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The efficacy of multiparametric prostate MRI in making treatment decisions and predicting early recurrence in localized prostate cancer

Multiparametrik prostat MRI'nın lokalize prostat kanserinde tedavi seçimi ve erken nüks saptamaya etkisi

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ABSTRACT

Aim: This study investigates the potential role of multiparametric magnetic resonance imaging (mp-MRI) in localized prostate cancer, its impact on treatment decision-making and its predictability of the likelihood of cancer recurrence after treatment.

Material and Method: The relationships between ISUP grade groups, prostate volume, prostate-specific antigen (PSA), and free PSA values that determine the risk classification of 114 cases diagnosed with localized prostate cancer, mp-MRI findings, including index lesion diameter, apparent diffusion coefficient (ADC) value, capsule contact length, extracapsular extension, and presence of seminal vesicle invasion, and biochemical recurrence, were investigated.

Results: Of the 114 patients included in the study, 49 underwent radiotherapy and 61 underwent radical prostatectomy as curative treatments. Four patients were enrolled in an active surveillance protocol to delay potential side effects. PSA or local recurrence occurred in 13 (11.4%) patients during the follow-up period. There was a significant correlation between stable disease and absence of extracapsular invasion (*p=0.022*) and ISUP grade (*p=0.025*). There was also a significant correlation between index lesion diameter (*p=0.005*), capsule contact length (*p=0.015*), and recurrence. Additionally, the ADC value decreased as the ISUP grade and clinical stage increased (*p=0.001*).

Conclusion: This study's findings indicate that mp-MRI can be used for risk stratification and making risk-based treatment decisions in localized prostate cancer patients.

Keywords: Prostate cancer, multiparametric prostate MRI, risk factors, lesion diameter, capsule contact length.

ÖZ

Amaç: *Çalışmada amacımız, prostat kanseri tanısında, giderek kullanımı artan multiparametrik prostat MRG'nin lokalize hastalıkta tedavi kararlarındaki potansiyel rolünü ve tedavi sonrası erken dönemde nüksü belirlemede prognostik önemini araştırmaktır.*

Gereç ve Yöntem: *Lokalize prostat kanseri tanısı alan 114 olgunun risk sınıflamasını belirleyen ISUP derecesi, prostat spesifik antijen (PSA), serbest PSA, prostat volüm ile mp-MRI incelemede indeks lezyon çapı, görünür difüzyon katsayısı (ADC) değeri, kapsül temas uzunluğu, ekstrakapsular uzanım ve seminal vezikül invazyonu varlığının biyokimyasal nüks ile ilişkisi araştırılmıştır. Gruplar arasındaki radyolojik ve klinik özelliklerin dağılımındaki farklılıklar, ki-kare testi kullanılarak istatistiksel olarak değerlendirildi.*

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Bulgular: *Çalışmaya dahil edilen 114 hastanın 49'una radyoterapi, 61'ine radikal prostatektomi olmak üzere küratif tedavi uygulanmıştır. Dört hasta ise yan etkileri ertelemek amacıyla aktif izlem protokolüne alınmıştır. Takipte 13 (11,4%) hastada PSA veya lokal nüks meydana gelmiştir. Nüksüz hastalık ile ekstrakapsüler invazyon yokluğu(p=0,022) ve ISUP derecesi (p=0,025) arasında istatistik olarak anlamlı bir ilişki gözlenmiştir. İndeks lezyon çapı ölçümü (p=0,005) ve kapsül temas uzunluğu ölçümü(p=0,015) ile erken dönem nüks hastalık arasında istatiksel olarak anlamlı ilişki gözlenmiş olup, ISUP derecesi arttıkça ve klinik evre arttıkça ADC değeri düşmekteydi (p=0,001).*

Sonuç: *Bu çalışmanın bulguları, mp-MRI'nin lokalize prostat kanseri hastalarında risk sınıflandırması ve riske dayalı tedavi kararları vermek için kullanılabileceğini göstermektedir.*

Anahtar Sözcükler: *Prostat kanser, multiparametrik MRI, risk faktörleri, lezyon çapı, kapsül temas uzunluğu.*

