

# Transition Zone Prostate Cancers: Features, Detection, Localization, and Staging at Endorectal MR Imaging<sup>1</sup>

Oguz Akin, MD  
Evis Sala, MD, PhD, FRCR  
Chaya S. Moskowitz, PhD  
Kentaro Kuroiwa, MD  
Nicole M. Ishill, MS  
Darko Pucar, MD, PhD  
Peter T. Scardino, MD  
Hedvig Hricak, MD, PhD

## Purpose:

To retrospectively evaluate the accuracy of endorectal magnetic resonance (MR) imaging in the detection and local staging of transition zone prostate cancers, with pathologic analysis serving as the reference standard, and to assess MR imaging features of these cancers.

## Materials and Methods:

The institutional review board approved this HIPAA-compliant retrospective study and waived the informed consent requirement. An institutional database of 986 patients who underwent MR imaging before radical prostatectomy yielded 148 consecutive patients with at least one transition zone cancer at step-section pathologic analysis. An additional 46 patients without transition zone cancer were randomly selected as a control group. Two readers independently reviewed MR studies to identify patients with transition zone cancers and determine the location and local extent of these cancers. Imaging features that helped in the identification of transition zone cancers were recorded. Descriptive and  $\kappa$  statistics, as well as receiver operating characteristic and multivariate logistic regression analyses, were used.

## Results:

For identification of patients with transition zone cancers, sensitivity and specificity were 75% and 87%, respectively, for reader 1 and 80% and 78%, respectively, for reader 2. Interreader agreement was fair. For detection of the location of transition zone cancer, the area under the receiver operating characteristic curve was 0.75 for reader 1 and 0.73 for reader 2. Interreader agreement was fair. The readers' accuracy in detecting transition zone cancer foci increased significantly ( $P = .001$ ) as tumor volume increased. In the detection of extraprostatic extension of transition zone cancers, sensitivity and specificity were 56% and 94%, respectively, for reader 1 and 28% and 93%, respectively, for reader 2. Homogeneous low T2 signal intensity ( $P = .001$  for reader 1,  $P < .001$  for reader 2) and lenticular shape ( $P = .017$  for reader 1) were significantly associated with the presence of transition zone cancer.

## Conclusion:

MR imaging can be used to detect, localize, and stage transition zone prostate cancers.

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<sup>1</sup> From the Departments of Radiology (O.A., E.S., D.P., H.H.), Epidemiology and Biostatistics (C.S.M., N.M.I.), Pathology (K.K.), and Urology (P.T.S.), Memorial Sloan-Kettering Cancer Center, 1275 York Ave, New York, NY 10021. Received June 6, 2005; revision requested August 1; revision received August 9; accepted September 7; final version accepted October 10. Supported by NIH grant R01 CA76423. Address correspondence to O.A. (e-mail: [akino@mskcc.org](mailto:akino@mskcc.org)).

The management of prostate cancer is challenging because this disease has variable clinical and pathologic findings. Patients with prostate cancer are treated with a risk-adjusted patient-specific method that is designed to improve the control of cancer while reducing the risk of treatment-related complications. There is a growing demand for further individualization of treatment plans, which necessitates the accurate characterization of the location and extent of cancer.

The prostate zonal anatomy and the periprostatic structures are superbly depicted on T2-weighted magnetic resonance (MR) images. This makes MR imaging a useful tool in the evaluation of the location and local extent of prostate cancer. In prostate cancer staging and treatment planning, MR imaging has been shown to have an incremental value that is additive to the value of clinical nomograms (1).

In 75%–85% of cases, prostate cancer occurs in the peripheral zone; however, it has been shown that the transition zone harbors cancer in up to 25% of radical prostatectomy specimens (2–6). Cancers located in the transition zone show some pathologic and clinical features that are different from the features shown by cancers located in the peripheral zone (7,8). It is important to accurately distinguish transition zone cancers with imaging to guide biopsy, plan disease-targeting therapies, and avoid positive anterior surgical margins at radical prostatectomy (9–13).

#### Advances in Knowledge

- To our knowledge, this is the first published study addressing the accuracy of MR imaging in the detection, localization, and staging of transition zone cancers.
- New imaging features (lenticular shape and invasion of the anterior fibromuscular stroma) were analyzed.
- It is possible to detect transition zone cancers with MR imaging by using the features described in this report.

