VILNIUS UNIVERSITY
FACULTY OF MEDICINE

Medicine

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INTEGRATED STUDY MASTER´S THESIS

Comparing Biparametric to Multiparametric Magnetic Resonance of Prostate Cancer Diagnosis

Biparametrinio ir daugiaparametrinio magnetinio rezonanso palyginimas prostatos vėžio diagnostikoje

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Vilnius, 2026

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ABSTRACT (ENGLISH)

Background: Multiparametric magnetic resonance imaging (mpMRI) has become a central component of the pre-biopsy diagnostic pathway in prostate cancer. Biparametric MRI (bpMRI), which omits the dynamic contrast-enhanced (DCE) sequence, has been proposed as a faster and less costly alternative.

Aim: To review current evidence regarding biparametric and multiparametric MRI in prostate cancer diagnosis and to explore associations between MRI-derived clinical variables and pathological outcomes in a small retrospective cohort.

Methods: A literature review was conducted focusing on prostate MRI, PI-RADS, csPCa, and the diagnostic role of dynamic contrast enhancement. In addition, retrospective analysis of 12 biopsy-proven prostate cancer cases was performed. Associations between PI-RADS score, Grade Group, ADC values, lesion size, and PSA density were analysed descriptively and exploratively.

Results: PI-RADS 5 lesions were significantly larger than PI-RADS 4 lesions. A non-significant trend toward lower ADC values was observed in higher PI-RADS categories ($p = 0.073$). No statistically significant association was found between PI-RADS score and Grade Group or between PSA density and tumour grade.

Conclusions: Current literature suggests comparable diagnostic performance of bpMRI and mpMRI for detection of csPCa in selected settings. In this cohort, MRI-derived variables showed limited but clinically plausible associations with pathological findings. Larger prospective studies are needed.

SANTRAUKA (LITHUANIAN)

Įvadas:

Daugiaparametrinis magnetinio rezonanso tyrimas (mpMRI) tapo svarbia prostatos vėžio diagnostikos dalimi. Biparametrinis magnetinio rezonanso tyrimas (bpMRI), neatliekant dinaminio kontrastinio sustiprinimo, siūlomas kaip greitesnė ir ekonomiškesnė alternatyva.

Tikslas:

Apžvelgti esamus mokslinius duomenis apie biparametrinio ir daugiaparametrinio magnetinio rezonanso vaidmenį prostatos vėžio diagnostikoje bei ištirti ryšius tarp MRT pagrįstų klinikinių rodiklių ir patologinių rezultatų mažoje retrospektyvinėje pacientų grupėje.

Metodai:

Atlikta literatūros analizė, orientuota į prostatos MRT, PI-RADS sistemą, kliniškai reikšmingą prostatos vėžį ir dinaminio kontrastinio sustiprinimo diagnostinę reikšmę. Papildomai retrospektyviai išanalizuota 12 biopsija patvirtintų prostatos vėžio atvejų. Aprašomuoju ir eksploraciniu būdu vertintos sąsajos tarp PI-RADS skalės, Gleason'o balų, ADC reikšmių, židinio dydžio ir PSA tankio.

Rezultatai:

PI-RADS 5 kategorijos židiniai buvo statistiškai reikšmingai didesni nei PI-RADS 4 kategorijos židiniai. Nustatyta statistiškai nereikšminga mažesnių ADC reikšmių tendencija aukštesnėse PI-RADS kategorijose ($p = 0,073$). Statistiškai reikšmingo ryšio tarp PI-RADS skalės ir Gleason'o balų bei tarp PSA tankio ir naviko laipsnio nenustatyta.

Išvados:

Esama literatūra rodo panašų bpMRI ir mpMRI diagnostinį efektyvumą nustatant kliniškai reikšmingą prostatos vėžį tam tikrose klinikinėse situacijose. Šioje mažoje pacientų grupėje MRT pagrįsti rodikliai parodė ribotas, tačiau kliniškai logiškas sąsajas su patologiniais radiniais. Reikalingi didesni perspektyviniai tyrimai.

Raktažodžiai:

prostatos vėžys, biparametrinis MRT, daugiaparametrinis MRT, PI-RADS, ADC, kliniškai reikšmingas prostatos vėžys

ABBREVIATIONS

ADC – Apparent Diffusion Coefficient

bpMRI – Biparametric Magnetic Resonance Imaging

csPCa – Clinically Significant Prostate Cancer

DCE – Dynamic Contrast-Enhanced Imaging

DRE – Digital Rectal Examination

DWI – Diffusion-Weighted Imaging

GG – Grade Group

MRI – Magnetic Resonance Imaging

mpMRI – Multiparametric Magnetic Resonance Imaging

PCa – Prostate Cancer

PI-RADS – Prostate Imaging Reporting and Data System

PSA – Prostate-Specific Antigen

PZ – Peripheral Zone

SD – Standard Deviation

TZ – Transition Zone

T2WI – T2-Weighted Imaging

TRUS – Transrectal Ultrasound

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1. INTRODUCTION

1.1 BACKGROUND AND CLINICAL RELEVANCE OF PROSTATE CANCER

Prostate cancer (PCa) is the second most frequently diagnosed malignancy in men globally and remains a leading cause of cancer-related mortality. In Europe, it is the most commonly diagnosed male cancer and represents a relevant public health burden (1,2).

The disease shows a broad biological spectrum. Some tumors grow slowly and remain indolent for years. Others behave aggressively and may progress beyond the prostate. This variation makes risk stratification essential. The main diagnostic challenge is to distinguish harmless disease from tumors that require treatment. In current practice, csPCa is usually defined as Grade Group 2 or higher (2).

This distinction has direct consequences for patient care. Detection of low-risk tumors may lead to unnecessary biopsy, anxiety, and overtreatment. In contrast, delayed recognition of aggressive disease may reduce the chance of timely intervention. The goal of modern diagnostics is therefore selective detection. Relevant cancer should be found early, while clinically insignificant lesions should not trigger avoidable procedures (2,3).

Conventional diagnostic tools have important limitations. Prostate-specific antigen (PSA) is widely used, but it is not specific for cancer. Increased PSA levels may also occur in benign prostatic hyperplasia, prostatitis, or other non-malignant conditions. Digital rectal examination has limited sensitivity, in particular for anteriorly located or small lesions. Systematic biopsy also has weaknesses. Significant lesions may be missed, whereas small low-grade tumors may be sampled despite limited clinical relevance (2,4).

Because of these shortcomings, magnetic resonance imaging has gained a central role in the diagnostic pathway of suspected PCa. MRI improves lesion detection and supports clinical risk assessment. It also helps guide targeted biopsy. In recent years, multiparametric MRI (mpMRI) has become the established imaging approach in many settings. At the same time, biparametric MRI (bpMRI) has emerged as a simpler alternative. It avoids contrast administration, shortens scan time, and may reduce cost. This has led to ongoing debate about whether bpMRI can offer diagnostic performance similar to mpMRI in selected patients (3–10).

1.2 ROLE OF MRI IN PROSTATE CANCER DIAGNOSIS

Magnetic resonance imaging has become a key part of the modern diagnostic pathway in suspected prostate cancer. It offers better soft tissue contrast than ultrasound and improves visualization of suspicious intraprostatic lesions. MRI also supports lesion localization, risk stratification and biopsy planning. For these reasons, it is now widely used before biopsy in men with clinical suspicion of prostate cancer (2,3,8).

The main clinical value of MRI lies in its ability to improve detection of clinically significant disease. The integration of pre-biopsy MRI into the diagnostic pathway was strongly influenced by the landmark PROMIS and PRECISION trials. PROMIS reported a sensitivity of 93% for mpMRI in detecting csPCa, compared with 48% for transrectal ultrasound-guided biopsy, and suggested that approximately 27% of men could potentially avoid biopsy if a triage MRI strategy were used (11). The PRECISION trial subsequently showed that MRI-targeted biopsy detected clinically significant cancer in 38% of men compared with 26% in the standard biopsy group, while reducing detection of clinically insignificant cancer (9% vs. 22%) (12). At the same time, it can reduce unnecessary biopsy in men with low-suspicion findings. This is important because traditional systematic biopsy may miss relevant tumors and may also detect lesions of limited biological importance. MRI therefore helps shift diagnostics toward a more targeted and clinically relevant approach (2–4).

The standard imaging approach in many centres is multiparametric MRI. This protocol combines T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced imaging. Each sequence contributes different information. T2-weighted imaging provides anatomical detail. Diffusion-weighted imaging reflects tissue cellularity and and plays a central role for lesion detection. Dynamic contrast-enhanced imaging gives additional information on vascular enhancement and may help in selected equivocal cases (4,6,13).

MRI findings are usually interpreted within the PI-RADS framework. This system standardizes lesion assessment and improves communication between radiologists and urologists. It also supports decisions about targeted biopsy and further management. Within PI-RADS, diffusion-weighted imaging has a dominant role in the peripheral zone, while T2-weighted imaging is dominant in the transition zone. The contribution of DCE is more limited, but it still remains part of the standard mpMRI protocol in current recommendations (2,4,13).

In recent years, interest has increased in biparametric MRI as a simplified alternative. bpMRI omits the contrast-enhanced sequence and relies mainly on T2-weighted and diffusion-weighted imaging. This reduces scan time, lowers cost, and avoids contrast-related risks. Several studies suggest that this abbreviated protocol may achieve comparable diagnostic performance in selected patient groups, in particular for the detection of clinically significant cancer. However, the role of DCE remains debated, and mpMRI is still commonly preferred when lesion characterization is uncertain or when more detailed local assessment is needed (3–9,14).