INTRODUCTION

Prostate cancer tops the charts as the most common cancer affecting men globally (1). Most patients with prostate cancer are diagnosed in the localized disease stage. Therefore, this patient group is treated with local treatment options such as active surveillance, radiotherapy (RT), or radical prostatectomy (RP) based on their risk classification (2). When planning optimal treatment for men with prostate cancer, it is essential to avoid unnecessary overtreatment in the low-risk patient group and not to cause recurrence of the disease and treatment failures in men who choose active surveillance (3). Currently used risk stratification for prostate cancer relies on findings like PSA level, ISUP grade, and clinical stage from digital rectal exams. However, these findings can vary depending on the examining physician, highlighting the need for more accurate assessment of clinically significant lesions, disease extent at diagnosis, and future progression risk (4). For example, interobserver agreement for clinical staging is strikingly low, and ISUP grade of approximately one-third of patients are increased based on radical prostatectomy materials relative to biopsy specimens (5, 6). Therefore, new assessment methods are needed to improve the risk stratification of prostate cancer patients.

Many publications in the literature address risk assessments after radical prostatectomy (7). However, these reference standards may not apply to determining prognosis in patients undergoing RT (8, 9). In particular, the fact that ISUP's grade is histopathologically upgraded after radical prostatectomy reveals the necessity of additional criteria in the pre-RT evaluation.

MRI is gaining importance in prostate cancer imaging due to its reliability in detecting clinically significant cancers. This allows for better patient selection for biopsy and more precise targeting of lesions during the procedure. The spread of cancerous tissue within the prostate gland and its spread to surrounding tissues is better assessed by MRI. In addition, detailed information about the exact location and size of the cancerous tissue provides guidance in planning treatments such as surgery or radiotherapy.

Considering the foregoing, the objective of this study is to investigate the potential role of mp-MRI, which is increasingly used in the diagnosis of prostate cancer, in making treatment decisions in localized prostate cancer patients and its prognostic value in predicting early recurrence after treatment.

MATERIALS and METHODS

Study design and setting

Prior to conducting this retrospective study, informed consent was obtained from all participants. The study protocol was approved by the University's ethics committee (Approval Date: 24.05.2023, Approval No.424), ensuring adherence to the ethical principles outlined in the revised Declaration of Helsinki adopted by the World Medical Association General Assembly in Edinburgh in 2000.

Population and Sample

A total of 406 patients who underwent mp-MRI in our tertiary university hospital between 2015 and 2022 were identified from the SECTRA picture archiving and communication system (PACS) (Sectra Workstation IDS7; Sectra AB, Linköping, Sweden). These patients' biopsy and follow-up results were accessed from the hospital archive system (MIAMED, 1.0.1.3295). Consequently, 221 patients, who were determined to have been diagnosed with prostate cancer, constituted the study population. Of these patients, patients with

metastatic disease at the time of diagnosis (n: 11), no lesion finding on MRI at the time of diagnosis (n: 70), whose information could not be accessed as they were treated outside our hospital after having an MRI in our hospital (n: 12), and whose MRI scan quality was not optimal (n:14) due to reasons such as hip replacement artifact, motion artifact, etc. were excluded from the study. The remaining 114 patients constituted the study sample. These patients' demographic and clinical characteristics, including age, ISUP grade, tumor rate in biopsy materials, PSA and free PSA values, treatments received, and follow-up duration after treatment, were obtained from the patients' archive files and recorded.

MRI Analysis

All mp-MRI scans performed before the treatment were reviewed by an abdominal radiologist (A.K.) with 18 years of experience knowing the diagnosis of prostate cancer but blinded to the clinical and pathological results. The Prostate Imaging-Reporting and Data System (PI-RADS) score was determined according to the PI-RADS v2.1 guideline published by the European Society of Urogenital Radiology (ESUR) in 2019 with the latest revisions. Prostate volume was measured via axial and sagittal T2WI, the longest dimension of the index lesion via axial T2WI images and apparent diffusion coefficient (ADC) maps, and the index lesion's capsule contact length via axial T2WI images. In addition, all images were evaluated together, and the presence of accompanying lymphadenopathy, extra prostatic extension, and seminal vesicle invasion was assessed. The ADC value was determined by selecting the largest region of interest (ROI) of the targeted tissue in the ADC map containing the largest tumor section, but without approaching the tumor borders so that the signal would not interfere with the normal tissue.