A substantial amount of literature addresses MR imaging of prostate cancer—mainly that which occurs in the peripheral zone (14). However, the diagnostic performance of MR imaging in the assessment of transition zone cancers has not been widely studied. MR imaging is generally considered inadequate for use in the evaluation of transition zone cancers because of the heterogeneous T2 signal intensity in the normal transition zone. Findings of two pilot studies, however, have suggested that MR imaging features—such as homogeneous low T2 signal intensity, ill-defined margins, and lack of capsule—can be useful in the identification of these lesions (15,16). Thus, the purpose of our study was to retrospectively evaluate the accuracy of endorectal MR imaging in the detection and local staging of transition zone cancers, with pathologic analysis serving as the reference standard, and to assess the MR imaging features of these cancers.

#### Materials and Methods

In this retrospective cross-sectional single-institution study, patients were recruited as part of an ongoing National Institutes of Health study investigating the use of MR imaging in patients with prostate cancer. Written informed consent was obtained from each patient prior to MR imaging. Subsequently, the institutional review board approved our retrospective study and waived the informed consent requirement. This study was compliant with the Health Insurance Portability and Accountability Act. Patient data were collected and handled in accordance with institutional and federal guidelines.

#### Patients

For patient selection, step-section pathologic maps from radical retropubic prostatectomy were used to localize cancers in the prostate. All of the patients with at least one tumor located predominantly in the transition zone (>50% of the tumor located within the transition zone) were consecutively selected from 986 patients who underwent MR imaging and radical prostatectomy between December 1999

and October 2004 and placed in the transition zone group ( $n = 148$ ). Patients with only peripheral zone cancer but without transition zone cancer (control group,  $n = 46$ ) were selected randomly to have 80% power by using a one-sided .05 level test to show that the area under the receiver operating characteristics curve (AUC) for detecting transition zone cancers is at least 0.70. Sample size was calculated with formulas described by Pepe (17). Thus, 194 patients comprised the study group (Table 1). There were no significant differences in patient characteristics between patients in the transition zone group and those in the control group.

#### Pathologic Analysis

Step-section pathologic maps, which served as the reference standard, were evaluated by a pathologist (K.K.) with 3 years of experience in pathologic examination of prostate cancer. The pathologist, who was blinded to MR imaging results, determined the tumor location, surgical Gleason score, and pathologic stage for each patient. In the transition zone group, tumor volume for each focus of transition zone cancer was calculated with computerized planimetry by using image analysis and measurement software (Image-Pro Plus 4.0; Media Cybernetics, Silver Spring, Md), as described previously (18).

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#### Abbreviations:

AUC = area under the receiver operating characteristics curve

BPH = benign prostatic hyperplasia

CI = confidence interval

#### Author contributions:

Guarantors of integrity of entire study, O.A., H.H.; study concepts/study design or data acquisition or data analysis/interpretation, all authors; manuscript drafting or manuscript revision for important intellectual content, all authors; manuscript final version approval, all authors; literature research, O.A., E.S., H.H.; clinical studies, O.A., E.S., K.K., D.P., P.T.S., H.H.; statistical analysis, C.S.M., N.M.L.; and manuscript editing, O.A., H.H.

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### MR Imaging Technique

MR imaging was performed with a 1.5-T whole-body MR imager (Signa; GE Medical Systems, Milwaukee, Wis). Patients were examined in the supine position; the body coil was used for excitation, and the pelvic phased-array coil (GE Medical Systems) was used in combination with an expandable endorectal coil (Medrad, Pittsburgh, Pa) for signal reception. Transverse spin-echo T1-weighted images were obtained from the aortic bifurcation to the symphysis pubis with the following parameters: repetition time msec/echo time msec, 400–600/8–10; section thickness, 5 mm; intersection gap, 1 mm; field of view, 24 cm; matrix, 256 × 192; and two signals acquired. Thin-section, high-spatial-resolution transverse, coronal, and sagittal T2-weighted fast spin-echo images of the prostate and seminal vesicles were obtained with the following parameters: 4000–6000/96–120; echo train length, 12–16; section thickness, 3 mm; intersection gap, 0 mm; field of view, 12–14 cm; matrix, 256 × 192; and four signals acquired. T2-weighted images were postprocessed to correct for the reception profile of the endorectal coil.

