Value of Endorectal Magnetic Resonance Imaging at 3T for the Local Staging of Prostate Cancer

Wertigkeit der 3-T-MRT zur Vorhersage eines kapselüberschreitenden Tumorwachtums beim Prostatakarzinom

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Key words
- MR imaging
- staging
- prostate
- neoplasms

Zusammenfassung

Ziel: Bestimmung der Wertigkeit der Magnetresonanztomografie (MRT) bei 3T zur Differenzierung zwischen organbegrenztem und kapselüberschreitendem Tumorwachstum beim Prostatakarzinom (PCa).

Material und Methoden: Bei 38 konsekutiven Patienten mit histologisch gesichertem PCa erfolgte eine multiparametrische 3-T-MRT-Untersuchung mit endorektaler Spule. Zwei Radiologen mit 9 (A) bzw. 4 (B) Jahren Erfahrung in abdomineller und urogenitaler MRT-Bildgebung bewerteten die bildmorphologische Erkennbarkeit einer Kapselüberschreitung (ECE) bzw. Samenblaseninfiltration (SVI). Als Referenz diente die intraoperative Schnellschnittdiagnostik in den sechs Regionen apikal, dorsolateral und harnblasennah, jeweils beidseits sowie die postoperative Aufarbeitung des Prostatektomie-Präparats und der Samenblasen.

Ergebnisse: Die histopathologische Auswertung ergab eine ECE in 15 von 222 Regionen (10 von 37 Patienten) und eine SVI in 8 von 74 Regionen (5 von 37 Patienten). Sensitivitäten, Spezifitäten und Genauigkeiten der Detektion einer ECE betrugen für Radiologe A/B 93 %/67 %, 92 %/95 % und 92 %/93 % pro Region bzw. 90 %/80 %, 74 %/82 % und 78 %/81 % pro Patient. Die entsprechenden Werte für die SVI lagen bei 80 %/100 %, 96 %/99 % und 95 %/97 %.

Schlussfolgerung: Die MRT der Prostata stellt eine zuverlässige, nicht-invasive Methode zum lokalen Staging beim PCa dar.

Kernaussagen:
- Die endorektale 3-T-MRT erreicht hohe Genauigkeiten beim lokalen Staging des Prostatakarzinoms.
- Die patientenbasierte Sensitivität zur Detektion eines extrakapsulären Tumorwachstums betrug 80 % und höher.
- Die entsprechende Spezifität zur Detektion eines organüberschreitenden Tumorwachstums (pT3) war hoch.

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Abstract

Purpose: To assess the accuracy of endorectal 3 T magnetic resonance imaging (MRI) in detecting extracapsular extension (ECE) and seminal vesicle invasion (SVI) of prostate cancer (PCa).

Materials and Methods: 38 consecutive patients with biopsy-proven PCa underwent multiparametric endorectal MRI at 3 T prior to prostatectomy. Two readers (A with nine years of experience and B with four) used established criteria for ECE and SVI to diagnose the extent of local disease in six regions (apical, dorsolateral, basal; left and right each) with the highest chance of ECE. The standard of reference was provided by intraoperative frozen section analysis and prostatectomy specimens.

Results: Histopathology revealed ECE in 15 of the 222 regions (10 of 37 patients) and SVI in 8 of 74 potential regions (5 of 37 patients). The sensitivity, specificity, and accuracy in detecting ECE for reader A/B were 93 %/67 %, 92 %/95 % and 92 %/93 % per region and 90 %/80 %, 74 %/82 % and 78 %/81 % per patient, respectively. The corresponding values for the detection of SVI were 80 %/100 %, 96 %/99 % and 95 %/97 %, respectively.

Conclusion: Endorectal 3 T MRI is a highly reliable noninvasive technique for the local staging of PCa.

Key points:
- Endorectal 3 T MRI provided high accuracy for the local staging of prostate cancer.
- The sensitivity in detecting extracapsular tumor growth per patient was 80 % or higher.
- The specificity in detecting extracapsular extension (pT3 stage) was good.

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Introduction

Magnetic resonance imaging (MRI) is widely accepted as the most accurate noninvasive diagnostic tool for the local staging of prostate cancer (PCa) [1]. Different studies on the accuracy of 1.5 T MRI for the local staging of PCa have reported average specificities higher than 80 %. Some studies suggest that 1.5 T MRI with an endorectal coil can provide specificities of up to 99 % in detecting extracapsular tumor growth (stage T3) of the disease [2]. On the other hand, the range of corresponding sensitivities, 14 – 94 %, is very broad with an average value around 60 % [3, 4]. This finding may have limited the clinical use of 1.5 T MRI as a routine tool for staging, as previously remarked by Fütterer et al. [5].

The introduction of clinical 3 T MRI has led to a number of studies aiming to determine the value of 3 T imaging for PCa staging. The higher signal-to-noise ratio generally provides a better image quality and will potentially allow for more accurate staging. Some studies that have compared the use of a standard phased-array coil at 3 T with that of an endorectal coil at 1.5 T, however, have shown that the former imaging technique is not necessarily superior in terms of local staging accuracy [6, 7]. Heijmink et al. have recently compared the use of phased-array and endorectal coils at 3 T and found that the latter seems to provide a clear benefit in terms of diagnostic image quality and staging accuracy [8]. It is presently difficult to assume an improved PCa staging accuracy for higher field strengths due to the very limited number of dedicated studies. Therefore, the aim of this study was to assess the sensitivity and specificity of an endorectal 3 T MRI examination in detecting extracapsular extension.