1.3 BIPARAMETRIC VERSUS MULTIPARAMETRIC MRI

The main difference between biparametric MRI and multiparametric MRI is the imaging protocol. mpMRI includes T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced imaging. In contrast, bpMRI uses only T2-weighted and diffusion-weighted sequences and omits contrast administration (2,6,13,14).

This technical difference has practical consequences. bpMRI is shorter, less expensive, and does not require gadolinium-based contrast agents. This may improve patient comfort and workflow efficiency. It also avoids potential contrast-related adverse effects. These aspects have made bpMRI increasingly attractive, above all in the initial assessment of men with suspected prostate cancer (3,5,7,8,14).

Several studies suggest that bpMRI and mpMRI have similar diagnostic performance for the detection of csPCa. This has been shown in retrospective studies, prospective cohorts, and meta-analyses. In many settings, omission of DCE does not appear to cause a major loss in overall diagnostic accuracy. This is relevant because diffusion-weighted imaging has a dominant role in lesion detection, in particular in the peripheral zone (3,5–10).

At the same time, the role of DCE has not become irrelevant. Current guidelines still recommend mpMRI as the standard prostate MRI protocol. Within PI-RADS, DCE has a secondary but defined function. It may help in equivocal lesions in the peripheral zone. It can also contribute in selected cases when lesion characterization is uncertain or when a more complete local assessment is needed. For this reason, the omission of DCE remains a matter of debate rather than a fully settled issue (2,4,8,13,14).

The current evidence therefore supports a balanced view. bpMRI appears to be a reliable and efficient option in selected diagnostic settings. This holds when the main question is lesion detection or exclusion of clinically significant disease. However, mpMRI still offers the most complete imaging assessment and remains the preferred approach when higher diagnostic confidence or more detailed local characterization is required (2,4,5,8,9,14).

1.4 AIM OF THE STUDY AND RESEARCH QUESTIONS

The overall aim of this thesis is to review current evidence regarding biparametric and multiparametric MRI in prostate cancer diagnosis and to explore associations between MRI-derived clinical variables and histopathological findings in a small retrospective cohort. A central question is whether omission of the dynamic contrast-enhanced sequence still allows reliable identification of clinically significant disease in selected patients.

The first part of the thesis is a literature review. It summarizes the current evidence on prostate MRI, PI-RADS, csPCa, and the diagnostic performance of bpMRI compared with mpMRI. It also addresses the debated role of dynamic contrast-enhanced imaging in prostate MRI protocols.

The second part of the thesis is based on a small retrospective clinical cohort. It explores the relationship between MRI findings and histopathological results in patients with biopsy-proven prostate cancer. The analysis focuses on clinical mpMRI findings, lesion size, ADC minimum, PSA, PSA density, and Gleason score. Because of the small sample size, this analysis is descriptive and exploratory.

A further question is which imaging-derived variables show the clearest association with histopathological tumor grade in the available cohort.

The working hypothesis is that bpMRI provides similar diagnostic performance to mpMRI in many clinical settings, in particular for the detection of clinically significant lesions. However, mpMRI may still offer advantages in selected equivocal or more complex cases, where the additional information from DCE can remain useful.

Given the retrospective nature and small sample size of the available dataset, the cohort analysis is explicitly designed as illustrative and exploratory, and does not constitute a formal diagnostic accuracy comparison between bpMRI and mpMRI.

1.5 STRUCTURE OF THE THESIS

This thesis is divided into two main parts. The first part is a literature review. It provides the theoretical and clinical background of prostate cancer diagnosis. It also summarizes the current evidence on prostate MRI, PI-RADS, csPCa, and the diagnostic role of bpMRI and mpMRI.

The thesis begins with an introduction. This section outlines the clinical relevance of prostate cancer and the growing importance of MRI in the diagnostic pathway. It also introduces the main differences between biparametric and multiparametric MRI and defines the aim of the study.

The second chapter presents the theoretical background and literature review. It describes the diagnostic pathway in suspected prostate cancer and explains the principles of prostate MRI. Particular attention is given to T2-weighted imaging, diffusion-weighted imaging, apparent diffusion coefficient values, dynamic contrast-enhanced imaging, and the PI-RADS system. This chapter also reviews the current literature comparing bpMRI and mpMRI.

The third chapter describes the materials and methods of the original analysis. It explains the study design, patient selection, available imaging and clinical variables, histopathological reference standard, and statistical approach. Because the clinical cohort is small, the analysis is primarily descriptive and exploratory.

The fourth chapter presents the results of the cohort analysis. It includes the baseline characteristics of the included patients, the distribution of PI-RADS categories and Gleason scores, and the association between imaging findings and histopathological results. It also reports exploratory analyses of lesion size, ADC minimum, PSA, and PSA density.

The fifth chapter discusses the main findings. It places the results in the context of the published literature and examines their possible clinical relevance. This chapter also addresses the strengths and limitations of the study and outlines implications for future research.

The thesis ends with a conclusion. This final chapter summarizes the most important findings and provides a brief outlook on the role of simplified MRI protocols in prostate cancer diagnostics.

2. THEORETICAL BACKGROUND AND LITERATURE REVIEV

2.1 DIAGNOSTIC PATHWAY IN SUSPECTED PROSTATE CANCER

The diagnostic work-up in suspected prostate cancer usually begins with clinical assessment and laboratory testing. The most common initial tools are prostate-specific antigen (PSA) testing and digital rectal examination. Both methods are widely used in routine practice. However, neither is sufficiently accurate on its own. PSA is organ-specific, but not cancer-specific. Elevated values may also occur in benign prostatic hyperplasia, prostatitis, or other non-malignant conditions. Digital rectal examination may detect palpable abnormalities, but its sensitivity is limited in small or non-palpable tumors (2).

For many years, systematic transrectal ultrasound-guided biopsy was the standard next step in men with persistent suspicion of malignancy. This approach remains important, but it has clear limitations. Ultrasound has limited ability to visualize many prostate tumors directly. As a result, systematic biopsy may miss clinically significant lesions. At the same time, it may detect small low-grade tumors with limited biological relevance. This contributes to both underdiagnosis of relevant disease and overdiagnosis of indolent cancer (2,3).

The introduction of prostate MRI has changed this pathway substantially. MRI is now used before biopsy in many men with clinical suspicion of prostate cancer. This so-called MRI pathway improves lesion detection and helps select patients for biopsy more accurately. Men with suspicious MRI findings can undergo targeted sampling of the most relevant lesion. In selected cases, men with non-suspicious findings may avoid immediate biopsy. This makes the diagnostic pathway more focused and clinically meaningful (2,7).

Targeted biopsy can be performed in different ways. These include cognitive targeting, MRI-ultrasound fusion-guided biopsy, and in-bore MRI-guided biopsy. All of these techniques aim to improve sampling of lesions identified on MRI. Compared with systematic biopsy alone, targeted biopsy improves the detection of csPCa and reduces the diagnosis of insignificant disease. This is one

of the main reasons why MRI now plays a central role in the modern diagnostic work-up of suspected prostate cancer (2,7,8).

Within this modern pathway, multiparametric MRI remains the established imaging standard. It combines anatomical and functional sequences and supports lesion localization, risk stratification, and biopsy planning. At the same time, biparametric MRI has gained increasing attention as a shorter and simpler alternative. By omitting contrast-enhanced imaging, bpMRI reduces scan time and avoids contrast administration. This has raised the question of whether a simplified protocol may be sufficient for many patients in the initial diagnostic setting (2,7,13).

2.1.1 PSA, DIGITAL RECTAL EXAMINATION, AND BIOPSY

The first step in the evaluation of suspected prostate cancer usually includes prostate-specific antigen testing and digital rectal examination. These two methods are well established in daily practice. They are easy to perform and widely available. However, both have important limitations (2).

PSA is one of the most commonly used markers in prostate cancer diagnostics. Its main advantage is its sensitivity for prostatic pathology. However, PSA is not specific for malignancy. Elevated values may also be seen in benign prostatic hyperplasia, prostatitis, urinary retention, or after prostatic manipulation. For this reason, PSA alone cannot reliably distinguish between malignant and benign conditions. It should always be interpreted in the clinical context (2).

Digital rectal examination remains part of the standard clinical assessment. It may reveal nodules, induration, or asymmetry of the gland. These findings can increase the suspicion of malignancy. Nevertheless, its diagnostic performance is limited. Small lesions and non-palpable tumors may easily be missed. The method is therefore useful, but insufficient as a stand-alone tool (2).

If clinical suspicion persists, histological confirmation is required. For many years, systematic transrectal ultrasound-guided biopsy was the standard method for tissue sampling. Usually, multiple cores are taken from predefined regions of the prostate. This approach is still used, but it has clear weaknesses. Because tumor sampling is partly random, clinically significant lesions may be missed. At the same time, low-grade tumors with limited biological relevance may be detected. This may result in both underdiagnosis of aggressive disease and overdiagnosis of indolent cancer (2,3).

Systematic biopsy is also associated with procedure-related morbidity. Possible complications include bleeding, pain, urinary infection, and sepsis. These limitations have contributed to the development of more targeted diagnostic strategies. In particular, MRI has improved the selection of men for biopsy and the localization of suspicious lesions before sampling. This has changed the role of biopsy from a mainly systematic procedure toward a more imaging-guided approach (2,8).