### MR Image Interpretation

Two junior radiologists (E.S., O.A.) interpreted all of the studies. Each reader was a fellowship trainee in body imaging and had interpreted more than 500 endorectal MR imaging studies of the prostate. Before this study started, the readers received training in the anatomic and pathologic features of the prostate from a senior radiologist (H.H.) with more than 15 years of experience in prostate MR imaging. Thereafter, the readers independently reviewed all of the study cases, which were randomly mixed and presented to them. The readers were aware that the patients had biopsy-proved prostate cancer but were blinded to patients' clinical data and surgical pathologic findings. Readers mainly evaluated T2-weighted MR images because zonal anatomy of the prostate can be seen on only these images.

On the basis of a review of the literature by the authors (O.A., E.S., D.P.,

H.H.), the following MR imaging features were considered indicative of transition zone prostate cancer: homogeneous low T2 signal intensity, ill-defined margins, and lack of capsule. On the basis of personal observations of the senior radiologist (H.H.) and urologist (P.T.S.), additional features that were considered indicative of transition zone prostate cancer included lenticular shape and invasion of the anterior fibromuscular stroma.

Initially, the readers independently recorded whether or not they thought a patient had transition zone cancer. For the purposes of this study, the transition zone was divided into the upper third—which included the region in the base of the prostate, the middle third—which included the region at the level of the verumontanum, and the lower third—which included the remaining inferior portion of the transition zone. In young men, the transition zone makes up only a small portion of the prostate and is located on either side of the proximal urethra; however, the proportion of the transition zone increases with age and may extend

below the level of the verumontanum. The left and right sides of the transition zone were separated by the median sagittal plane through the verumontanum. The location of the transition zone cancer in the prostate was recorded with a five-point scale (1, definitely absent; 2, probably absent; 3, possibly present; 4, probably present; 5, definitely present). If there were two or more transition cancer foci in a given patient, the locations of these foci were recorded separately. The readers also independently assessed the transition zone tumors for extraprostatic extension, seminal vesicle invasion, and invasion of the urethra and bladder neck. The presence or absence of the previously mentioned MR imaging features was determined for each lesion. Finally, MR imaging findings were directly compared with step-section pathologic maps by both readers in consensus.

### Statistical Methods

The accuracy of readers using MR imaging to identify patients with transition zone cancer was assessed by estimating

**Table 1**

Patient Characteristics		
Characteristic	Patients with Transition Zone Cancers ( <i>n</i> = 148)	Patients without Transition Zone Cancers ( <i>n</i> = 46)
<b>Age (y)</b>		
Median	60	58
Range	41–75	38–72
<b>Prostate-specific antigen level (ng/mL)</b>		
Median	5.9	4.7
Range	2.1–28.0	1.5–16.0
<b>Pathologic stage</b>		
T1c	1 (1)	0 (0)
T2a	12 (8)	8 (17)
T2b	100 (68)	27 (59)
T2+	15 (10)	1 (2)
T3a	18 (12)	8 (17)
T3b	0 (0)	2 (4)
T4	2 (1)	0 (0)
<b>Surgical Gleason score</b>		
3+3	83 (56)	22 (48)
3+4	50 (34)	16 (35)
4+3	12 (8)	7 (15)
4+4	2 (1)	1 (2)
5+3	1 (1)	0 (0)

Note.—Unless otherwise indicated, data are the number of patients. Numbers in parentheses are percentages.

sensitivity and specificity, together with 95% exact Clopper-Pearson binomial confidence intervals (CIs), separately for each reader (19).

To evaluate accuracy in determining the locations of the transition zone cancers, receiver operating characteristic analysis was conducted. For each reader, AUC and the corresponding CI were estimated nonparametrically by using the method described by Obuchowski (20) to account for the correlation due to the multiple observations per patient. To assess interrater variability in determining tumor location, a weighted  $\kappa$  statistic was used with weights  $1-|i-j|/(5-1)$ , where  $i, j = 1, \dots, 5$  denote the rating categories for the readers (21,22). To determine whether cancer volume influenced reader accuracy, a regression model for the receiver operating characteristics curve was fitted by using methods described by Pepe (17). We modeled  $\text{logit ROC}(t) = \alpha_0 + \alpha_1(\text{logit } t) + \beta_1(\text{reader}) + \beta_2(\text{volume})$ , where  $t$  (which ranges from 0–1) is the false-positive fraction and  $\text{ROC}(t)$  is the sensitivity as a function of the false-positive fraction. By testing whether  $\beta_2$  was significantly different from zero, we could determine whether accuracy as measured with the receiver operating characteristics curve was significantly affected by tumor volume. The parameters in the model, together with their standard errors, were estimated by using generalized estimating equations with robust sandwich variance estimates and an independence working correlation matrix.