Materials and Methods

Patient characteristics

After obtaining IRB approval, 38 consecutive patients (February–June 2010) with histologically confirmed PCa underwent endorectal 3 T prostate MRI prior to radical prostatectomy. All patients gave written informed consent. 37 of them (mean age 65 years, range 53 to 75 years) were analyzed retrospectively and one patient was excluded because his urinary bladder opening was resected without prostatectomy. The general exclusion criteria were contraindications to MRI (e. g., pacemaker or cerebral metal clips), gadolinium-based MR contrast agents or endorectal coil insertion (e. g., prior anorectal surgery, inflammatory bowel disease or high anal sphincter tension), as well as severe claustrophobia. The median prostate-specific antigen (PSA) level was 13.5 ng/ml (range 3.7 – 56 ng/ml) and the median postoperative Gleason Score (GS) was 7.0 (range 6 – 9). MRI was performed 1 – 16 days (mean 1.9 days) before prostatectomy. The mean time between transrectal ultrasound (TRUS)-guided biopsy and MRI was 55 days (range 11 – 119 days) for all patients and 58 days (range 33 – 114) for 10 patients with extracapsular extension. All patients underwent one TRUS-guided biopsy with a mean count of 11.6 (range 6 – 27) tissue samples and an average of 4.0 (range 1 – 12) of them being positive for PCa. The mean time between TRUS-guided biopsy and surgery was 57.6 days (range 12 – 120 days) for 27 patients without ECE and 61.4 days (range 34 – 115 days) for 10 patients with ECE. Patients were subdivided into three groups with low, intermediate and higher risk according to the D'Amico criteria (GS ≤ 6 and PSA ≤ 10 ng/ml, GS = 7 and PSA 10 – 20 ng/ml and GS ≥ 8 or PSA ≥ 10 ng/ml).

MRI protocol

MRI was performed in a 3 T MRI unit (Magnetom Trio, Siemens Healthcare, Erlangen, Germany) using the combination of pelvic phased-array and endorectal coils (eCoil, Medrad, Pittsburg, PA) for signal acquisition. The endorectal coil was filled with 30 – 40 ml of perfluorocarbon solution (Perfluorooctyl bromide, ABCR GmbH, Karlsruhe, Germany) to minimize susceptibility artifacts. Before the examination, all patients received an intravenous injection of either 40 mg butylscopolamine (Buscopan, Boehringer Ingelheim, Germany, in four patients) or 1 mg glucagon (Glucagen, Nordisk, Gentofte, Denmark, in 34 patients) to reduce peristalsis. Fast T1-weighted (T1w) localizer images were used to confirm the correct position of the endorectal coil and to define transverse slices orthogonal to the prostatic urethra. Morphologic imaging included a T2-weighted (T2w) fast spin-echo sequence (in-plane resolution IPR = 0.57 × 0.57 mm^2, repetition and echo time TR / TE = 4400 – 4600 / 126 ms, slice thickness ST = 3.0 mm, slice gap SG = 0.6 mm, 19 – 22 slices, field of view FOV = 110 × 110 mm^2, flip angle FA = 120 – 135°) covering the whole prostate and the seminal vesicles in transverse, coronal and sagittal planes. Diffusion-weighted imaging was performed with a single-shot echo planar imaging sequence (IPR = 1.0 × 1.0 mm^2, TR / TE = 3000 / 85 ms, ST = 3.0 mm, SG = 0.6 mm, 19 – 22 slices, FOV = 250 × 250 mm^2, FA = 90°) in transverse planes using *b*-values of 0, 50, 400 and 800 sec/mm^2. Spectroscopic imaging was performed using an established prostate protocol based on a combination of point-resolved spectroscopy volume localization and 3 D chemical shift imaging covering the whole prostate in 8 slices [1]. Dynamic contrast-enhanced imaging (DCEI) was based on a transverse T1w sequence (20 time steps of 12 s each, IPR = 0.57 × 0.57 mm^2, TR / TE = 4.7 / 1.7 ms, ST = 3.0 mm, SG = 0.6 mm, 19 – 22 slices, FOV = 110 × 110 mm^2, FA = 14°) following bolus injection of 15 – 20 ml of contrast agent (Dotarem, Guerbet, Paris, France).

MRI evaluation

All patients were evaluated by two readers who had full access to the image data on a conventional radiological workstation (SIENET MV 1000, Siemens, Erlangen, Germany). The readers were blinded to the individual serum level of PSA, GS and the results of the histopathologic TNM classification but knew that all subjects had biopsy-proven PCa. Both readers had only limited prior experience in endorectal MRI interpretation of the prostate at 3T: Reader A (M.S.), a radiology specialist with 9 years of experience in abdominal and genitourinary MR diagnostics had read 40 endorectal prostate MRI cases, while reader B (J.F.), a resident in radiology with 4 years of general MR experience, had read 15 such cases.