2.1.2 MRI-TARGETED BIOPSY AND CURRENT DIAGNOSTIC STRATEGIES

The use of MRI has changed the diagnostic approach in suspected prostate cancer. In many centres, MRI is now performed before biopsy. This pre-biopsy strategy improves lesion detection and helps identify men who are more likely to have clinically significant disease. It also supports a more selective use of biopsy and reduces purely random sampling (2,3,8).

MRI-targeted biopsy is based on the identification of suspicious lesions on prostate MRI. These lesions can then be sampled more precisely than with systematic biopsy alone. Different techniques are available. These include cognitive targeting, MRI-ultrasound fusion-guided biopsy, and in-bore MRI-guided biopsy. All of these approaches aim to improve sampling of the most relevant lesion within the gland (2,8).

Compared with systematic biopsy alone, MRI-targeted biopsy improves the detection of csPCa. At the same time, it reduces the diagnosis of insignificant disease. This is one of the main advantages of the modern MRI-based pathway. It shifts the diagnostic focus toward lesions that are more likely to be biologically important and clinically relevant (2,3).

Another important aspect is patient selection. Men with low-suspicion or non-suspicious MRI findings may, in selected cases, avoid immediate biopsy. This can reduce unnecessary invasive procedures and their associated complications. On the other hand, men with suspicious lesions on MRI can undergo targeted sampling with a higher likelihood of detecting significant cancer. This makes the overall diagnostic pathway more efficient and more individualized (2,8).

Current diagnostic strategies therefore increasingly combine clinical parameters, MRI findings, and histopathological verification. Within this pathway, MRI is not only an imaging test. It has become a decision-making tool that influences whether biopsy is performed, how biopsy is performed, and which lesion is sampled. This development is central to the current debate on the role of bpMRI and mpMRI in routine prostate cancer diagnostics (2,3,8).

Detection of clinically significant prostate cancer (ISUP GG 2 and higher)					
		PSA-density risk groups			
PI-RADS risk categories	Prevalence ISUP ≥ 2 PCa	Low < 0.10	Intermediate-low 0.10–015	Intermediate-high 0.15–0.20	High ≥ 0.20
		31% (678/2199)	28% (612/2199)	16% (360/2199)	25% (553/2199)
Compiled totals of csPCa risk					
PI-RADS 1–2	6% (48/839)	3% (11/411)	7% (17/256)	8% (8/104)	18% (12/68)
PI-RADS 3	16% (41/254)	4% (3/74)	13% (11/88)	29% (12/41)	29% (15/51)
PI-RADS 4–5	62% (687/1106)	31% (59/189)	54% (144/286)	69% (148/215)	77% (336/434)
All PI-RADS	35% (776/2199)	11% (73/674)	28% (172/612)	47% (168/360)	66% (363/553)

Table 1. Risk-adapted biopsy decision matrix based on PI-RADS category and PSA density
Abbreviations: PI-RADS, Prostate Imaging Reporting and Data System; PSA, prostate-specific antigen; csPCa, clinically significant prostate cancer; ISUP GG, International Society of Urological Pathology Grade Group; PCa, prostate cancer. Darker shading indicates a higher estimated probability of csPCa. The table illustrates how the risk of csPCa increases with both higher PI-RADS category and higher PSA density. Adapted from the EAU Guidelines 2025.

2.2 PRINCIPLES OF PROSTATE MRI

Magnetic resonance imaging has become a central tool in the diagnosis of prostate cancer. Its main advantage is its high soft tissue contrast. This allows a much better visualization of the prostate than ultrasound. MRI can identify suspicious lesions, assess their location, and estimate their biological relevance more accurately than traditional imaging alone (2,13).

A further strength of MRI is its role in the detection of clinically significant disease. The method does not only show anatomy. It also provides functional information. This is important in prostate cancer, because lesion appearance, diffusion restriction, and enhancement behavior may help distinguish aggressive tumors from less relevant findings. MRI therefore supports both lesion detection and clinical risk assessment (2,13,14).

In current practice, MRI is mainly used before biopsy in men with suspected prostate cancer. It helps identify suspicious targets and improves biopsy planning. At the same time, a low-suspicion examination may reduce the need for immediate invasive sampling in selected patients. This has made MRI an important part of the modern diagnostic pathway rather than only a supplementary imaging test (2,7).

The established standard protocol is multiparametric MRI. It combines T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced imaging. These sequences provide

complementary information. T2-weighted imaging mainly reflects anatomy. Diffusion-weighted imaging and ADC maps reflect tissue cellularity. Dynamic contrast-enhanced imaging gives additional information on vascular behavior. Together, these sequences form the basis of structured prostate MRI interpretation (2,13,14).

MRI findings are commonly interpreted using the PI-RADS system. This framework standardizes lesion assessment and improves communication between radiologists and urologists. It also helps determine which lesions should be targeted during biopsy. Within this system, different sequences have different weight depending on lesion location. This makes MRI interpretation structured, but also technically demanding. Good image quality and appropriate reading experience remain essential for reliable results (2,14).

Because MRI now has such an important role, simplified protocols have also gained attention. In particular, biparametric MRI has been proposed as a shorter alternative to the standard multiparametric protocol. The main question is whether omission of the contrast-enhanced sequence leads to relevant diagnostic loss. This issue is examined in more detail in the following sections (2,7,13,14).

2.2.1 T2-WEIGHTED IMAGING

T2-weighted imaging is a core sequence in prostate MRI. It provides high-resolution anatomical information and allows detailed assessment of the zonal anatomy of the gland. This is important because prostate cancer does not arise uniformly throughout the prostate. Clear visualization of the peripheral zone, transition zone, capsule, and adjacent structures is essential for accurate lesion localization and local assessment (2,14).

On T2-weighted images, the normal peripheral zone usually appears with high signal intensity. Suspicious lesions often appear as focal low-signal areas. However, this finding is not specific for malignancy. Similar appearances may also be seen in prostatitis, fibrosis, post-biopsy change, or other benign conditions. T2-weighted imaging is therefore important, but it cannot reliably characterize a lesion on its own (13,14).

The role of T2-weighted imaging is important in the transition zone. Within the PI-RADS framework, this is the dominant sequence for transition zone lesions. It helps assess lesion margins, shape, homogeneity, and relation to benign prostatic hyperplasia nodules. In this region, careful morphological assessment is essential, because lesion interpretation may be more difficult than in the peripheral zone (2,13,14).

T2-weighted imaging also contributes to local staging. It helps evaluate the capsule, seminal vesicles, and possible extraprostatic extension. This is relevant for treatment planning, in particular in patients with more suspicious or larger lesions. Although functional sequences are crucial for lesion detection,

T2-weighted imaging remains indispensable for anatomical interpretation and structured reporting (2,14).

For these reasons, T2-weighted imaging is included in both mpMRI and bpMRI protocols. Even in simplified MRI approaches, this sequence remains essential. It forms the anatomical basis of prostate MRI and supports lesion localization, zonal classification, and morphological assessment (10,14).

2.2.2 DIFFUSION-WEIGHTED IMAGING AND ADC

Diffusion-weighted imaging is one of the most important sequences in prostate MRI. It provides functional information about the movement of water molecules within tissue. In malignant tissue, water diffusion is more restricted because of increased tissue cellularity, reduced extracellular space and disrupted glandular architecture. As a result, suspicious lesions usually appear hyperintense on high b-value images and hypointense on ADC maps (2,14).

This sequence plays a dominant role in the detection of lesions in the peripheral zone. Within the PI-RADS framework, DWI is the key sequence for lesion assessment in this region. It is therefore central to both lesion detection and risk stratification. Strong diffusion restriction generally increases the suspicion of clinically significant disease (2,6,14).

The apparent diffusion coefficient is derived from diffusion-weighted imaging and provides a quantitative estimate of diffusion restriction. Lower ADC values are generally associated with higher tissue cellularity and more aggressive tumor features. They also represents an established semi-quantitative imaging marker of tumour aggressiveness, although thresholds remain variable across institutions and scanners. Several studies have reported an inverse relationship between ADC values and csPCa or higher histopathological grade (6,9,14).

Despite its importance, diffusion-weighted imaging also has limitations. Image quality may be affected by motion, susceptibility artifacts, rectal gas, or technical factors. In addition, ADC values are influenced by acquisition parameters and region-of-interest placement. This means that quantitative diffusion analysis must be interpreted with care, above all when comparing findings across different scanners or study designs (2,4).

Even with these limitations, DWI and ADC remain indispensable in prostate MRI. They are included in both mpMRI and bpMRI protocols. In fact, the increasing interest in bpMRI is largely based on the strong diagnostic contribution of diffusion-weighted imaging. This sequence provides much of the functional information needed for lesion detection, in particular when combined with anatomical assessment on T2-weighted imaging (6,9,14).

2.2.3 DYNAMIC CONTRAST-ENHANCED IMAGING

Dynamic contrast-enhanced imaging is the third main component of multiparametric prostate MRI. It is performed after intravenous administration of gadolinium-based contrast medium. The sequence evaluates the vascular behavior of a lesion over time. Malignant tissue typically shows early arterial enhancement and washout, reflecting tumour-associated neoangiogenesis with increased microvascular density and abnormal vessel permeability (2,14).