Local staging of the tumor was performed using mp-MRI using the American Joint Committee on Cancer guidelines (10). Cases where no lesion could be detected on MRI but were histopathologically diagnosed with prostate cancer were excluded from the study.

MRI Protocol

All mp-MRI examinations were performed using a 3.0 Tesla Magnetic Resonance Imaging (3T-MRI) device (MAGNETOM Spectra; Siemens Healthcare, Erlangen, Germany) and a 16-channel phased array body coil (Siemens Healthcare, Erlangen, Germany). MRI sequences utilized were T1 weighted-imaging (T1WI) and T2WI sequences in the axial plane, high-resolution small field-of-view T2 (FOV T2) sequences in axial, sagittal, and coronal planes, diffusion-weighted imaging (DWI) (b 50, b800, b 1000 and b1400 sec/mm^2), ADC map and T1-weighted dynamic contrast-enhanced (T1W DCE) sequences with fat suppression in the axial plane (Table-1). ADC maps were automatically calculated by the software (Syngo via Siemens Medical Systems) using all available b-values integrated into least squares monoexponentially fitting. DCE sequences were taken at the thirtieth, sixtieth-, and ninetieth-seconds following administration of the contrast material.

Table-1. MRI sequence parameters.

Parameters	Axial TSE T2WI	Coronal TSE T2WI	Echo planar imaging DWI	Axial T1W DCE
TR (ms)	3720	4320	7700	5.12
TE (ms)	101	101	94	1.78
FOV (mm)	154x70	200x20	211x250	259x259
Matrix size	218x320	224x320	122x144	138x192
Slice thickness (mm)	3	3.5	5	3.5
b-values (s/mm^2)	-	-	b0, b400, b800, b1000, b1400	-
Flip angle	160	160	90	15

TR: Repetition time; TE: Echo time; FOV: Field of view; T2WI: T2-weighted imaging; DWI: Diffusion-weighted imaging; T1W:cT1 weighted-imaging; DCE: Dynamic contrast-enhanced.

Table-2. Demographic and clinical characteristics of the patients included in the study.

Variables (n=114)	
Age (years). Median (IQR)	65.4 ± 7.7
Prostate volume (cc)	50.9 ± 25.2
PSA (ng/mL)	8.86 (±7.33)
Free PSA	2.89 (±10.29)
PIRADS score. n (%)	
Stage 2	1 (0.9%)
Stage 3	18 (15.8%)
Stage 4	53 (46.5%)
Stage 5	42 (36.8%)
ISUP grade. n (%)	
Grade 1	70 (61.4%)
Grade 2	16 (14.0%)
Grade 3	14 (12.3%)
Grade 4	8 (7.0%)
Grade 5	6 (5.3%)
Clinical stage. n (%)	
T2 A	32 (28.1%)
T2 B	18 (15.8%)
T2 C	35 (30.7%)
T3 A	17 (14.9%)
T3B	12 (10.5%)
Pelvic lymphadenopathy. n (%)	**8 (7.0%)**
Extracapsular extension. n (%)	**31 (27.2%)**
Seminal vesicle invasion	**16 (14.0%)**
İndex lesion diameter (mm)	**14.18 (±8.25)**
ADC	**732.83 (±191.45)**
Capsule contact length (mm)	**11.43 (±12.23)**
Percent of biopsy cores	**11.65 (±14.52)**

PSA: Prostate-specific antigen; ADC: Apparent diffusion coefficient SD. Standard deviation, p value <0.05

Table-3. The relationships between stable or recurrent disease status and the categorical variables.