The presence of extracapsular extension (ECE) was based on five established T2w imaging criteria: 1. asymmetry of the neurovascular bundle, 2. obliteration of the rectoprostatic angle, 3. irregular bulging of the prostatic contour, 4. low signal intensity in the rectoprostatic fat, and 5. overt extracapsular cancer [9]. Infiltration of the prostate capsule was defined by a regularly delineated tumor contact with a length of at least 10 mm, similar to the criteria reported by Yu et al. [10]. If such a tumor contact showed irregular delineations or signal defects of the prostate capsule, even without hypointense T2w areas in the periprostatic fat or neurovascular bundles, this region was considered as extracapsular extension (ECE) [11]. Previously reported criteria in the literature were used to identify seminal vesicle invasion (SVI) and involved at least one of the following findings: disruption or loss

of normal vesicle architecture, focal or diffuse areas of low signal intensity within the vesicles, asymmetric thickening or irregular shape of the vesicle wall as well as evident tumor at the prostate base extending into the seminal vesicles [12]. In addition, DWI and DCEI findings were used to rule out false-positive findings caused by hemorrhage or inflammation after TRUS-guided biopsy [1]. Hypointense T2w areas in the prostate or seminal vesicles in combination with high signal intensities in pre-contrast T1w images were associated with hemorrhage. Linear, wedge-shaped or hypointense prostate areas as well as wall thickening or hypointense lumina of the seminal vesicles on T2w without restricted diffusion or suspicious DCEI were regarded as (chronic) inflammation [12].

Image analysis was confined to six regions that are generally assumed to have the highest probability for ECE and SVI, namely the left and right sides of the apical, dorsolateral midgland and basal parts of the prostate (**Fig. 1**) [13]. The readers first decided for (+) or against (–) the presence of ECE and SVI. In the (+) case, they were further asked to rate the confidence level of the above criteria (CL) on a five-point scale as clearly not applicable (CL = 1), probably not applicable (CL = 2), unclear (CL = 3), probably applicable (CL = 4) and clearly applicable (CL = 5).

Histopathological work-up

Immediately after surgical resection, the urologist inked the apical, dorsolateral midgland and basal portions of the prostate before sending it to the institutional pathology department. After separation and histological staining of the highlighted regions, frozen sections were intraoperatively analyzed by a senior pathologist (L.C.H. 13 years of experience in urogenital pathology) with respect to the status of the surgical margins. The remaining prostate sample was then processed according to a clinically established protocol [13]. This involved transverse, 4 to 5-mm thick step sections perpendicular to the prostatic urethra yielding about 10 tissue slices per prostate. Each slice was subdivided into four quarters resulting in approximately 40 sequentially labeled specimens per case. The final pathological report contained histological results of the analyses of both the fresh frozen samples (intraoperatively) as well as the prostatectomy specimens (postoperatively).

Correlation between MRI and histopathology

All intraoperative and postoperative histological results were used for radiologic-pathologic correlation. The results of the MRI-based reader ratings were compared to the histopathologic findings by a supervisor (J.O.), a resident in radiology with a total of 120 prostate MRI examinations, who was aware of all clinical data. The MRI-based reader findings were evaluated for each region where the pathologist identified extraprostatic extension. The MRI rating was counted as a true positive, if at least one of the CL was 4 or higher (CL ≥ 4), and as a false negative, if all scores were less than or equal to 3 (CL ≤ 3). Suspicious regions with CL ≥ 4 and no histopathological correlate were not necessarily counted as a false positive, but double-checked by the supervisor regarding potential errors in spatial mapping caused by gland deformation, fixation-related shrinkage and misaligned tissue slicing. Following the "alternative neighbor correction" described by Turkbey et al., successful tumor mapping was assumed if respective findings were observed within immediately adjacent "neighbor" regions [14]. An extracapsular extension to the right dorsolateral midgland, for example, might effectively belong to a histopathological ECE of the right basal sample. If the supervisor located the MRI focus very close to the basolateral portion, which actually occurred in one case, the rating was still considered to be a true positive.

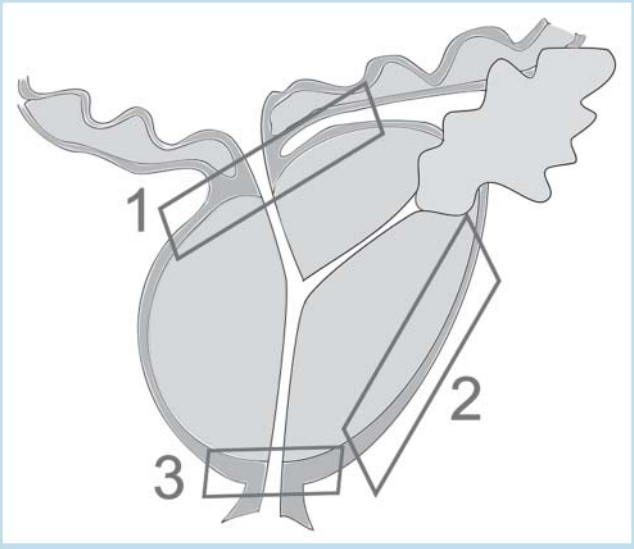

Fig. 1 Schematic sagittal cross section of the prostate gland showing the three (in total six for both sides) regions with the highest chance of ECE: basal (1), dorsolateral (2), and apical (3). These regions were all intraoperatively analyzed in frozen sections with respect to the status of surgical resection margins and the presence of extraprostatic extension.