The role of DCE in prostate MRI is more limited than that of T2-weighted imaging and diffusion-weighted imaging. Within the PI-RADS framework, DCE has a secondary function. It is mainly used in the peripheral zone, where positive enhancement may support upgrading an equivocal lesion. For this reason, DCE may be useful in selected cases, but it is not the dominant sequence for general lesion detection (2,13,14).

This has led to an ongoing debate about its real diagnostic value. Several studies suggest that omission of DCE does not substantially reduce overall diagnostic performance, not least for the detection of clinically significant cancer. This is a major argument in favor of bpMRI (7,9,13,14).

DCE also has practical disadvantages. It increases examination time and cost. In addition, it requires intravenous contrast administration. This introduces potential risks such as allergic reactions and concerns related to gadolinium exposure. Although severe adverse effects are uncommon, these issues become important when patients require repeated imaging(7,14).

Overall, DCE remains part of the standard mpMRI protocol. However, its contribution is more selective than fundamental. The current literature does not support the view that DCE is always essential for every patient. Instead, its value appears to depend on the clinical question, lesion characteristics, and the required level of diagnostic confidence. This is why DCE remains central to the discussion about whether bpMRI can replace mpMRI in selected diagnostic settings (2,7,14).

2.2.4 PI-RADS AND STANDARDIZED MRI REPORTING

The Prostate Imaging Reporting and Data System (PI-RADS), currently in version 2.1 (2019), was developed to standardise the acquisition, interpretation and reporting of prostate MRI. Its main goal is to reduce variability between readers and to improve communication between radiologists and clinicians. Standardized reporting is important because prostate MRI findings directly influence biopsy decisions and further patient management (2,14,15).

PI-RADS uses a five-point scoring system. A score of 1 indicates that clinically significant cancer is highly unlikely. A score of 5 indicates that clinically significant cancer is highly likely. Scores 2, 3, and 4 represent increasing levels of suspicion between these two extremes. This structured system helps classify lesions according to the probability of clinically significant disease (2,14).

An important feature of PI-RADS is that it assigns different weight to different MRI sequences depending on lesion location. In the peripheral zone, diffusion-weighted imaging is the dominant sequence. In the transition zone, T2-weighted imaging is dominant. Dynamic contrast-enhanced imaging has a secondary role and is mainly used in selected equivocal peripheral zone lesions. This zonal approach makes the system more structured and clinically relevant (2,13,14).

PI-RADS has improved consistency in prostate MRI reporting, but it also has limitations. Some degree of interobserver variability remains. This issue is most apparent in category 3 lesions and in technically difficult examinations. Image quality, reader experience, and adherence to technical standards all influence diagnostic reliability. For this reason, structured reporting alone is not sufficient. It must be combined with adequate image acquisition and appropriate radiological expertise (2,4).

Despite these limitations, PI-RADS remains the standard framework for prostate MRI interpretation. It provides a common language for lesion assessment and supports more reproducible clinical decision-making. It is also of clear relevance to the present thesis, because both mpMRI and bpMRI are interpreted in relation to the same general principles of structured lesion evaluation and clinically significant cancer detection (2,13,14).

Feature	**Peripheral zone (PZ)**	**Transition zone (TZ)**
Dominant sequence	Diffusion-weighted imaging (DWI)	T2-weighted imaging (T2WI)
Main role of dominant sequence	Primary lesion detection and suspicion assessment	Primary morphological assessment and suspicion assessment
Supporting sequence	T2WI	DWI
Role of dynamic contrast-enhanced imaging (DCE)	Secondary role; may support upgrading of selected equivocal lesions	Limited role; not dominant for lesion scoring
Typical suspicious MRI features	Marked diffusion restriction, low ADC, focal abnormality	Homogeneous low T2 signal, ill-defined margins, lenticular or non-encapsulated appearance
PI-RADS score 1	Clinically significant cancer highly unlikely	

PI-RADS score 2	Low likelihood of clinically significant cancer
PI-RADS score 3	Intermediate / equivocal probability
PI-RADS score 4	High probability of clinically significant cancer
PI-RADS score 5	Very high probability of clinically significant cancer

Table 2. Dominant MRI sequences and structured PI-RADS assessment in prostate MRI (adapted from published PI-RADS reviews and guidelines).
Abbreviations: PI-RADS, Prostate Imaging Reporting and Data System; PZ, peripheral zone; TZ, transition zone; T2WI, T2-weighted imaging; DWI, diffusion-weighted imaging; ADC, apparent diffusion coefficient; DCE, dynamic contrast-enhanced imaging. Adapted from current PI-RADS-based literature and guideline summaries (15,16).

2.3 CLINICALLY SIGNIFICANT PROSTATE CANCER

The concept of csPCa is central to modern prostate cancer diagnostics. Not every detected tumor has the same biological relevance. Some lesions remain indolent and may never cause symptoms or affect survival. Others are associated with progression, metastasis, and cancer-related death. For this reason, current diagnostic strategies aim to identify tumors that are likely to require treatment while avoiding overdiagnosis of low-risk disease (2).

In clinical practice, csPCa is commonly defined by histopathological grade. A widely used threshold is Grade Group 2 or higher. This corresponds to tumors that contain Gleason pattern 4 and are therefore considered biologically more relevant than Grade Group 1 disease. This distinction is important because low-grade tumors are often suitable for active surveillance, whereas higher-grade lesions are more likely to require definitive treatment (2,9).

The distinction between clinically significant and insignificant disease also has direct implications for imaging. The main purpose of prostate MRI is not simply to detect any abnormality. Its main value lies in identifying lesions that are likely to represent clinically relevant cancer. This is why MRI studies, biopsy strategies, and reporting systems such as PI-RADS are mainly designed around the detection of significant disease rather than any prostate cancer (2,7,13).

This concept is also important in the comparison between biparametric and multiparametric MRI. Many studies show that the central question is not whether both methods detect every lesion equally. The more relevant issue is whether they detect csPCa with similar reliability. This explains why most comparative studies use Grade Group 2 or higher as their main endpoint (7,9,10,13).

For the present thesis, csPCa is therefore defined as Grade Group 2 or higher on biopsy. This definition follows the current literature and guideline-based clinical practice. It also provides the most appropriate histopathological reference point for interpreting MRI findings in the available cohort (2,9).

2.3.1 HISTOPATHOLOGICAL CLASSIFICATION

Histopathology remains the reference standard for the diagnosis of prostate cancer. Imaging can identify suspicious lesions and estimate the probability of malignancy, but final confirmation still requires tissue sampling. For this reason, biopsy findings remain essential for diagnosis, grading, and treatment planning (2).

The histopathological assessment of prostate cancer is based on glandular architecture. This evaluation reflects how much the tumor differs from normal prostatic tissue. A more disorganized structure usually indicates a more aggressive biological behavior. Histopathological classification therefore provides important prognostic information and remains central to risk stratification (2,9).

In routine practice, biopsy tissue is examined for the presence of carcinoma and then graded according to the Gleason system and the corresponding Grade Group classification. These systems help distinguish low-risk from more aggressive disease. They also provide the basis for defining csPCa in both clinical care and research studies (2).

Histopathological classification is also important when evaluating prostate MRI. The value of bpMRI and mpMRI is usually assessed by comparison with biopsy results. In most comparative studies, imaging findings are not judged only by whether cancer is present, but by whether clinically relevant histopathological disease is present. This is why histopathology is not only a confirmatory tool, but also the key endpoint in studies on prostate MRI performance (7,9,13).

For the present thesis, histopathological classification is used as the clinical outcome reference. The biopsy result forms the basis for classifying cases into lower-grade and clinically significant disease. This allows the MRI findings in the cohort to be interpreted in relation to tumor grade rather than simple cancer presence alone (2,9).

2.3.2 GLEASON SCORE AND GRADE GROUP

The Gleason score is the most established histopathological grading system in prostate cancer. It is based on the architectural growth pattern of the tumor. The pathologist identifies the two most relevant glandular patterns and combines them into one score. A higher score reflects a more disorganized structure and usually a more aggressive tumor biology (2).

In current clinical practice, the Grade Group system is used together with the Gleason score. This system was introduced to simplify prognostic classification and make reporting more clinically

intuitive. Grade Group 1 corresponds to Gleason score 6. Grade Group 2 usually corresponds to Gleason score 3+4=7. Higher Grade Groups reflect increasing histological aggressiveness and a less favorable prognosis (2).

This distinction has clear consequences for clinical management. Grade Group 1 disease is often considered low risk and may be managed with active surveillance in appropriate patients. In contrast, Grade Group 2 and higher are more likely to represent clinically significant cancer and may require active treatment. For this reason, many MRI studies use Grade Group 2 or higher as the main endpoint when evaluating diagnostic performance (2,9,10).

The relationship between MRI findings and Gleason grade is of particular interest. Lesions with higher PI-RADS scores, stronger diffusion restriction, and lower ADC values are often associated with higher tumor grade. However, this relationship is not perfect. Imaging can suggest aggressiveness, but it cannot replace histopathological grading. Final classification still depends on biopsy or surgical pathology (9,10,14).

In the present thesis, both Gleason score and Grade Group are relevant for interpretation of the cohort data. Since the available cases mainly fall into Gleason score 6 and 7 categories, these values form the basis for exploratory comparison with MRI-derived variables such as PI-RADS score, lesion size, ADC minimum, PSA, and PSA density. This allows the imaging findings to be interpreted in relation to histopathological tumor grade in a clinically meaningful way (2,9).