		Follow-up results				
		stable		recurrence		
		N	%	N	%	*p.
PIRADS	2	1	100.0%	0	0.0%	.267
	3	17	94.4%	1	5.6%	
	4	49	92.5%	4	7.5%	
	5	34	81.0%	8	19.0%	
Pelvic lymphadenopathy	yes	7	87.5%	1	12.5%	.919
	no	94	88.7%	12	11.3%	
Extracapsular extension	yes	24	77.4%	7	22.6%	**.022**
	no	77	92.8%	6	7.2%	
Seminal vesicle invasion	yes	12	75.0%	4	25.0%	.065
	no	89	90.8%	9	9.2%	
Gleason score	3+3=6	64	91.4%	6	8.6%	**.025**
	4+3=7	11	78.6%	3	21.4%	
	3+4=7	16	100.0%	0	0.0%	
	4+4=8	7	87.5%	1	12.5%	
	4+5=9	2	50.0%	2	50.0%	
	5+5=10	1	50.0%	1	50.0%	
Clinical stage	T2A	32	100.0%	0	0.0%	.106
	T2B	16	88.9%	2	11.1%	
	T2C	31	88.6%	4	11.4%	
	T3A	13	76.5%	4	23.5%	
	T3B	9	77.8%	3	22.2%	

*Significance level according to chi-square test results

Statistical Analysis

Statistical analyses were performed using SPSS 26.0 (IBM Corp., Armonk, NY, U.S., 2019), Jamovi (Version 2.3.28, The Jamovi Project, 2023), and JASP (Version 0.19.1, Jeffreys' Amazing Statistics Program, 2024). SPSS was utilized for basic statistical analyses, while Jamovi and JASP were employed for advanced statistical procedures, visualization, and ROC curve analyses with associated metrics. The sample size was determined to ensure at least 80% test power and 5% types-1 error rate for each variable analyzed. To determine the appropriate statistical tests, the normality of continuous variables was assessed using the Kolmogorov-Smirnov test for samples exceeding 50 and the Skewness-Kurtosis test. Based on these tests, parametric tests were employed due to the confirmation of normal distribution in the continuous variables. Descriptive statistics were generated for the collected data. Continuous variables are presented as mean ± standard deviation (SD), while categorical variables are represented by frequency (n) and percentage (%) values. Categorical variables were compared between groups using the independent samples t-test for two groups and one-way analysis of variance (ANOVA) for three or more groups. Following a significant ANOVA result, Duncan's multiple range test (DMRT) was used to identify specific groups with statistically different means. The relationship between continuous variables was assessed with Pearson correlation analysis. Chi-square tests were employed to evaluate associations between categorical variables. Receiver Operating Characteristic (ROC) curve

analyses were conducted to determine optimal cut-off values for imaging parameters. The Youden index (J = sensitivity + specificity - 1) was used to identify optimal cut-off points. Area Under the Curve (AUC) values were calculated with 95% confidence intervals, and DeLong's test was used to compare the diagnostic performance of different parameters. Sensitivity, specificity, positive and negative predictive values, and likelihood ratios were calculated for the identified cut-off points. A p-value of less than or equal to 0.05 was considered statistically significant.

RESULTS

Patients' Characteristics

The mean age of the patients included in the study was 65.4 ± 7.7 years, and the mean follow-up period was 31.7 ± 14.2 months. Patient's demographic and clinical characteristics are detailed in Table-2. Of the 110 patients who received curative treatment, 49 underwent radiotherapy and 61 underwent radical prostatectomy. Four additional patients were enrolled in an active surveillance protocol. Among patients receiving curative treatment, biochemical recurrence occurred in 13 patients (11.4%; 7 in the surgery group and 6 in the radiotherapy group). The active surveillance group was excluded from recurrence analysis due to different progression criteria.

The relationships between stable or recurrent disease status and the categorical variables are given in Table-3. Accordingly, there was a statistically significant relationship between stable disease status and the absence of extracapsular invasion. The majority (92.8%) of the cases lacking extracapsular invasion remained clinically stable (*p=0.022*). Similarly, there was a statistically significant correlation between the patients' ISUP grade and stable disease status (*p=0.025*). On the other hand, there was no statistically significant relationship between the variables other than those listed above and stable or recurrent disease status (p>0.05).