Abb. 1 Schematischer Sagittalschnitt durch die Prostata mit Darstellung der drei (insgesamt sechs für beide Seiten) Regionen mit der höchsten Wahrscheinlichkeit eines kapselüberschreitenden Tumorwachstums: basal (1), dorsolateral (2) und apikal (3). Diese Regionen wurden alle intraoperativ mithilfe einer histopathologischen Schnellschnittdiagnostik zur Beurteilung des Resektionsrandes und dem Vorhandensein eines extrakapsulären Tumorwachstums untersucht.

Differences in the preoperative staging performance between both readers were analyzed with a one-way ANOVA with factor reader. Statistical analyses were performed using SPSS 18 (SPSS Inc., Chicago, IL) and a significance level of 5 %.

Results

Histopathology revealed extraprostatic extension into the periprostatic fatty tissue in 15 of the 222 (6.8 %) regions considered here (in 10 of 37 patients; 27 %) and into the seminal vesicles in 8 of the 74 potential regions (5 of 37 patients), respectively (**Fig. 2, 3, 4**). The sensitivity, specificity, and accuracy in detecting ECE for reader A/B were 93 %/67 %, 92 %/95 % and 92 %/93 % per region and 90 %/80 %, 74 %/82 % and 78 %/81 % per patient, respectively (**Table 1, 2**). The corresponding values for the detection of a SVI were 80 %/100 %, 96 %/99 % and 95 %/97 % for the respective reader (**Table 3, 4**). **Table 5** summarizes the results of both uncorrected and alternative neighboring approaches. Differences between the readers were not significant, neither per region ($p = 0.072$) nor per patient ($p = 0.556$). Interobserver agreement κ was 0.72 per region and 0.89 per patient. Histopathology revealed low, intermediate and high-risk PCa in 7, 19, and 11 of 37 patients with average PSA levels of 6.2, 8.4 and 28.8 ng/ml and median GS of 6 (no range), 7 (range 6 – 7) and 8 (range 6 – 9), respectively. None of the low-risk (0 %), four

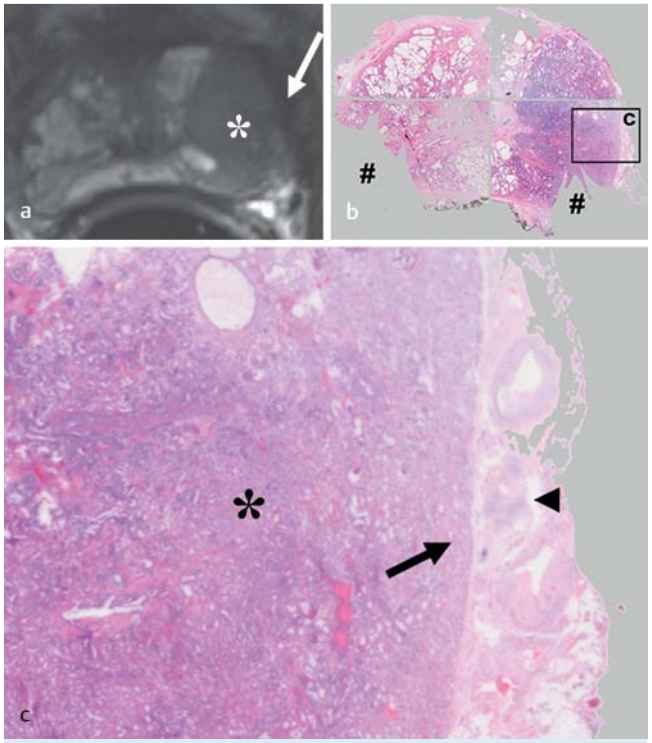

Fig. 2 73-year-old man with a PSA level of 10 ng/ml and GS 7 (3 + 4) carcinoma. **a**: axial MRI with T2w hypointense mass (asterisk) in the left transitional and peripheral zone obscuring the prostate capsule with asymmetrical, irregular bulging of the prostate contour (arrow). **b**: corresponding reconstruction of perpendicular histological section of the specimen after radical prostatectomy. Dorsolateral edges (number) are missing because of prior frozen section analysis (see text and ▶ **Fig. 1**) **c**: magnified area from **b** showing tumor cells (arrow head) in the periprostatic fat (stage pT3a) within a depth of less than 1 mm.

Abb. 2 73-jähriger Mann mit PSA-Serumlevel von 10 ng/ml und GS 7 (3 + 4) PCa. **a**: Axiales MRT mit Nachweis einer T2w-hypointensen Raumforderung (Sternchen) von Transitional- und peripherer Zone links mit vollständigem Kontakt zur Prostatakapsel und seitenasymmetrischer, irregulärer Vorwölbung der Prostata (Pfeil). **b**: Korrespondierendes histopathologisches Schnittpräparat nach radikaler Prostatektomie. Dorsolaterale Defektareale beidseits (Raute) aufgrund der intraoperativen Schnellschnittdiagnostik (siehe Text und ▶ **Abb. 1**). **c**: Die Vergrößerung aus **b** zeigt Tumorzellen (Pfeilspitze) im periprostatischen Fettgewebe (pT3a Stadium) mit einer Infiltrationstiefe von weniger als 1 mm.