Accuracy levels in the detection of extraprostatic extension, seminal vesicle invasion, and invasion to the urethra and bladder neck were assessed by estimating sensitivities and specificities, together with 95% exact binomial CIs, separately for each reader.

To analyze MR imaging features, each reader's findings of a feature were correlated with the presence of cancer in the transition zone. The MR imaging features were also examined in multivariate logistic regression analyses with odds ratios to search for a combination of features that would be predictive of transition zone cancer. These analyses were performed separately for each

reader. The association between a given MR imaging finding and cancer in the transition zone was considered significant if the  $P$  value was less than .05.

All analyses were performed with Stata software (Stata, version 8.0 for Windows; College Station, Tex) except for the receiver operating characteristics analysis used to assess accuracy in determining transition zone tumor location, which was performed with S-Plus software (version 6.2 for Windows; Insightful, Seattle, Wash).

## Results

### Pathologic Findings

In total, there were 223 transition zone cancer foci in 148 patients (one focus in 82 patients, two foci in 57, and three foci in nine). The volumes of these transition zone cancers ranged from 0.0015 to 16.2 mL, with a median volume of 0.77 mL.

Twenty-five (11%) of the transition zone cancers had extraprostatic extension. None of the lesions extended to the seminal vesicles, urethra, or bladder neck.

### MR Imaging Findings Correlated with Step-Section Pathologic Findings

**Detecting the presence of transition zone cancer in a patient.**—For detecting the presence of transition zone cancer in a patient, reader 1 had a sensitivity of 75% (95% CI: 67%, 82%) and a specificity of 87% (95% CI: 74%, 95%) and reader 2 had a sensitivity of 80% (95% CI: 72%, 86%) and a specificity of 78% (95% CI: 64%, 89%). The  $\kappa$  statistic was 0.50, indicating fair agreement between readers.

**Detecting transition zone cancer foci and their locations.**—Reader 1 correctly identified 126 (56%) of the 223 transition zone cancer foci and reader 2 correctly identified 141 (63%). Of the 132 lesions that reader 1 identified as transition zone cancers, six (5%) were false-positive findings. Of the 151 lesions that reader 2 identified as transition zone cancers, 10 (7%) were false-positive findings.

In determining the locations of tran-

sition zone cancers, the AUC for reader 1 was 0.75 (95% CI: 0.72, 0.79) and the AUC for reader 2 was 0.73 (95% CI: 0.70, 0.77). The weighted  $\kappa$  statistic was 0.64, indicating fair agreement between readers (Fig 1).

**Effect of transition zone cancer volume on detection with MR imaging.**—Readers' accuracy in the detection of the transition zone cancer foci increased significantly as the tumor volume increased ( $P = .001$ ). Transition zone cancer volume was dichotomized at a median tumor volume of 0.77 mL (Fig 2). For detecting transition zone cancers with a volume of less than 0.77 mL, reader 1 had an AUC of 0.67 (95% CI: 0.62, 0.73) and reader 2 had an AUC of 0.66 (95% CI: 0.60, 0.71). For detecting transition zone cancers with a volume greater than or equal to 0.77 mL, reader 1 had an AUC of 0.84 (95% CI: 0.79, 0.88) and reader 2 had an AUC of 0.82 (95% CI: 0.77, 0.86).

**Transition zone cancer local staging with MR imaging.**—The numbers presented in this section represent the accuracy of each reader in detecting extraprostatic extension in combination with transition zone cancer, as during the interpretation of MR images readers first attempted to identify transition zone cancers and then attempted to identify extraprostatic extension from the transition zone cancers. Thus, the prediction of extraprostatic extension from transition zone cancers depended on the accuracy with which the readers detected transition zone cancers in the first place.

For the detection of extraprostatic extension, reader 1 had a sensitivity of 56% (95% CI: 36%, 74%) and a specificity of 94% (95% CI: 88%, 97%) and reader 2 had a sensitivity of 28% (95% CI: 13%, 50%) and a specificity of 93% (95% CI: 88%, 96%).

Pathologic analysis revealed that none of the patients had invasion of the seminal vesicles, urethra, or bladder neck. However, reader 1 falsely identified one seminal vesicle invasion and one urethral invasion, whereas reader 2 falsely identified one urethral invasion and one bladder neck invasion.