Mp-MRI Findings

The distribution of patients' mp-MRI findings by stable or recurrent disease status revealed a statistically significant difference between index lesion diameter and recurrent disease status (*p=0.005*). Accordingly, the index lesion size was significantly higher in patients with recurrent disease than in patients with stable disease (Table-4).

Similarly, there was a statistically significant difference between patients' capsule contact length in MRI and recurrent disease status(*p=0.015*). Accordingly, the capsule contact length was significantly higher in patients with recurrent disease than in those with stable disease (Table-4).

Additionally, it was determined that ADC value was significantly correlated with the ISUP grade and clinical stage. Accordingly, as the ISUP grade and the clinical stage increased, the ADC value decreased (*p=0.001*) (Table-5).

Furthermore, it was determined that the capsule contact length was significantly correlated with findings such as pelvic lymphadenopathy, extracapsular extension, and seminal vesicle invasion. Accordingly, patients with the said findings had significantly higher capsule contact lengths than others (*p=0.001*) (Table-6).

Table-4. Distribution of patients' mp-MRI findings and clinical findings by stable or recurrent disease status.

	Follow-up results		
	stable	**recurrence**	***p.**
Index lesion diameter (mm)	13.41±7.57	20.15±10.97	***.005***
ADC	736.42±183.88	705.00±249.92	*.580*
Capsule contact length (mm)	10.44±10.62	19.15±19.92	***.015***
PSA	9.27±7.65	5.65±2.23	*.093*
Free PSA	3.09±10.92	1.38± 7.1	*.574*
Percent of biopsy cores	10.30±10.08	22.15±31.67	***.004***

Values are shown as mean ± standard deviation. ADC: Apparent diffusion coefficient; PSA: Prostate-specific antigen

*Significance levels according to independent samples t-test results.

Table-5. Analysis of correlations of ADC with Gleason score and clinical stage.

		ADC (**)	*p.
Gleason score	3+3=6	792.97±190.00 [a]	.001
	4+3=7	627.43 ±186.08 [b]	
	3+4=7	664.56±167.47 [b]	
	4+4=8	607.00±106.05 [b]	
	4+5=9	653.00±67.12 [b]	
	5+5=10	575.00±52.33 [c]	
Clinical stage	T2A	868.8 ±181.27 [a]	.001
	T2B	689.22 ±151.13 [a]	
	T2C	764.29±174.60 [a]	
	T3A	578.41±114.51 [b]	
	T3B	566.00±57.71 [b]	

* Values are shown as mean ± standard deviation. Significance levels according to one-way ANOVA test results.
a.b.c: Shows the difference between the groups (Tukey's post-hoc test)
** ADC: apparent diffusion coefficient

Table-6. Analysis of the correlations of capsule contact length with categorical variables

		Capsule contact length **(mm)**	*p.
Lymphadenopathy	Yes	33.25±17.25	.001
	No	9.79±10.11	
Extracapsular extension	Yes	25.23±14.22	.001
	No	6.28±5.79	
Seminal vesicle invasion	Yes	30.63±13.50	.001
	No	8.30±8.69	

* Values are shown as mean ± standard deviation. Significance levels according to independent samples t-test results

ROC Curve Analysis

ROC curve analysis was performed to determine optimal cut-off values for both index lesion diameter and capsule contact length in predicting recurrence (Table-7, Figure-1). The index lesion diameter demonstrated fair diagnostic performance with an AUC of 0.712 (95% CI: 0.619-0.793, p=0.006), yielding an optimal cut-off value of >15 mm (sensitivity: 69.23%, specificity: 70.30%). Similarly, capsule contact length showed good diagnostic accuracy with a higher AUC of 0.778 (95% CI: 0.678-0.860, p=0.001), with an optimal cut-off value of >18 mm (sensitivity: 66.67%, specificity: 81.25%). The positive likelihood ratio was notably higher for capsule contact length (3.56, 95% CI: 1.86-6.81) compared to index lesion diameter (2.33, 95% CI: 1.46-3.73), suggesting stronger predictive value for recurrence. These findings indicate that both parameters, particularly capsule contact length, can serve as valuable imaging biomarkers for risk stratification in localized prostate cancer, with capsule contact length >18 mm associated with a significantly increased risk of recurrence.