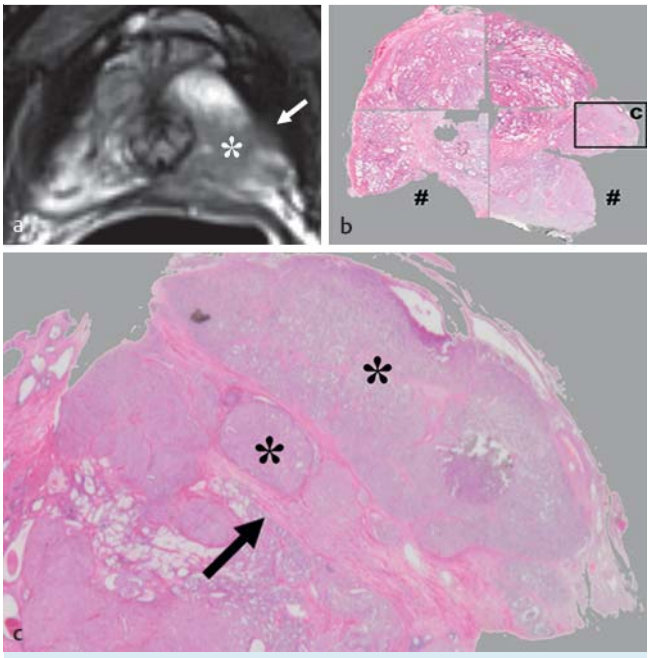

Fig. 3 69-year-old patient with a PSA level of 8.4 ng/ml and GS 8 (4 + 4) carcinoma. **a**: axial MRI with hypointense T2w signal (asterisk) of the left peripheral zone. The prostate capsule is obscured and capsular bulging is visible. **b**: corresponding reconstruction of perpendicular histological section of the specimen after radical prostatectomy. Dorsolateral edges (number) are missing because of prior frozen section analysis (see text and ▶ **Fig. 1**) **c**: magnified area from **b** showing capsular thickening (arrow) and extracapsular tumor growth (asterisks) into the periprostatic fat (stage pT3a).

Abb. 3 69-jähriger Patient mit PSA-Serumlevel von 8,4 ng/ml und GS 8 (4 + 4) PCa. **a**: Axiales MRT mit Nachweis einer T2w-hypointensen Signalveränderung (Sternchen) der apikal linken peripheren Zone mit Kontakt zur irregulär vorgewölbten Prostatakapsel auf korrespondierender Höhe. **b:** Korrespondierendes histopathologisches Schnittpräparat nach radikaler Prostatektomie. Dorsolaterale Defektareale beidseits (Raute) aufgrund der intraoperativen Schnellschnittdiagnostik (siehe Text und ▶ **Abb. 1**). **c**: Die Vergrößerung aus **b** zeigt eine irreguläre Verbreiterung der Prostatakapsel (Pfeil) mit nach extrakapsulär, in das periprostatische Fettgewebe wachsenden Tumoranteilen (Asterisks) (pT3a Stadium).

Table 1 Extracapsular extension (ECE) of prostate cancer per individual region.

Tab. 1 Regionenbasierte Analyse eines extrakapsulären Tumorwachstums.

ECE per region		histopathology		sensitivity	specificity	accuracy
MRI		+	–			
reader A	+	14	17	93 %	92 %	92 %
	–	1	190	(14/15)	(190/207)	(204/222)
reader B	+	10	10	67 %	95 %	93 %
	–	5	197	(10/15)	(197/207)	(207/222)

Table 2 Extracapsular extension (ECE) of prostate cancer per patient.

Tab. 2 Patientenbasierte Analyse eines extrakapsulären Tumorwachstums.

ECE per patient		histopathology		sensitivity	specificity	accuracy
MRI		+	–			
reader A	+	9	7	90 %	74 %	78 %
	–	1	20	(9/10)	(20/27)	(29/37)
reader B	+	8	5	80 %	82 %	81 %
	–	2	22	(8/10)	(22/27)	(30/37)

(22.2 %) of the intermediate-risk, and six (54.5 %) of the high-risk group were found to have locally advanced disease.

The mean CL ratings of the individual ECE criteria (in parentheses) averaged over 15 regions for reader A/B were 2.5/2.0 (asymmetry of the neurovascular bundle), 1.6/1.6 (obliteration of the rectoprostatic angle), 3.9/4.2 (irregular bulging of the prostatic contour), 3.1/3.1 (low signal intensity in the rectoprostatic fat) and 2.2/1.6 (overt extracapsular cancer).

