiveness of their treatment. A larger prospective study with a longer follow-up period designed to assess the future role of bp-MRI in biopsy-naive men is strongly warranted.

CORRESPONDENCE: *Mads Dochedahl Winther.*
E-mail: sfc113@alumni.ku.dk

ACCEPTED: 27 January 2017

CONFLICTS OF INTEREST: Disclosure forms provided by the authors are available with the full text of this article at www.danmedj.dk

LITERATURE

1. Meyer MS, Mucci LA, Andersson S-O et al. Homogeneous prostate cancer mortality in the Nordic countries over four decades. Eur Urol 2010;58:427-32.
2. Epstein JI, Feng Z, Trock BJ et al. Upgrading and downgrading of prostate cancer from biopsy to radical prostatectomy: incidence and predictive factors using the modified Gleason grading system and factoring in tertiary grades. Eur Urol 2012;61:1019-24.
3. Djavan B, Ravery V, Zlotta A et al. Prospective evaluation of prostate cancer detected on biopsies 1, 2, 3 and 4: When should we stop? J Urol 2001;166:1679-83.
4. Ukimura O, Coleman JA, de la Taille A et al. Contemporary role of systematic prostate biopsies: indications, techniques, and implications for patient care. Eur Urol 2013;63:214-30.
5. Peltier A, Aoun F, Lemort M et al. MRI-targeted biopsies versus systematic transrectal ultrasound guided biopsies for the diagnosis of localized prostate cancer in biopsy naïve men. Biomed Res Int 2015;2015:571708.
6. Pokorny MR, de Rooij M, Duncan E et al. Prospective study of diagnostic accuracy comparing prostate cancer detection by transrectal ultrasound-guided biopsy versus magnetic resonance (MR) imaging with subsequent mr-guided biopsy in men without previous prostate biopsies. Eur Urol 2014;66:22-9.
7. Abd-Alazeez M, Kirkham A, Ahmed HU et al. Performance of multiparametric MRI in men at risk of prostate cancer before the first biopsy: a paired validating cohort study using template prostate mapping biopsies as the reference standard. Prostate Cancer Prostatic Dis 2014;17:40-6.
8. Barentsz JO, Richenberg J, Clements R et al. ESUR prostate MR guidelines 2012. Eur Radiol 2012;22:746-57.
9. Weinreb JC, Barentsz JO, Choyke PL et al. PI-RADS Prostate Imaging – Reporting and Data System: 2015, Version 2. Eur Urol 2016;69:16-40.
10. De Visschere PJL, Naesens L, Libbrecht L et al. What kind of prostate cancers do we miss on multiparametric magnetic resonance imaging? Eur Radiol 2016;26:1098-107.
11. Boesen L, Noergaard N, Chabanova E et al. Early experience with multiparametric magnetic resonance imaging-targeted biopsies under visual transrectal ultrasound guidance in patients suspicious for prostate cancer undergoing repeated biopsy. Scand J Urol 2015;49:25-34.
12. Rais-Bahrami S, Siddiqui MM, Vourganti S et al. Diagnostic value of biparametric magnetic resonance imaging (MRI) as an adjunct to prostate-specific antigen (PSA)-based detection of prostate cancer in men without prior biopsies. BJU Int 2015;115:381-8.
13. Delongchamps NB, Peyromaure M, Schull A et al. Prebiopsy magnetic resonance imaging and prostate cancer detection: comparison of random and targeted biopsies. J Urol 2013;189:493-9.
14. Thestrup KCD, Logager V, Balslev I et al. Biparametric versus multiparametric MRI in the diagnosis of prostate cancer. Acta Radiol Open 2016;5:2058460116663046.
15. Li C, Chen M, Li S et al. Detection of prostate cancer in peripheral zone: comparison of MR diffusion tensor imaging, quantitative dynamic contrast-enhanced MRI, and the two techniques combined at 3.0 T. Acta Radiol 2014;55:239-47.
16. Roethke MC, Kuru TH, Schultze S et al. Evaluation of the ESUR PI-RADS

scoring system for multiparametric MRI of the prostate with targeted MR/TRUS fusion-guided biopsy at 3.0 Tesla. Eur Radiol 2014;24:344-52.
17. Renard-Penna R, Mozer P, Cornud F et al. Prostate imaging reporting and data system and likert scoring system: multiparametric MR imaging validation study to screen patients for initial biopsy. Radiology 2015;275:458-68.
18. Haffner J, Lemaitre L, Puech P et al. Role of magnetic resonance imaging before initial biopsy: comparison of magnetic resonance imaging-targeted and systematic biopsy for significant prostate cancer detection. BJU Int 2011;108:E171-E178.
19. Acar Ö, Esen T, Çolakoğlu B et al. Multiparametric MRI guidance in first-time prostate biopsies: what is the real benefit? Diagn Interv Radiol 2016;21:271-6.