**MR imaging features of transition**

zone cancers.—The following MR imaging features were used to detect transition zone cancers (Figs 3–5): homogeneous low T2 signal intensity, ill-defined margins, lack of capsule, lenticular shape, and invasion of anterior fibromuscular stroma. Table 2 summarizes the sensitivity and specificity values for each reader in the detection of transition zone cancers.

The results of multivariate logistic regression analyses with odds ratios for MR imaging features indicating an increased risk of a patient having a transition zone cancer showed that for both readers (Table 3), homogeneous low T2 signal intensity was significantly associated with the presence of a transition zone cancer ( $P = .001$  for reader 1,  $P < .001$  for reader 2). For reader 1, lenticular shape was also significantly associated with the presence of a transition zone cancer after adjusting for homogeneous low T2 signal intensity ( $P = .017$ ). For reader 2, no other variables were significantly associated with the presence of a transition zone cancer af-

ter adjusting for homogeneous low T2 signal intensity.

### Discussion

Cancers in the transition zone show clinical features that are different from those shown by cancers in the peripheral zone. With digital rectal examination, transition zone cancers are more difficult to detect than peripheral zone cancers because transition zone cancers are located anteriorly and are far from the rectum (3,12,23). In fact, most transition zone cancers are found incidentally in transurethral prostate resection specimens (2,24).

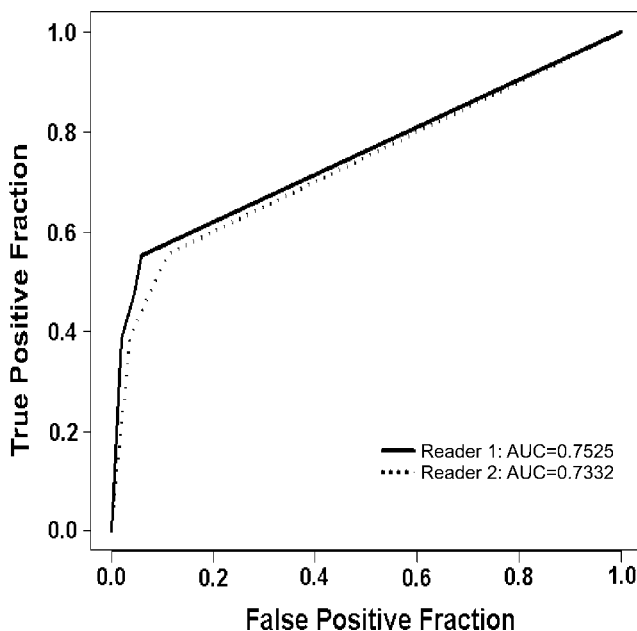
Systematic transrectal ultrasonographically guided needle biopsy of the transition zone is usually not performed (11,12,25–32). Prostate biopsy can be extended to include cores from the transition zone, but this is currently indicated in only those patients who are suspected of having prostate cancer and have prior negative biopsy findings (11,12,26).

Patients with transition zone can-

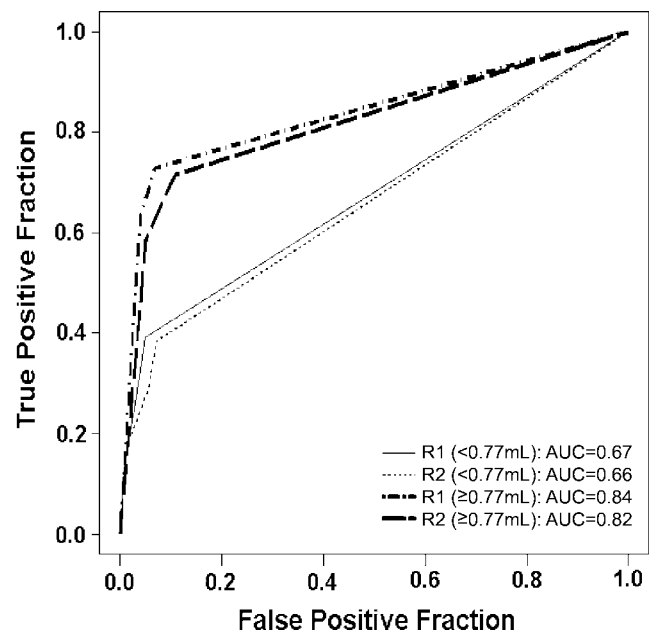
cers have markedly higher mean prostate specific antigen levels compared with those who have peripheral zone cancers (31 ng/mL and 11 ng/mL, respectively) (33,34). In addition, patients with transition zone cancers have higher tumor volumes than patients with peripheral zone cancers (11.2 mL and 5.0 mL, respectively) (35).