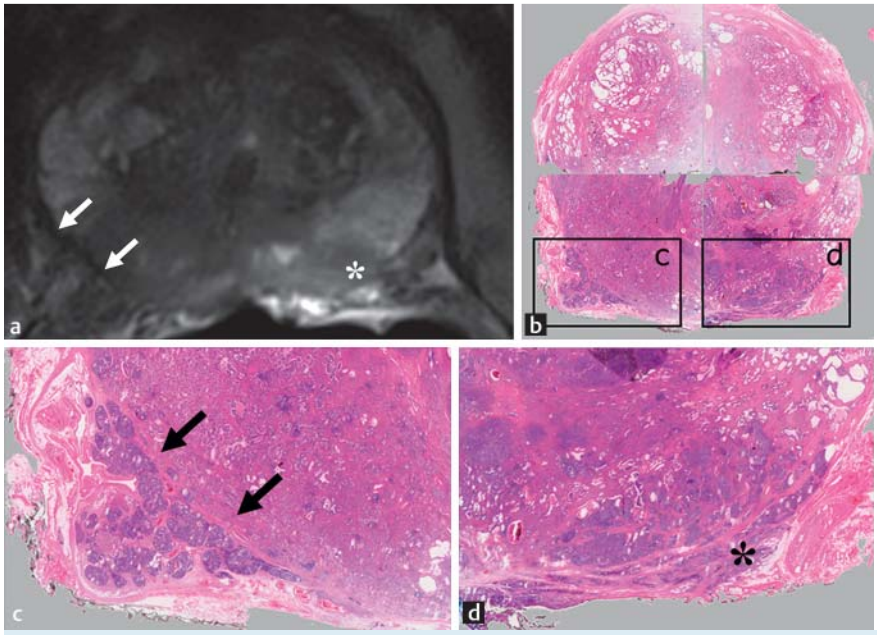

Fig. 4 66-year-old man with a PSA level of 47 ng/ml and GS 9 (4 + 5) carcinoma. **a**: para-axial T2w image at the level of the mid-prostate with an area of low signal intensity in the right dorsolateral peripheral zone with clearly visible prostate capsule and regularly shaped neurovascular bundle (arrows). T2w hypointense lesion (asterisk) is visible in the left peripheral zone with interruption of capsule signal and hypointense triangular area in the periprostatic fat. **b**: corresponding reconstruction of perpendicular histological section of the specimen after radical prostatectomy. **c**: well-defined prostate capsule (arrows) and regularly shaped neurovascular bundle on the right. **d**: extensive tumor invasion (asterisk) into the periprostatic fat on the left.

Abb. 4 66-jähriger Mann mit PSA-Serumlevel von 47 ng/ml und GS 9 (4 + 5) PCa. **a**: Para-axiales T2w-Bild auf Höhe des mittleren Prostatadrittels mit einem Nachweis hypointensen Signalveränderung der dorsolateralen peripheren Zone rechts bei scharf abgrenzbarer Prostatakapsel und regelrecht konfiguriertem neurovaskulären Bündel rechts (Pfeile). Auf korrespondierender Höhe Nachweis einer T2w-hypointensen Signalveränderung (Sternchen) der dorsolateralen peripheren Zone links mit Kontinuitätsunterbrechung der Prostatakapsel und dreieckig hypointenser Signalveränderung im periprostatisches Fett auf korrespondierender Höhe. **b**: Korrespondierendes histopathologisches Schnittpräparat nach radikaler Prostatektomie. **c**: Nachweis einer glatt konturierten Prostatakapsel dorsolateral rechts (Pfeile) mit regelrecht konfiguriertem neurovaskulären Bündel. **d**: Ausgedehnte Tumorinfiltration (Asterisk) in das periprostatische Fettgewebe auf der linken Seite.

Table 3 Seminal vesicle invasion (SVI) per region.

Tab. 3 Regionenbasierte Analyse einer Samenblaseninfiltration.

SVI per region		histopathology		sensitivity	specificity	accuracy
MRI		+	–			
reader A	+	7	3	88 % (7/8)	95 % (63/66)	95 % (70/74)
	–	1	63			
reader B	+	7	1	88 % (7/8)	98 % (65/66)	97 % (72/74)
	–	1	65			

Table 4 Seminal vesicle invasion (SVI) per patient.

Tab. 4 Patientenbasierte Analyse einer Samenblaseninfiltration.

SVI per patient		histopathology		sensitivity	specificity	accuracy
MRI		+	–			
reader A	+	4	2	80 % (4/5)	96 % (31/32)	95 % (35/37)
	–	1	31			
reader B	+	5	1	100 % (5/5)	99 % (31/32)	97 % (36/37)
	–	0	31			

Table 5 Detection of extracapsular extension (ECE) and seminal vesicle invasion (SVI) without and with correction for "alternative neighbors".

Tab. 5 Detektion eines kapselüberschreitenden Tumorwachstums (ECE) sowie einer Samenblaseninfiltration (SVI) ohne bzw. mit Berücksichtigung „alternativer Nachbarregionen".

	reader A			reader B		
ECE	**sensitivity**	**specificity**	**accuracy**	**sensitivity**	**specificity**	**accuracy**
uncorrected	71 %	87 %	86 %	47 %	92 %	89 %
corrected	93 %	95 %	92 %	67 %	95 %	93 %
SVI						
uncorrected	38 %	95 %	89 %	88 %	98 %	97 %
corrected	88 %	95 %	95 %	88 %	98 %	97 %

Discussion

According to statistical data of the German diagnosis-related group from 2006, two thirds of all patients diagnosed with PCa and under the age of 70 currently undergo radical prostatectomy [15]. This type of surgery carries the risk of damage to blood vessels and nerves that are responsible for urinary continence and erectile function, two important factors with regard to the patient's quality of life [16]. Only patients with organ-confined dis-

eases are eligible for surgical approaches sparing these sensitive structures [13]. It is therefore important to accurately stage PCa before radical prostatectomy, in particular with respect to extracapsular extension (pT3 stage). Diagnostic tools like digital rectal examination, PSA measurements, systematic TRUS-guided prostate biopsies, and meta-data in the form of nomograms [1] provide some clues to the local stage [13], but are often poorly reliable. An accurate determination of the tumor extent before radical prostatectomy, however, is practically impossible with these techniques [1]. The clinical benefit of preoperative MRI of the prostate is discussed controversially. Although MRI is widely accepted as the most reliable method for the local staging of PCa [1], some authors argue that it has little influence on therapeutic decision making [17].