Table-7. ROC curve analysis results for index lesion diameter and capsule contact length.

Parameter	Index Lesion Diameter	Capsule Contact Length
AUC (95% CI)	0.712 (0.619-0.793)	0.778 (0.678-0.860)
Cut-off value	>15 mm	>18 mm
Sensitivity	69.23%	66.67%
Specificity	70.30%	81.25%
Youden index	0.3953	0.4792
Recurrence rate	13 (11.40%)	9 (10.11%)
p-value	**0.006**	**0.001**

Note: Bold p-values indicate statistical significance (p≤0.05)

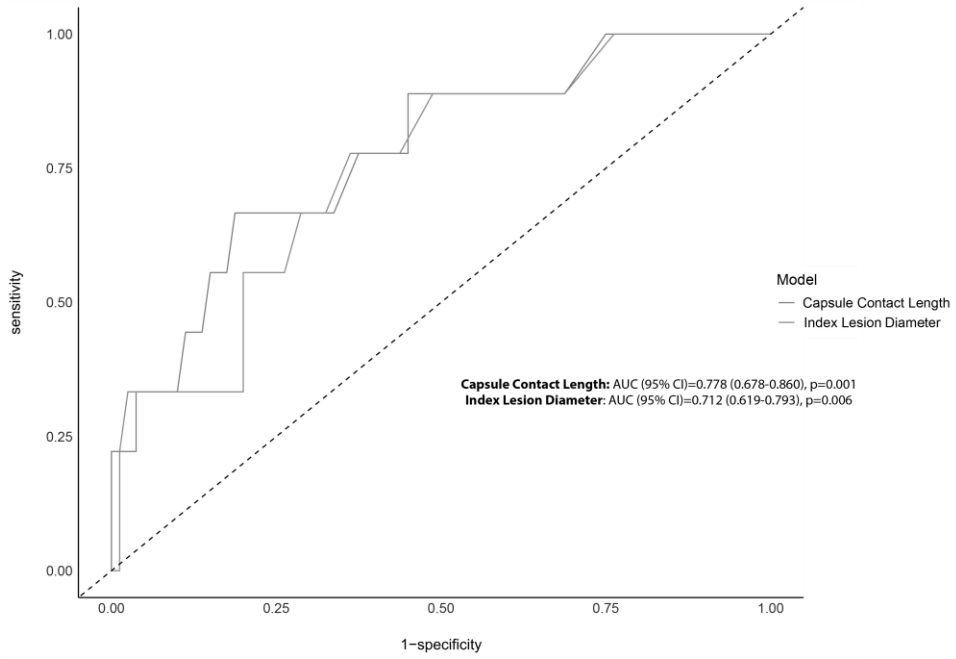

Figure-1. ROC analysis for index lesion diameter and capsular contact length. The optimal cut-off value for index lesion diameter was determined to be >15 mm (AUC: 0.712, 95% CI: 0.619-0.793, p=0.006), and for capsular contact length, it was >18 mm (AUC: 0.778, 95% CI: 0.678-0.860, p =0.001).

DISCUSSION

In this study, we evaluated the impact of mp-MRI findings on treatment decisions and prognosis in patients with localized prostate cancer. Our findings demonstrated significant associations between index lesion diameter (p=0.005) and capsule contact length (p=0.015) with biochemical recurrence. Moreover, we found that ADC values showed an inverse correlation with both Gleason score and clinical stage (p=0.001). The absence of extracapsular extension showed significant correlation with stable disease status (p=0.022). Additionally, patients' Gleason categories demonstrated significant association with disease stability (p=0.025). These findings suggest that quantitative mp-MRI parameters can serve as important prognostic indicators in localized prostate cancer management.