Patients with transition zone cancers have lower mean Gleason scores than patients with peripheral zone cancers (6.2 and 7.4, respectively) (35). In addition, transition zone cancers are more often confined to an organ (67%–89%) than are peripheral zone cancers (41%–56%) (6,35–37). Furthermore, extraprostatic extension occurs at a larger mean tumor volume in transition zone cancers than in peripheral zone cancers (4.98 mL vs 3.86 mL, respectively) (37). Even when tumor volumes are the same, a higher rate of organ-confined disease is seen in transition zone cancers (79% and 27%, respectively) (3,38).

Figures 1, 2



**Figure 1:** Graph shows receiver operating characteristic curve and AUC for each reader as a measure of accuracy of MR imaging findings in prediction of the location of transition zone cancers. Weighted  $\kappa$  statistic was 0.64, which indicates fair agreement between readers.



**Figure 2:** Graph shows receiver operating characteristic curve and AUC for each reader as a measure of the accuracy of MR imaging findings in detection of transition zone cancers according to tumor volume. Tumor volume was dichotomized at a median tumor volume of 0.77 mL.



Patients with transition zone cancers have more favorable prognoses than patients with peripheral zone cancers. After radical prostatectomy, patients with transition zone cancers have higher biochemical cure rates (72%–82%) than those with peripheral zone cancers (16%–56%) (3,6,33–35). However, Augustin et al (6) reported that when tumor stage, Gleason score, and surgical margin status were comparable, the 5-year biochemical cure rate did not differ significantly between patients with transition zone cancers and those with peripheral zone cancers.

Transition zone cancers and peripheral zone cancers differ not only in their clinical and pathologic characteristics but also in the imaging features they

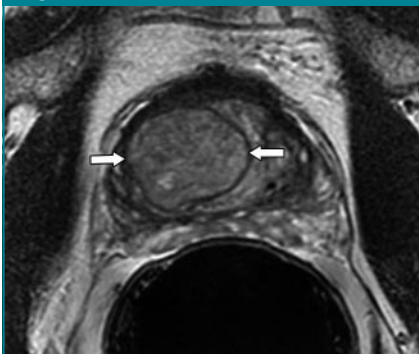
display. A substantial amount of literature addresses MR imaging of prostate cancer, with the focus being mainly on peripheral zone cancers. The role of MR imaging in the assessment of transition zone cancers has not been studied widely. This is likely because transition zone cancers are less common than peripheral zone cancers. In addition, MR imaging is hampered in the evaluation of transition zone cancers by the heterogeneous T2 signal intensity in the normal transition zone. On the other hand, peripheral zone cancers are depicted as

areas of low T2 signal intensity within the relatively homogeneous peripheral zone.

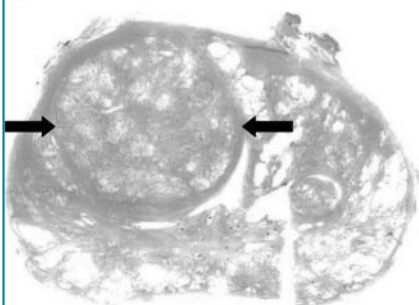
Previous studies performed with older technology and without use of an endorectal coil indicated that MR imaging had limited ability in the depiction of transition zone cancers (39,40). It is particularly difficult to distinguish transition zone cancers from fibromuscular (stromal) benign prostatic hyperplasia (BPH), because both conditions can demonstrate low T2 signal intensity on MR images (40). However, preliminary reports have shown that MR imaging features such as homogeneous low T2 signal intensity, ill-defined margins, and lack of capsule can be used to identify transition zone cancers on MR images (15,16). BPH nodules tend to have mixed high and low signal intensity on T2-weighted images because of their stromal and glandular components. BPH nodules with predominantly stromal components may show diffuse low signal intensity on images obtained with T2-weighted sequences, but BPH nodules often have well-defined margins and visible capsules, which are features not seen in transition zone cancers. In this study, we observed two other features that helped in the identification of transition zone cancers: lenticular shape and invasion of the anterior fibromuscular stroma. BPH nodules are typically round. They may displace, but they do not invade, the anterior fibromuscular stroma.