Grade Group	**Gleason score**	**General clinical interpretation**
Grade Group 1	Gleason score ≤ 6	Usually low-risk disease; often considered for active surveillance
Grade Group 2	Gleason score 3 + 4 = 7	Clinically significant disease
Grade Group 3	Gleason score 4 + 3 = 7	Clinically significant disease; more aggressive than Grade Group 2
Grade Group 4	Gleason score 8 (4 + 4, 3 + 5, or 5 + 3)	High-risk disease
Grade Group 5	Gleason score 9-10	Very high-risk disease

Table 3. Relationship between Gleason score, Grade Group, and clinical relevance in prostate cancer (adapted from published grading reviews and guidelines).

Grade Group 2 or higher is commonly used as the threshold for csPCa in clinical practice and MRI studies. Adapted from published histopathological grading reviews and guideline-based definitions (17,18).

2.3.3 DEFINITION AND CLINICAL RELEVANCE OF CLINICALLY SIGNIFICANT PROSTATE CANCER

The term clinically significant prostate cancer is used to distinguish tumours that are likely to affect prognosis from tumours with limited biological relevance. This distinction is a key concept in modern prostate cancer diagnostics. Not every detected lesion requires the same diagnostic or therapeutic response. Some tumours remain indolent for many years, while others are associated with progression, metastatic spread, and cancer-related death (2).

In contemporary studies and current clinical guidelines, clinically significant prostate cancer is most commonly defined as ISUP Grade Group ≥ 2, corresponding to a Gleason score of 3 + 4 = 7 or higher (2,17,18). This threshold reflects the presence of Gleason pattern 4, which is associated with a measurable risk of biochemical recurrence, metastatic progression, and prostate cancer-specific mortality (17,18). Although alternative definitions, such as combinations of Grade Group, lesion volume and PSA density, exist in some study settings, the histopathological criterion of ISUP Grade Group ≥ 2 remains the most widely used and clinically practical definition (2,7,9).

ISUP Grade Group 1 (Gleason 3 + 3 = 6) tumours are considered clinically insignificant in the strict histopathological sense and are eligible for active surveillance in most cases (2,17,18). However, Grade Group 1 disease is not entirely irrelevant clinically. Tumour volume, multifocality, PSA density, patient age, and the inherent risk of biopsy sampling error continue to influence individual risk assessment, and a subgroup of these tumours may harbour a higher-grade component that was missed on initial biopsy (2,18). Even patients with Grade Group 1 disease therefore require careful follow-up, and the term „clinically insignificant" should be understood in this nuanced sense rather than as a categorical exclusion of clinical relevance.

The distinction between clinically significant and clinically insignificant disease shapes both clinical management and imaging research. Grade Group ≥ 2 disease is more likely to require active treatment, while Grade Group 1 disease can often be managed conservatively. The concept also defines the main target for prostate MRI: the aim is not to detect any prostate cancer, but to identify lesions that are likely to represent clinically significant disease. For the same reason, Grade Group ≥ 2 is the standard endpoint in studies comparing diagnostic methods such as bpMRI and mpMRI (2,7,9,10).

In the present thesis, clinically significant prostate cancer is defined as Grade Group ≥ 2 on biopsy. This definition is consistent with current literature and provides the appropriate histopathological reference for interpretation of the cohort findings (2,9).

2.4 Biparametric versus Multiparametric MRI: Current Evidence

The comparison between biparametric MRI and multiparametric MRI has become an important topic in prostate cancer imaging. mpMRI is still the recommended standard in current guidelines. However, many studies have examined whether bpMRI can provide similar diagnostic performance in selected clinical settings. The main reason for this interest is practical. bpMRI is shorter, less expensive, and does not require contrast administration (2,7,14).

Several studies have shown that bpMRI and mpMRI achieve similar results for the detection of csPCa. This has been reported in retrospective studies, prospective studies, and meta-analyses. In particular, the omission of DCE often does not seem to cause a major loss in overall diagnostic accuracy. This is one of the strongest arguments in favor of bpMRI for the initial evaluation of men with suspected prostate cancer (6,7,9,10).

At the same time, the available evidence does not show that both methods are completely interchangeable in all situations. DCE may still add value in selected cases. This applies above all to equivocal lesions, difficult peripheral zone findings, and situations in which a more complete local assessment is needed. For this reason, the literature does not support a simple all-or-none conclusion. Instead, it suggests that the value of DCE depends on the clinical context and the diagnostic question (2,7,9,14).

Another important point is study design. Some published comparisons are retrospective and single-centre. Others use more robust paired designs. This means that results must be interpreted carefully. Even when the overall performance of bpMRI appears similar, differences in patient selection, lesion prevalence, biopsy strategy, and image quality may influence the findings. Therefore, current evidence supports bpMRI as a promising and often reliable alternative, but not as an unquestioned replacement for mpMRI in every clinical situation (6,7,10).

Overall, current evidence supports a balanced view. bpMRI appears sufficient in many diagnostic settings, in particular when the main aim is detection of clinically significant disease. However, mpMRI remains the more comprehensive examination and may still be preferred when diagnostic confidence must be maximized (2,7,14).

2.4.1 DIAGNOSTIC ACCURACY OF bpMRI

Biparametric MRI has been studied as a simplified alternative to the standard multiparametric protocol. Its main advantage is that it includes the two most important sequences for lesion detection, namely T2-weighted imaging and diffusion-weighted imaging, while omitting dynamic contrast-enhanced imaging. This shortens examination time, lowers cost, and avoids the need for contrast administration (7,8,14).

Several studies suggest that bpMRI has high diagnostic performance for the detection of csPCa. In the meta-analysis by Woo et al., the pooled sensitivity and specificity of bpMRI were similar to those of mpMRI, and MRI protocol itself was not a significant source of heterogeneity (7). Other comparative studies have also shown that bpMRI can achieve similar diagnostic accuracy where the main endpoint is clinically significant disease rather than overall cancer detection (6,9,14).

These findings carry particular weight in biopsy-naive patients and in initial diagnostic settings. In such situations, the main clinical aim is often to identify men with a high likelihood of clinically relevant cancer. In these settings, T2-weighted imaging and DWI may already provide the key diagnostic information (7,8,14).

However, the diagnostic value of bpMRI should not be overestimated. Its performance depends on image quality, reader experience, lesion location, and study design. In addition, some studies suggest that bpMRI may be less helpful in equivocal cases or when additional local characterization is needed. This means that high diagnostic accuracy in selected settings does not automatically imply universal equivalence to mpMRI (8,9,14).

Overall, the current evidence supports bpMRI as a reliable diagnostic method for the detection of csPCa in many patients. Its strongest role appears to be in situations where a fast, less invasive, and clinically efficient examination is needed. Nevertheless, its diagnostic accuracy must always be interpreted in relation to the clinical question and the limitations of the individual imaging setting (7,8,14).

2.4.2 DIAGNOSTIC ACCURACY OF mpMRI

Multiparametric MRI is currently the established standard protocol in prostate MRI. It combines T2-weighted imaging, diffusion-weighted imaging, and dynamic contrast-enhanced imaging. This combination provides both anatomical and functional information. For this reason, mpMRI is widely used for lesion detection, risk stratification, biopsy planning, and local assessment (2,14).

The diagnostic strength of mpMRI lies in its comprehensive approach. T2-weighted imaging allows anatomical assessment. Diffusion-weighted imaging provides information on tissue cellularity and is central to lesion detection. DCE may add supportive information in selected cases. Together, these sequences form the basis of structured lesion interpretation within the PI-RADS system (2,13,14).

Many studies have shown that mpMRI has high diagnostic performance for the detection of csPCa. This applies both to lesion-based and patient-based analyses. This is one reason why mpMRI remains the reference protocol in many comparative studies. In the current literature, mpMRI is generally considered highly accurate for identifying suspicious lesions that are more likely to represent clinically relevant disease (2,7,9).

At the same time, the diagnostic advantage of mpMRI over bpMRI is not always large. Several studies suggest that the overall difference may be small in many clinical settings. Nevertheless, mpMRI still offers the most complete examination. This may be important in equivocal lesions, technically difficult cases, or when additional local characterization is needed. Its value therefore lies not only in overall diagnostic accuracy, but also in broader clinical confidence and completeness of assessment (7,9,13,14).

Another relevant point is standardization. Current guidelines and PI-RADS recommendations are primarily based on mpMRI. This supports consistent reporting and structured clinical decision-making. Even if bpMRI may be sufficient in selected situations, mpMRI remains the protocol against which simplified approaches are usually measured. This is why it continues to serve as the reference standard in many diagnostic discussions (2,14).

Overall, mpMRI remains the most complete and widely accepted MRI protocol in prostate cancer diagnostics. Its high diagnostic performance and structured integration into current clinical practice explain why it is still considered the standard approach, even in the context of growing interest in simplified protocols (2,7,14).

2.4.3 POTENTIAL ADDED VALUE OF DCE

The possible added value of dynamic contrast-enhanced imaging remains one of the main points of debate in prostate MRI. DCE is included in the standard mpMRI protocol, but its diagnostic role is more limited than that of T2-weighted imaging and diffusion-weighted imaging. For this reason, many studies have asked whether the contrast-enhanced sequence truly changes clinical decision-making in a relevant number of cases (2,7,14).