Localized prostate cancer is characterized by the absence of identifiable regional lymph nodes or distant metastases. In this context, three primary treatment options are available for localized prostate cancer patients: active surveillance, surgery, and RT. Several cohort studies have identified a 0% to 6.1% risk of metastasis and death from prostate cancer in selected patients under active surveillance and thus concluded that active surveillance is beneficial in this patient group (11). Clinicians traditionally classify

prostate cancer diagnoses as low-, intermediate-, and high-risk based on a combination of factors: ISUP grade (tumor grade), prostate-specific antigen (PSA) level, and clinical stage determined by digital rectal examination. While the specific treatment options for prostate cancer may vary depending on individual factors, surgery and radiation therapy are commonly considered effective treatments for men with advanced-stage prostate cancer (11). One of the main objectives of using MRI is to accurately determine the tumor focus with the highest Gleason pattern and the T-stage of the tumor in order to make an accurate risk classification. Despite a smaller sample size compared to other relevant studies, this research identified a significant relationship between low ISUP grade and stable disease status, aligning with established literature. However, more importantly, it was found that as the ISUP grade and the clinical stage increase, the ADC value decreases in diffusion sequences. Taking samples from the tissue with a low ADC value while planning a biopsy allows for determining the highest Gleason score, which we think may increase the effectiveness of the treatment, especially in planning active surveillance or RT.

The other radiological parameter we found to be related to local recurrence was the index lesion size. Patients with recurrent disease had significantly larger index lesion sizes, supporting the established link between larger tumor volume in radical prostatectomy specimens and negative outcomes like recurrence, lymph node involvement, metastasis, and mortality (4). In the literature, lesions greater than 15 mm have been associated with a higher risk of extracapsular extension (ECE) and biochemical (PSA) recurrence (2,12,13). This criterion is used to differentiate PI-RADS 4 and 5 in the PI-RADS v.2 guidelines, and Gorovets et al (14). found a significant relationship between index lesion size and recurrence after stereotactic body radiotherapy (SBRT) in PI-RADS4 and PI-RADS 5 cases. Dahan et al (15). suggested that patients with a larger index lesion may benefit from an intraprostatic dose increase via external beam radiation therapy (EBRT) or an increase in brachytherapy. T stage has an important place in the risk stratification of prostate cancer patients in terms of selecting the optimal treatment in clinical practice. Yet, index lesion size, an mp-MRI parameter, is not included in the risk stratification. Some studies reported that tumor volume, another MRI parameter, has shown promising results over pathological tumor volume, with its relatively high correlation and low interobserver variability. However, other studies had reported that tumor volume showed poor correlation, mainly when only T2WI was used. Therefore, it has been speculated that tumor volume measurement in T2WI and DWI sequences can give results close to tumor volume in pathological preparations (4).

Since T1 tumors were not visible on MRI, we did not include them in our study. Nonetheless, another critical prognostic MRI finding is simply whether a lesion is visible or not. As a reason, visible lesions have been reported to increase the risk of developing metastases and death from prostate cancer more than tenfold compared to invisible lesions (15).

Our study revealed a positive correlation between capsule contact length and recurrent disease, with patients experiencing recurrence having significantly longer contact lengths. In addition, we also found pelvic lymphadenopathy, ECE, and seminal vesicle invasion to be significantly higher in cases with high capsule contact length. It has been shown in the literature that the tumor-to-capsule contact length on MRI is a strong predictor of ECE, with good to excellent interobserver agreement (16). A major challenge in diagnosing extracapsular extension (ECE) of prostate cancer lies in the subjective visual assessment of MRI findings by radiologists, leading to potential variability between examiners with different levels of experience. Capsule contact length, however, presents a unique opportunity for objective evaluation. It is currently the only known measurable and reproducible determinant for ECE. Despite its promise, there is a lack of standardized methods for measuring tumor contact surface. Studies have employed different approaches, including straight and curvilinear measurements. According to Eurboonyan et al. (17), measuring the total length of tumor-capsule contact along the longitudinal axis (absolute tumor-capsule contact length) provides a more accurate estimate of extra prostatic extension (ECE) compared to the curvilinear measurement. In addition, they found that the capsule contact length values above the 15 mm cut-off value, which they measured in dynamic contrast series, were highly correlated with the presence of ECE (17). While the American College of Radiology (ACR) recommends a 10mm contact surface as an indicator of ECE in their PI-RADS v2 guidelines, several studies have proposed or utilized higher cut-off values, ranging from 11mm to 20mm (17).