The presented MRI results are in good agreement with two studies of the staging accuracy of endorectal 3 T MRI [8, 18]. Our analysis of 222 regions revealed sensitivities of 67 % and 93 % for the individual readers (mean 80 %) and a mean specificity of 94 %. In 256 individual regions, Fütterer et al. reported mean values of 85 % (sensitivity) and 99 % (specificity) for two experienced readers and of 55 % and 94 % for one less experienced reader, respectively [18]. Heijmink et al. included 644 prostate segments and obtained sensitivities of 39 – 58 % and specificities of 79 – 91 % for a total of 4 readers with different levels of expertise [8]. With respect to the performance per patient, the above authors reported excellent specificities (> 90 %) for all readers. The corresponding sensitivity largely depended on the individual experience with endorectal 3 T MRI diagnosis showing good performance for advanced readers (73 – 88 %) and poor results for less experienced readers (13 – 50 %) [8, 18].

In our study, both readers reached good sensitivities (80 % and 90 %) and fair specificities (74 % and 82 %) for ECE detection per patient. In contrast to the results of Heijmink et al., where only T2w images were inspected, our readers had access to the results of diffusion-weighted, contrast-enhanced and MR-spectroscopic imaging as well. Although the impact of functional information on staging accuracy was beyond the aim of this study, we believe that the specificities without such information would have been lower. False-positive results from post-biopsy hemorrhage and inflammation could be ruled out by a systematical correlation of T2w with DWI and DCEI images. In two patients with confirmed ECE, 36 and 41 days after TRUS-guided biopsy, post-biopsy hemorrhage could be detected by a low T2w signal in combination with an increased precontrast T1w finding. The more experienced reader correctly related the signal changes to the TRUS biopsy and also detected extracapsular tumor growth near the respective regions. In one patient, hypointense T2w changes at the dorsolateral midgland level with corresponding high signals on T1w images were interpreted as post-biopsy hemorrhage without detecting capsule infiltration by the less experienced reader. Fütterer et al. have previously reported that the combined use of T2w and dynamic contrast-enhanced MR images may significantly improve staging performance, in particular for less experienced readers [19]. Therefore, we also believe that a further inclusion of DCEI data will generally help to draw the attention to cancerous areas.

These preliminary results suggest that the staging accuracy of endorectal MRI is not necessarily low for readers with little experience in endorectal 3 T MRI. It should be noted, however, that the number of patients with extracapsular extension was relatively small here, which compromises the statistical power of the reported values, in particular the specificity. More confident findings need to be obtained from larger study groups.

Minimal technical requirements and potential clinical benefit of MRI examinations for PCa staging are still discussed controversially. While a number of studies at 1.5 T have clearly shown a better staging performance with endorectal imaging, the variability between reported 1.5 T results is generally significant (**Table 6**). Researchers also come to different conclusions depending on the individual risk of the patient [5, 9, 11, 22]. Roethke et al., for example, have recently found the benefit of presurgical endorectal MRI to be more pronounced in patients with a higher risk of pathologic T3 disease, in particular for intermediate and high-risk PCa. In these patients, the neurovascular bundle could potentially be spared during surgery if the disease is confined to the organ [22]. At the same time, Cornud and coworkers have stressed the need for highly specific local staging for such patients to ensure that they are not excluded from curative surgical treatment [11]. For patients with low-risk PCa, Cornud et al. see a benefit of higher image resolution in detecting even subtle extracapsular tumor growth (high sensitivity) [11]. We agree that false-negative results should be avoided in these patients to refer them to timely treatment instead of keeping them under active surveillance, for example. In that respect, however, our results at 3 T do not provide further evidence because none of our low-risk patients showed subtle extracapsular tumor growth. We believe that the higher signal-to-noise ratio makes endorectal imaging the preferred option, even at 3 T, although care must be taken to not misidentify subtle changes as potential T3 disease (false positives). The benefit for staging is also suggested by a 3 T study by Heijmink et al., who observed better performance with endorectal coils reaching sensitivities and specificities in the 70 – 100 % range [8].

Table 6 gives an overview of studies on the local PCa staging accuracy of MRI at different field strengths both with and without the use of an endorectal coil. Owing to the large variety of study conditions, in particular with respect to patient groups, readers and methodology, it is generally difficult to evaluate the results independently. For 3 T studies without an endorectal coil, however, it can be observed that either the sensitivity [8, 20, 23] or specificity was found to be below 80 % [6] while both values were higher than 80 % [8, 18] in two studies with an endorectal coil, at least for experienced prostate MRI readers (3 years, 250 cases). The good local staging accuracy of 3 T MRI with an endorectal coil, with sensitivities and specificities for ECE and SVI detection largely above 80 %, is confirmed in this study.