One argument in favor of DCE is that it may help in equivocal lesions. Within the PI-RADS system, DCE has a secondary role, with its main use in the peripheral zone. In selected cases, positive enhancement may support lesion upgrading. This may improve confidence when diffusion findings are not fully decisive. DCE may also provide useful information in some technically difficult or clinically unclear cases (2,14).

However, many comparative studies have shown that omission of DCE does not substantially reduce the overall diagnostic performance of prostate MRI. This has been one of the strongest arguments for the use of bpMRI. Several authors conclude that T2-weighted imaging and DWI provide most of the

relevant diagnostic information, while DCE mainly adds support in a smaller subgroup of cases (6,7,9,14).

DCE also has disadvantages. It increases scan time and cost. It requires intravenous access and contrast administration. Although serious adverse effects are uncommon, the use of gadolinium-based contrast agents still introduces additional burden and potential risk. These practical issues weigh more heavily if the diagnostic benefit is only marginal in many routine cases (7,14).

Taken together, the literature suggests that DCE may add value, but not equally in all patients. Its contribution appears to be selective rather than universal. This explains why mpMRI remains the recommended standard, while bpMRI is increasingly considered a reasonable alternative in many diagnostic settings. The question is therefore not whether DCE has any value at all, but in which situations that value is clinically meaningful (2,7,14).

2.4.4 ADVANTAGES AND LIMITATIONS OF bpMRI AND mpMRI

Both bpMRI and mpMRI have strengths and limitations. The choice between them depends on the clinical setting, the diagnostic question, and the required level of certainty (2,7,14).

The main advantage of bpMRI is its simplicity. The examination is shorter, less expensive, and does not require intravenous contrast administration. This improves patient comfort and reduces practical burden. These aspects make bpMRI attractive in the initial evaluation of men with suspected prostate cancer and in settings where fast and accessible imaging is important (6,7,9,14).

A second strength of bpMRI is its diagnostic performance for clinically significant disease. Comparative studies and meta-analyses indicate that omission of DCE does not lead to a substantial reduction in the overall ability to detect Grade Group ≥ 2 cancer in biopsy-naive men, provided that DWI is of high technical quality (6,7,9,10).

bpMRI has limitations in specific clinical scenarios. It may be less reliable in equivocal PI-RADS 3 lesions in the peripheral zone, where DCE is part of the PI-RADS upgrading rule, and in examinations with technically limited DWI due to motion or susceptibility artefacts (4,14,15). bpMRI is also not considered sufficient for detailed local assessment, including the evaluation of extracapsular extension, seminal vesicle invasion, or post-treatment changes, where mpMRI remains preferable (2,14).

The main advantage of mpMRI is its completeness. It combines anatomical and functional sequences and remains the standard protocol in current guidelines. This gives it a strong role in structured reporting, lesion characterisation, biopsy planning, and local assessment. mpMRI may therefore offer greater diagnostic confidence in more complex or uncertain cases (2,7,14).

The disadvantages of mpMRI relate to time, cost, and contrast administration. These factors may limit efficiency and accessibility in routine practice. If the added diagnostic contribution of DCE is small

in many cases, the practical burden of the full mpMRI protocol becomes a relevant trade-off, which is one of the main reasons why simplified MRI protocols continue to attract interest (7,14).

Overall, bpMRI provides a practical and reliable alternative for the initial detection of clinically significant prostate cancer in biopsy-naive men with high-quality imaging, while mpMRI retains a clear role in lesion characterisation, equivocal cases, and detailed local staging (2,7,14).

2.4.5 SUMMARY OF CURRENT EVIDENCE AND REMAINING UNCERTAINTIES

The current literature shows that bpMRI has become a serious alternative to mpMRI in prostate cancer diagnostics, with several studies and meta-analyses reporting similar diagnostic performance for the detection of clinically significant disease in biopsy-naive men (2,7,8,10). At the same time, the available evidence does not support the conclusion that bpMRI can replace mpMRI in all clinical situations. mpMRI remains the guideline-based standard and provides the most complete examination, with its strongest contribution in selected equivocal or more complex cases (2,14).

A relevant uncertainty in the comparative literature is heterogeneity between studies. Published data differ in patient selection, MRI protocols, reader experience, lesion prevalence, and biopsy strategy, which makes direct comparison difficult and limits broad generalisations (7,8,10). Image quality and reader expertise remain critical for both protocols, and a simplified protocol is only useful if technical standards and interpretive accuracy are maintained (2,14).

Based on the current literature, biparametric MRI appears most suitable as an initial diagnostic examination in biopsy-naive men with suspected prostate cancer, in whom the main clinical aim is the detection or exclusion of clinically significant disease (6,7,9,10). Several comparative studies and meta-analyses have shown that omission of the dynamic contrast-enhanced sequence does not lead to a clinically relevant reduction in diagnostic accuracy in this setting, provided that image quality is high, diffusion-weighted imaging is technically adequate, and the examinations are interpreted by experienced prostate MRI readers (5–7,9,10,14). Biparametric MRI may also be a reasonable option in patients in whom gadolinium-based contrast administration should be avoided, for example in renal impairment or known contrast hypersensitivity, and in clinical settings where rapid, high-throughput diagnostic MRI is required (5,7,14).

Multiparametric MRI, in contrast, remains the preferable protocol in clinical situations in which the additional diagnostic information from dynamic contrast-enhanced imaging is more likely to influence management. According to the current EAU guidelines and the PI-RADS framework, this applies to equivocal PI-RADS 3 lesions in the peripheral zone, in which positive enhancement may support upgrading and selection for targeted biopsy (2,14,15). mpMRI is also preferred when diffusion-weighted imaging is technically limited, for example by motion, susceptibility artefacts after hip prostheses, or rectal gas (4,14). It is also recommended when the clinical question goes

beyond lesion detection and includes local staging, such as the assessment of suspected extracapsular extension or seminal vesicle invasion, as well as post-treatment evaluation following radiotherapy or focal therapy (2,14). In patients on active surveillance with complex or evolving MRI findings, mpMRI may also provide greater diagnostic confidence than the abbreviated protocol (2,7,14).

Taken together, the available evidence supports a context-specific use of prostate MRI rather than a categorical preference for either protocol. bpMRI is well suited to high-volume, biopsy-naive screening pathways with strict quality control, while mpMRI retains a clear role in selected diagnostic and staging scenarios in which dynamic contrast-enhanced imaging adds clinically meaningful information (2,6,7,14).

3. MATERIALS AND METHODS

3.1 STUDY DESIGN AND SETTING

This study was designed as a retrospective, single-centre observational cohort study conducted at the National Cancer Institute, Vilnius. It included a small real-world series of patients with biopsy-proven prostate cancer who underwent clinical prostate MRI as part of their diagnostic work-up during the study period. The study was descriptive and exploratory in nature. It was not intended as a formal diagnostic accuracy trial.

The analysis was based on 12 patients with available clinical MRI findings and histopathological verification. The MRI examinations had been performed in routine clinical practice and were assessed using the corresponding radiology reports. Histopathological biopsy results served as the clinical reference standard for tumor grade.

The study was carried out in a clinical setting in which prostate MRI formed part of the standard diagnostic pathway for suspected prostate cancer. Clinical and imaging-related variables were collected retrospectively from the available records and entered into a predefined database for analysis. Because of the small sample size, the main aim was to explore associations between MRI-derived variables and histopathological findings rather than to make broad generalizable conclusions.

The study setting reflects routine clinical practice rather than a controlled prospective trial environment. This is important for interpretation of the results. On the one hand, it allows assessment of MRI findings in a real-world context. On the other hand, it limits the strength of statistical inference and requires cautious interpretation of all exploratory findings.

3.2 PATIENT SELECTION

Patients were selected retrospectively from a small clinical cohort of men with biopsy-proven prostate cancer. Inclusion in the present analysis required availability of clinical prostate MRI findings and corresponding histopathological verification. Only patients with sufficient clinical and imaging data for descriptive analysis were included.

The final study cohort consisted of 12 patients. All included cases had undergone prostate MRI as part of the diagnostic work-up for suspected prostate cancer. Histopathological confirmation was available in all cases and formed the basis for tumor grading and classification.

Because the study was exploratory and based on an existing small dataset, no formal sample size calculation was performed. The cohort should therefore be understood as a pragmatic convenience sample derived from the available clinical material rather than a statistically powered study population.

The inclusion of only biopsy-proven prostate cancer cases has important implications for interpretation. The cohort was suitable for exploratory analysis of relationships between MRI-derived variables and histopathological tumor grade. However, it was not designed to assess the full diagnostic pathway in men without cancer or to estimate sensitivity and specificity in a screening population.

All patients had previously provided informed consent allowing the use of their imaging data for scientific and educational purposes. The present work utilised only anonymised data, with no possibility of patient identification.

The analysis was performed as a retrospective academic study using anonymised routine clinical data. According to institutional regulations, secondary use of such anonymised data for student research purposes does not require additional ethics committee approval.

The study was conducted in accordance with the principles of the Declaration of Helsinki.

3.3 CLINICAL AND IMAGING DATA COLLECTION

Clinical and imaging-related data were collected retrospectively from the available study records and entered into a predefined database. The recorded clinical variables included age, serum PSA, and PSA density. These parameters were used for descriptive characterization of the cohort and for exploratory comparison with imaging findings and histopathological tumor grade.

Imaging-related variables were derived from the clinical prostate MRI assessment and the structured study dataset. The available MRI parameters included clinical PI-RADS category, lesion size, ADC minimum, and lesion location. Lesion location was extracted from the original sector-based descriptions and recoded into simplified categories for descriptive and exploratory analysis.