MR imaging has already been shown to be useful in the detection of peripheral zone cancers. In previous studies in which step-section histopathologic correlation has been used, 67%–76% of peripheral zone cancers were detected with MR imaging (41,42). The results of our study show that it is possible to detect transition zone cancers at MR imaging by using the previously mentioned features. None of these features is pathognomonic for transition zone cancer; however, in our study, readers combined these features and assigned higher scores to transition zone cancers than to benign lesions. However, volume was an important factor in the detection of transition zone cancers. Both

**Figure 3**



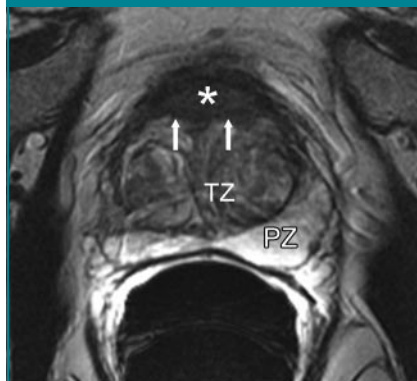
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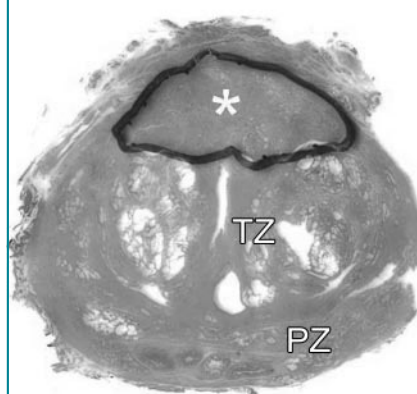
b.

**Figure 3:** Images in a 66-year-old man with Gleason grade 3 + 3 pT2b prostate cancer. **(a)** Transverse T2-weighted MR image shows a typical BPH nodule (arrows) demonstrating mixed T2 signal intensity with well-defined margins and a distinct capsule. **(b)** Corresponding step-section pathologic findings confirm the presence of a BPH nodule (arrows), without any cancer foci in the transition zone.

**Figure 4**



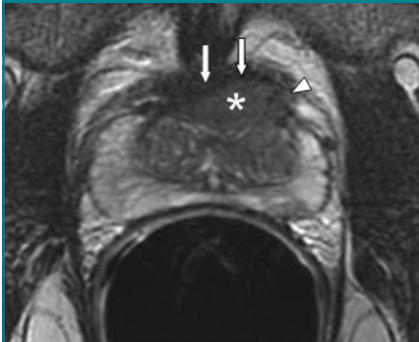
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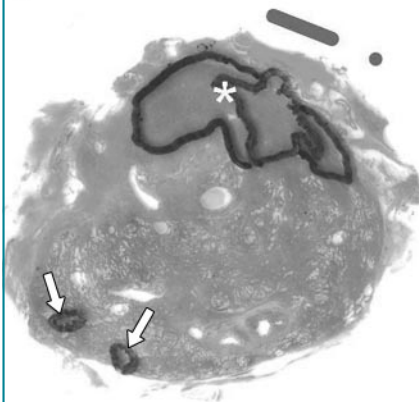
b.

**Figure 4:** Images in a 60-year-old man with Gleason grade 3 + 3 pT2b prostate cancer. **(a)** Transverse T2-weighted MR image shows a lenticular lesion (\*) demonstrating homogeneous low T2 signal intensity with ill-defined margins and without a distinct capsule (arrows). **(b)** Corresponding step-section pathologic findings confirm the presence of transition zone (TZ) cancer (\*) without extraprostatic extension. PZ = peripheral zone.

**Figure 5**



**a.**



**b.**

**Figure 5:** Images in a 59-year-old man with Gleason grade 4 + 3 pT3a prostate cancer. **(a)** Transverse T2-weighted MR image shows transition zone cancer (\*) invading the anterior fibromuscular stroma (arrows) and extending (arrowhead) beyond the confines of the prostate anteriorly on the left side. **(b)** Corresponding step-section pathologic findings confirm the presence of transition zone cancer (\*) with established (line) and focal (●) extraprostatic extension. Two small foci of peripheral zone cancer (arrows) are also seen.

readers performed significantly better when cancers had large volumes.