This work was generally limited by the retrospective design and the fact that both readers knew that patients had biopsy-proven PCa and were scheduled for prostatectomy at our Urology Department. Like similar studies (**Table 6**), our results might not be representative for the general patient population because they were obtained on a limited number of patients at a single institution. The choice of a consecutive patient group and the relatively low prevalence of locally advanced disease resulted in 10 positive patients only, so that the reported values for sensitivity and specificity should be interpreted with care. More refined regional analysis, where the entire prostate is divided into 16 or even 27 segments and whole-mount step sections serving the reference standard, are generally preferable to not miss locally advanced disease in other regions. In our study, however, the simpler approach turned out to be sufficient for analysis, because extracapsular extension was actually observed in these six key regions only with slight extension into adjacent sectors.

Table 6 Comparative overview of the accuracy of MRI for the local staging of prostate cancer.

Tab. 6 Vergleichende Übersicht zur Genauigkeit der MRT für das lokale Staging des Prostatakarzinoms.

						ECE			SVI		
	field strength	number of patients	endo-rectal coil	phased-array coil	reader's experience in years (number of exams)	sens (%)	spec (%)	acc (%)	sens (%)	spec (%)	acc (%)
Beyersdorff 2005 [7]	1.5 T	24	X	X	–	–	–	73	–	–	–
Fütterer 2006 [24]	1.5 T	76		X	10 (650)	50	72	63	50	80	76
			X	X	10 (650)	57	96	80	90	99	98
Torricelli 2006 [20]	1.5 T	29	X		–	83	90	–	–	–	–
Bloch 2007 [21]	1.5 T	32	X	X	15 (1 300)	82	95	96	100	100	100
			X	X	4 (500)	91	95	95	100	100	100
Chandra 2007 [26]	1.5 T	38	X	X	–	69	82	76	60	100	95
Graser 2007 [27]	1.5 T	106	X	X	(800)	91	78	92	–	–	–
			X	X	(600)	85	83	86	–	–	–
			X	X	(400)	88	80	83	–	–	–
Latchamsetty 2007 [31]	1.5 T	40	X	X	–	31	71	53	22	100	80
			X	X	–	65	78	73	20	94	85
Park 2007 [6]	1.5 T	54	X		–	71	73	72	75	92	91
Zhang 2007 [2]	1.5 T	110	X	X	–	55	99	91	80	100	99
Tan 2008 [4]	1.5 T	32	X	X	–	14	94	59	–	–	–
Lee 2010 [28]	1.5 T	44		X	–	29	90	–	50	92	–
			X		–	32	96	–	50	92	–
Park 2010 [29]	1.5 T	54	X	X	–	50	83	78	75	92	81
Ruprecht 2011 [30]	1.5 T	46	X	X	15	78	93	–	–	–	–
					5	33	71	–	–	–	–
Renard-Penna 2011 [3]	1.5 T	100		X	7	94	–	81	100	–	–
				X	0.5	92	–	44	100	–	–
Roethke 2012 [22]	1.5 T	385	X	X	4 – 14 (300 – 1,000)	42	92	–	–	–	–
Beyersdorff 2005 [7]	3.0 T	24		X	–	–	–	73	–	–	–
Fütterer 2006 [18]	3.0 T	32	X	X	10 (700)	88	96	94	100	100	100
			X	X	3 (250)	88	96	94	100	100	100
			X	X	0.5 (30)	50	92	81	100	100	100
Torricelli 2006 [20]	3.0 T	29		X	–	75	90	–	–	–	–
Heijmink 2007 [8]	3.0 T	46		X	4 (400)	7	100	70	–	–	–
				X	2 (150)	7	94	65	–	–	–
				X	0.25 (20)	7	100	70	–	–	–
				X	0.25 (20)	13	81	59	–	–	–
			X		4 (400)	80	100	93	–	–	–
			X		2 (150)	73	97	89	–	–	–
			X		0.25 (20)	13	94	67	–	–	–
			X		0.25 (20)	33	94	74	–	–	–
Park 2007 [6]	3.0 T	54		X	–	81	67	72	50	100	98
Augustin 2009 [23]	3.0 T	27		X	–	67	100	85	–	–	–
current study 2013	3.0 T	37	X	X	9 (40)	90	74	78	80	96	95
			X	X	4 (15)	80	82	81	100	99	97

ECE = extracapsular extension, SVI = seminal vesicle invasion, Sens = sensitivity, Spec = specificity, Acc = accuracy
ECE = Extrakapsuläres Tumorwachstum, SVI = Samenblaseninfilration. Sens = Sensitivität, Spec = Spezifität, Acc = Genauigkeit

In conclusion, these preliminary results provide additional evidence that the local staging of PCa at 3 T with an endorectal coil is a highly reliable technique to noninvasively detect extraprostatic tumor growth. More extensive studies will be needed to provide more reliable estimates of the predictive power of endorectal 3 T MRI and also further assess the impact of reader experience.

Clinical relevance of study

- Endorectal MRI at 3 T provides high accuracy for the detection of pT3 stage prostate cancer.
- MRI may potentially be an alternative staging method to more invasive techniques such as ultrasound-guided biopsy.
- Endorectal 3 T MRI assessment of extracapsular tumor growth may be particularly helpful for patients scheduled for nerve-sparing surgical treatment.

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