Three simplified lesion location variables were used. Zonal location was classified as peripheral zone, transition zone, or mixed involvement. Lesion laterality was classified as right-sided, left-sided, or bilateral. Craniocaudal extent was categorized as apex, base-mid, mid-apex, or base-apex. In addition, binary location variables were created for selected exploratory analyses. Zonal location was grouped into peripheral zone versus non-peripheral zone, and laterality was grouped into unilateral versus bilateral involvement.

All variables were entered into a structured dataset for further statistical analysis. The aim of data collection was not to reconstruct a full paired bpMRI versus mpMRI comparison, but to create a consistent dataset for exploratory evaluation of the relationship between clinical MRI findings and biopsy results in the available cohort.

Because data collection was retrospective, the analysis was limited to parameters that were available in the existing records. Additional advanced imaging features, such as ADC mean, ADC maximum, structured T2 signal grading, DWI signal intensity grading, lesion contour, and lesion shape, were not consistently available for all cases at the time of analysis.

3.4 MRI VARIABLES AND DEFINITIONS

The MRI variables included in the present study were based on the clinical prostate MRI assessment and the available structured dataset. The main imaging variable was the clinical PI-RADS category. This variable was used as the primary MRI-based measure of lesion suspicion and was analyzed in relation to histopathological tumor grade and other clinical parameters.

Lesion size was recorded as the maximum lesion diameter in millimetres. It was treated as a continuous variable and used for group comparisons and correlation analysis. ADC minimum was included as a quantitative diffusion-related parameter. Lower ADC values were interpreted as reflecting stronger diffusion restriction and therefore potentially greater lesion suspicion.

Lesion location was analyzed using simplified categorical variables derived from the original sector-based lesion descriptions. Zonal location was classified as peripheral zone, transition zone, or mixed involvement. Laterality was classified as right-sided, left-sided, or bilateral. Craniocaudal lesion extent was categorized as apex, base-mid, mid-apex, or base-apex.

For additional exploratory analyses, binary location variables were created. Zonal location was recoded as peripheral zone versus non-peripheral zone. Laterality was recoded as unilateral versus bilateral. These binary variables were introduced to allow more robust exploratory comparisons in view of the very small sample size.

For histopathological comparison, Gleason score and Grade Group were used as the main pathological variables. In the present cohort, the available Gleason scores were limited to Gleason

score 6 and 7. Clinically significant prostate cancer was defined as Grade Group 2 or higher, in accordance with current literature and guideline-based clinical practice.

All MRI-derived variables were interpreted as exploratory study variables. Because of the retrospective design and small sample size, they were not treated as definitive diagnostic markers, but as parameters for descriptive analysis and assessment of possible associations with histopathological tumor grade.

3.5 HISTOPATHOLOGICAL REFERENCE STANDARD

Histopathological biopsy findings served as the clinical reference standard in this study. Tissue diagnosis was used to confirm the presence of prostate cancer and to determine tumor grade. This made histopathology the key outcome measure for interpretation of the MRI-derived variables.

The main histopathological parameters used for analysis were Gleason score and Grade Group. These variables were used to describe tumor grade within the cohort and to explore potential associations with MRI findings. In the available dataset, tumor grading was limited mainly to Gleason score 6 and Gleason score 7, corresponding to Grade Group 1 and Grade Group 2.

For the purposes of the study, csPCa was defined as Grade Group 2 or higher. This definition is consistent with current guideline-based clinical practice and with the endpoint used in many MRI studies. It was therefore considered the most appropriate histopathological threshold for interpretation of lesion suspicion in the present cohort.

Histopathology was not used in this study to construct a full diagnostic accuracy model. Instead, it functioned as the reference standard for exploratory comparison with clinical MRI variables such as PI-RADS category, lesion size, ADC minimum, PSA, and PSA density. This approach reflects the descriptive nature of the study and the restricted size of the cohort.

3.6 STUDY ENDPOINTS

Primary endpoint

The primary endpoint was the association between clinical PI-RADS category and csPCa, defined as Grade Group 2 or higher.

Secondary endpoints

Secondary endpoints included the association between ADC minimum and Gleason score, lesion size and PI-RADS category, and PSA density and histopathological grade.

3.7 STATISTICAL ANALYSIS

All statistical analyses were performed using R version 4.2.2 (R Foundation for Statistical Computing, Vienna, Austria) with the R Commander interface (Rcmdr package). A two-sided p-value < 0.05 was considered statistically significant. Because of the small sample size, the analysis was primarily descriptive and exploratory. No formal power calculation was performed.

Continuous variables were summarized using median, range, and, where appropriate, mean and standard deviation. Categorical variables were summarized using absolute frequencies and percentages. This approach was used to describe the baseline characteristics of the cohort and the distribution of MRI, lesion location, and histopathological variables.

Exploratory group comparisons were performed according to clinical PI-RADS category and Gleason score group. For continuous variables, non-parametric testing was used because of the small sample size and the limited distribution of the data. The Wilcoxon rank-sum test was applied to compare lesion size, ADC minimum, PSA, PSA density, and age between groups.

Associations between categorical variables were assessed using contingency tables and Fisher's exact test. This approach was used to explore the relationship between lesion location variables and PI-RADS category or histopathological grade group. In addition, exploratory comparisons of ADC minimum and PSA density according to binary lesion location categories were performed using the Wilcoxon rank-sum test.

Correlation analysis was performed using Spearman's rank correlation coefficient to assess associations between selected imaging, clinical, and histopathological variables.

All statistical results were interpreted cautiously. Because of the exploratory design, very small cohort size, and limited range of histopathological grades, the analyses were not intended to establish definitive diagnostic performance. Instead, they were used to describe patterns within the available data and to identify potentially relevant associations for further discussion.

4. RESULTS

4.1 COHORT CHARACTERISTICS

The cohort consisted of 12 patients with biopsy-proven prostate cancer. The median age was 67 years, with a range from 58 to 85 years. Median serum PSA was 9.76 ng/mL, ranging from 5.7 to 28.0 ng/mL. Median lesion size was 17.5 mm, with a range from 8 to 40 mm. The median ADC minimum value was 421×10^{-6} mm²/s (range 219–613×10^{-6} mm²/s). With regard to MRI findings, four lesions (33.3%) were classified as PI-RADS 4 and eight lesions (66.7%) as PI-RADS 5 on the clinical mpMRI assessment. Histopathologically, five cases (41.7%) had Gleason score 6 and seven cases (58.3%) had Gleason score 7. Accordingly, five lesions (41.7%) were classified as Grade Group 1 and seven lesions (58.3%) as Grade Group 2.

Overall, the cohort was characterized by a predominance of high-suspicion MRI findings, with two-thirds of lesions classified as PI-RADS 5. Histopathological grading was limited to Gleason score 6 and 7, which reflects the narrow spectrum of tumor grade in this small retrospective series.

4.2 LESION LOCATION CHARACTERISTICS

Lesion location was assessed descriptively according to prostate zone, side, and craniocaudal level. Most lesions were located in the peripheral zone. Ten of 12 lesions (83.3%) were classified as peripheral zone lesions, while one lesion (8.3%) was located in the transition zone and one lesion (8.3%) showed mixed zonal involvement.

With regard to laterality, five lesions (41.7%) were located on the right side, four lesions (33.3%) on the left side, and three lesions (25.0%) showed bilateral involvement. Regarding craniocaudal extent, four lesions (33.3%) extended from base to apex, four lesions (33.3%) were located in the mid-to-apex region, two lesions (16.7%) were confined to the apex, and two lesions (16.7%) were located between the base and mid-gland.

Exploratory analysis showed no significant association between zonal location and Gleason score group (Fisher's exact test, $p = 0.152$). There was also no association between zonal location and clinical PI-RADS category ($p = 1.000$). Lesion laterality was not significantly associated with Gleason score group ($p = 0.470$). However, lesion laterality showed an association with clinical PI-RADS category ($p = 0.030$). Left-sided and bilateral lesions were more often classified as PI-RADS 5, whereas right-sided lesions were more often classified as PI-RADS 4. Given the very small sample size, this finding should be interpreted cautiously. No significant association was found between lesion level and Gleason score group ($p = 0.758$).

Additional exploratory analyses were performed to assess whether simplified lesion location categories were associated with quantitative imaging and clinical variables. No significant differences were found in PSA density between unilateral and bilateral lesions ($p = 1.000$) or between peripheral zone and non-peripheral zone lesions ($p = 0.606$). Likewise, ADC minimum did not differ significantly between unilateral and bilateral lesions ($p = 0.727$) or between peripheral zone and non-peripheral zone lesions ($p = 0.485$). These findings suggest that, within this small cohort, simplified lesion location categories were not clearly associated with PSA density or ADC minimum.

4.3 DISTRIBUTION OF PI-RADS CATEGORIES AND HISTOPATHOLOGICAL FINDINGS

Clinical mpMRI showed a predominance of high-suspicion lesions in the studied cohort. Four of 12 lesions (33.3%) were classified as PI-RADS 4, whereas eight lesions (66.7%) were classified as PI-RADS 5. This indicates that most lesions were considered highly suspicious on the clinical MRI assessment.