MR imaging is a valuable tool in the assessment of local staging of prostate cancer. The literature shows a wide range (50%–92%) in the accuracy of local staging with MR imaging (14). Previous studies mainly concentrated on the local staging capability of MR imaging in peripheral zone cancers, although this was not explicitly stated in the reports. To our knowledge, no other report on the local staging ability of MR imaging in patients with transition zone

**Table 2**

**MR Imaging Features with Corresponding Sensitivity and Specificity Values for Transition Zone Cancers**

Feature	No. of Patients with Transition Zone Cancers (n = 148)	Sensitivity (%)	No. of Patients without Transition Zone Cancers (n = 46)	Specificity (%)
<b>Homogeneous low T2 signal intensity</b>				
Reader 1	112	76 (68, 82)	40	87 (74, 95)
Reader 2	116	78 (71, 85)	36	78 (64, 89)
<b>Ill-defined margins</b>				
Reader 1	112	76 (68, 82)	41	89 (76, 96)
Reader 2	116	78 (71, 85)	36	78 (64, 89)
<b>Lack of capsule</b>				
Reader 1	97	66 (57, 73)	40	87 (74, 95)
Reader 2	116	78 (71, 85)	36	78 (64, 89)
<b>Lenticular shape</b>				
Reader 1	83	56 (48, 64)	45	98 (88, 100)
Reader 2	71	48 (40, 56)	39	85 (71, 94)
<b>Invasion of anterior fibromuscular stroma</b>				
Reader 1	34	23 (17, 31)	46	100 (90, 100)
Reader 2	29	20 (14, 27)	44	96 (84, 99)

Note.—Data in parentheses are 95% CIs.

**Table 3**

**Multivariate Logistic Regression Analysis of MR Imaging Features in Predicting the Presence of Transition Zone Cancer**

Feature	Reader 1		Reader 2	
	Odds Ratio	95% CI	Odds Ratio	95% CI
Homogeneous low T2 signal intensity	6.4	2.3, 18.0	13	5.8, 29.0
Lenticular shape	14	1.6, 128.0	...	...

cancers is available in the literature. The results of the current study show that local staging of transition zone cancers is possible with MR imaging. It should be kept in mind, however, that the number of transition zone cancers with extraprostatic extension in this study was small; furthermore, because of the study design, the prediction of extraprostatic extension depended on the accuracy with which transition zone cancers were detected on MR images. In addition, patients with obvious extraprostatic extension probably did not undergo surgery and were not included in our study.

MR imaging features of prostate cancer in the peripheral zone are well known. Typically, cancers in the peripheral zone are seen on T2-weighted MR images as focal low-signal-intensity areas within the high-signal-intensity peripheral zone. In this study, several MR imaging features of transition zone cancers were investigated. The results of multivariate logistic regression analyses, however, indicated that among these features, homogeneous low T2 signal intensity (for both readers) and lenticular shape (for one of the readers) were significantly associated with the presence of transition zone cancer.

Our study had several limitations, including the fact that it was retrospective. A selection bias might have occurred because our study group included only patients who underwent radical prostatectomy and excluded those who were treated with other methods; however, this was necessary for the direct comparison of imaging findings with pathologic maps. Our use of consecutive sampling rather than random sampling might have introduced bias into our findings and interpretations. Additionally, the readers were instructed to look for specific MR imaging features in the transition zone, which might have resulted in improved tumor localization in the transition zone. Other MR imaging techniques besides the routine T2-weighted MR imaging protocol, such as contrast material-enhanced MR imaging and MR spectroscopic imaging, were not assessed. A difference in contrast material uptake between BPH and transition zone cancers has been observed with dynamic contrast-enhanced MR imaging (43,44). In addition, a metabolic difference between benign and cancerous transition zone tissue was reported with MR spectroscopic imaging (45). Thus, further studies are necessary to compare alternative MR imaging methods in the detection of transition zone cancer.

Because of the small numbers of patients classified as not having some of the previously mentioned MR imaging features, the models for prediction of transition zone cancer could not be validated entirely. These MR imaging features need to be validated with an independent data set by a different group of reviewers. Finally, we did not compare the accuracy of MR imaging in the detection and staging of transition zone cancers with the accuracy of MR imaging in the detection and staging of peripheral zone cancers. However, that was not the purpose of this study.

In conclusion, our findings show that the accuracy of transition zone cancer detection at MR imaging is related to the transition zone cancer volume, with higher accuracy for cancers with larger volumes. Further prospective studies are needed to test the proposed

MR imaging features, compare the accuracy levels of MR imaging in the peripheral zone and in the transition zone, and assess the effect that detection and staging of transition zone cancers with MR imaging have on patient treatment and outcome.

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