Due to ECE, patients experience a higher risk of lymph node or bone metastasis, tumor

recurrence after treatments like radical prostatectomy or radiation therapy, often requiring adjuvant therapy (18). Hricaket al (19), described asymmetry of the neurovascular bundle, tumor occlusion of the neurovascular bundle, a swollen prostate contour, obliteration of an irregular or prickly capsular margin, and the rectal-prostatic angle, capsular retraction, tumor capsule contact surface greater than 1 cm, and findings indicating direct tumor spread and a tear in the capsule on T2-weighted imaging as imaging findings associated with EPE. However, there are discrepancies between the results of various mp-MRI prostate cancer staging studies, which feature a wide range of sensitivity (23%-90%) and specificity (30%-95%) (18).

In our study, the absence of extra prostatic invasion was associated with stable disease status, in line with the literature findings. However, the inability to distinguish focal or non-focal spread in EPE by imaging causes diagnostic and prognostic uncertainty. The definition of ECE is also unclear in pathology. Various clinical variables, including the surgical procedure, the pericapsular environment, and the lack of guidelines for a true capsular space, can complicate determining the presence or extent of ECE (20). However, pretreatment diagnosis of ECE, which cannot be detected even during the surgery, is essential in planning the surgery and RT. Then again, ECE is often microscopic and is, therefore, below the detection threshold of mp-MRI.

Beyond the conventional MRI findings, our study demonstrated that quantitative parameters derived from mp-MRI, specifically the index lesion diameter and capsule contact length, can serve as objective imaging biomarkers for risk stratification. While both parameters showed significant predictive value for recurrence, capsule contact length emerged as a particularly robust predictor with superior diagnostic accuracy. This finding aligns with previous studies suggesting that tumor-capsule contact measurements might better reflect the biological aggressiveness of prostate cancer compared to simple size measurements alone. The higher specificity of capsule contact length in predicting recurrence suggests its potential utility in identifying patients who might benefit from more aggressive treatment approaches. Notably, our identified cut-off values for both parameters demonstrated practical clinical utility, with capsule contact length showing particular promise in risk stratification. These quantitative thresholds could potentially complement existing risk assessment tools, although prospective validation in larger cohorts would be valuable. The stronger predictive performance of capsule contact length compared to index lesion diameter might be explained by its direct relationship with tumor-capsule interaction, which is a critical determinant of local invasion potential. These findings support the integration of these quantitative mp-MRI parameters into clinical decision-making algorithms, particularly when determining treatment intensity and follow-up protocols.

The most important limitation of our study is that the biopsies were performed as transrectal ultrasound scan (TRUS)-guided biopsies, making it challenging to identify the patients who could be upgraded after surgery. For this reason, the decision for the biopsy site was made jointly together with the physicians who will perform the biopsy based on MRI images. Nonetheless, further prospective studies with MRI-guided fusion biopsies are needed to shed more light on the subject. The second limitation of our study is the short follow-up time after treatment and the fact that the small number of patients with recurrence might have provided limited data in predicting biochemical recurrence after treatment. Furthermore, the small number of patients in subgroups with different treatment options and the heterogeneity of patient characteristics resulted in a quite unbalanced dataset. Indeed, the relatively small dataset size was primarily due to the study design and inclusion criteria, which only included lesions visible on MRI. A further limitation of this research, especially in relation to biochemical and local recurrence, is the insufficient detail provided concerning the surgical interventions and radiation therapy regimens administered to the respective patient groups. Although this study's findings indicate that mp-MRI can play an active role in predicting early recurrence and selecting treatment. However, prospective studies with longer follow-up periods are needed.

CONCLUSION

In conclusion, mp-MRI has a high sensitivity in detecting clinically significant prostate cancer. This study's findings indicate that mp-MRI can be used for risk stratification and making risk-based treatment decisions in localized prostate cancer patients. Additionally, it was determined that high index lesion size, capsule contact length, and low ADC values predict poor prognosis, indicating the need for more aggressive treatments.

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