Histopathological analysis showed a relatively narrow distribution of tumor grade. Five of 12 cases (41.7%) had Gleason score 6, while seven of 12 cases (58.3%) had Gleason score 7. Accordingly, five lesions (41.7%) were classified as Grade Group 1 and seven lesions (58.3%) as Grade Group 2.

Cross-tabulation of PI-RADS category and Gleason score group showed no statistically significant association between clinical PI-RADS category and histopathological tumor grade (Fisher's exact test, $p = 0.576$). Among PI-RADS 4 lesions, one case had Gleason score 6 and three cases had Gleason score 7. Among PI-RADS 5 lesions, four cases had Gleason score 6 and four cases had Gleason score 7.

These findings suggest that, within this small cohort, a higher clinical PI-RADS category was not clearly associated with a higher Gleason score group. However, interpretation is limited by the small sample size and the restricted histopathological range of the cohort.

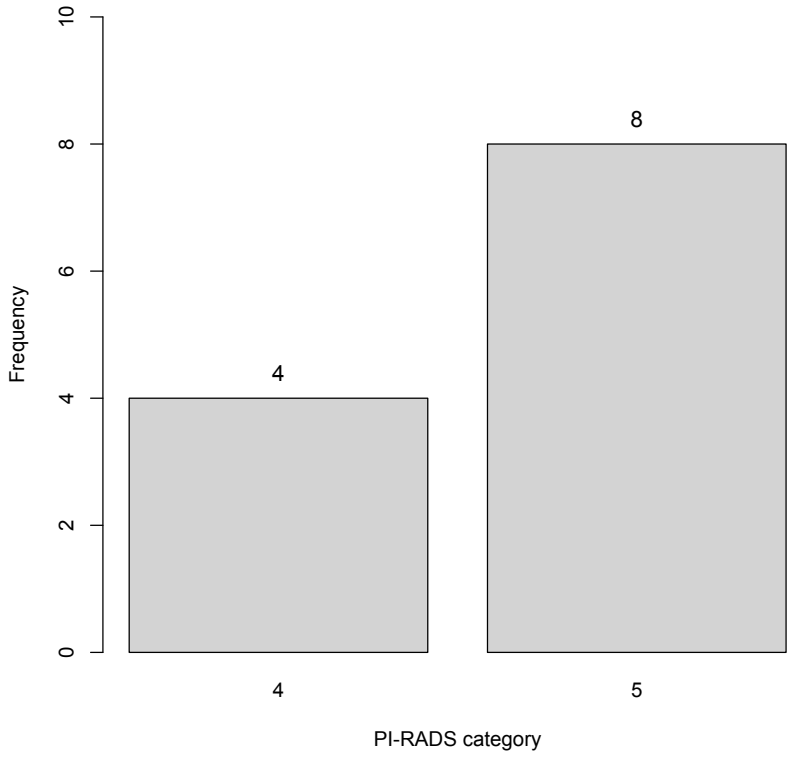

Figure 1. Bar chart of PI-RADS distribution in the study cohort.

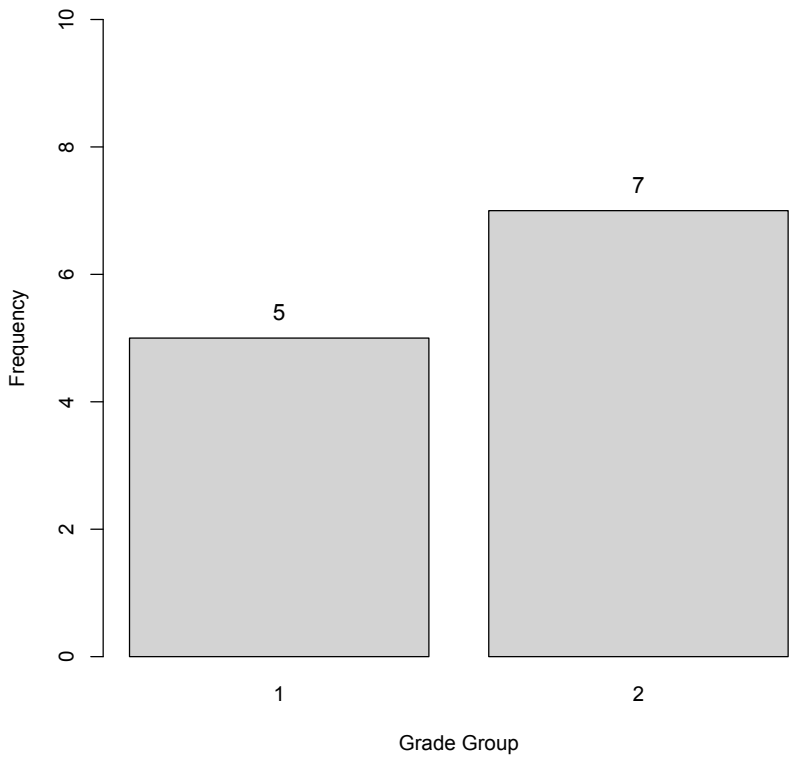

Figure 2. Bar chart of Grade Group distribution in the study cohort.

4.4 COMPARISON OF IMAGING AND CLINICAL VARIABLES BY GLEASON SCORE

Exploratory analyses were performed to compare selected imaging and clinical variables between lesions with Gleason score 6 and Gleason score 7. Median ADC minimum was 404×10^{-6} mm²/s in the Gleason score 6 group and 433×10^{-6} mm²/s in the Gleason score 7 group. This difference was not statistically significant (Wilcoxon rank-sum test, $p = 0.639$).

Median lesion size was 17 mm in lesions with Gleason score 6 and 18 mm in lesions with Gleason score 7. No significant difference was observed between the two groups ($p = 0.745$). Median PSA was also similar. It was 9.73 ng/mL in the Gleason score 6 group and 9.79 ng/mL in the Gleason score 7 group ($p = 0.432$). PSA density likewise showed no significant difference between the two groups ($p = 0.530$).

Age was comparable in both histopathological groups. The median age was 67 years in both Gleason score groups, and no significant difference was found ($p = 0.744$).

Overall, none of the examined imaging or clinical variables differed significantly between Gleason score 6 and Gleason score 7 in this cohort. These findings suggest that, within this small retrospective series, histopathological tumor grade was not clearly separated by ADC minimum, lesion size, PSA, PSA density, or age. Interpretation should be cautious because of the limited sample size and the narrow range of Gleason scores included in the analysis.

4.5 COMPARISON OF IMAGING AND CLINICAL VARIABLES BY PI-RADS CATEGORY

Exploratory analyses were also performed according to clinical PI-RADS category. Median ADC minimum was 499 × 10^{-6} mm²/s in PI-RADS 4 lesions and 387 × 10^{-6} mm²/s in PI-RADS 5 lesions. This difference did not reach statistical significance, although a trend toward lower ADC minimum values in PI-RADS 5 lesions was observed (Wilcoxon rank-sum test, p = 0.073).

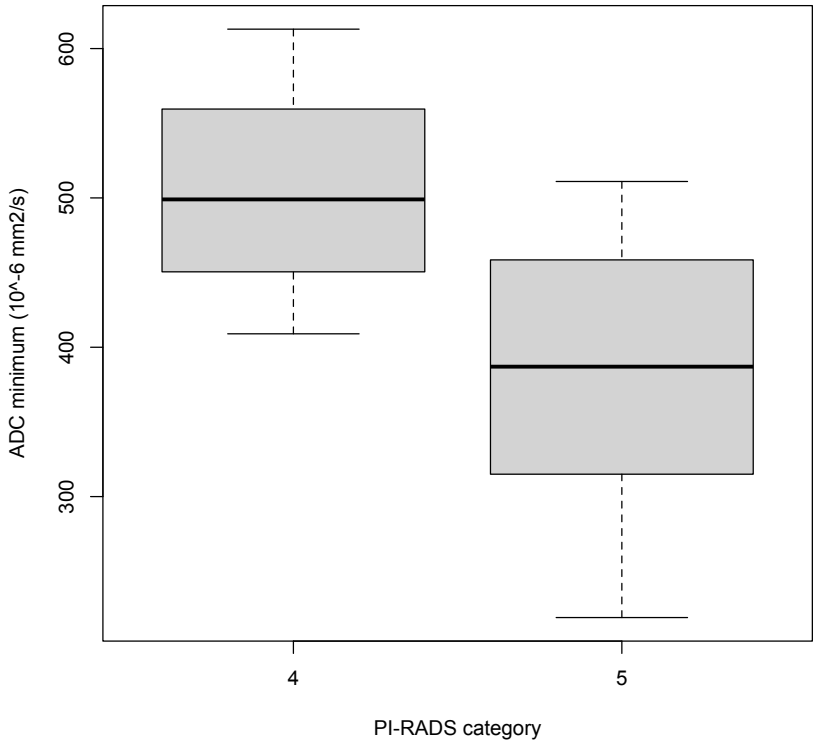

Figure 3. Boxplot of ADC minimum according to clinical PI-RADS category.

Lesion size differed more clearly between the two groups. Median lesion size was 10.5 mm in PI-RADS 4 lesions and 20.0 mm in PI-RADS 5 lesions. This difference was statistically significant (p = 0.008). PI-RADS 5 lesions were therefore substantially larger than PI-RADS 4 lesions in this cohort.

PI-RADS 5 lesions demonstrated significantly larger lesion diameters compared with PI-RADS 4 lesions. This finding supports the known association between increasing lesion volume and higher MRI suspicion categories. However, lesion size alone did not correlate with tumour grade in this cohort.

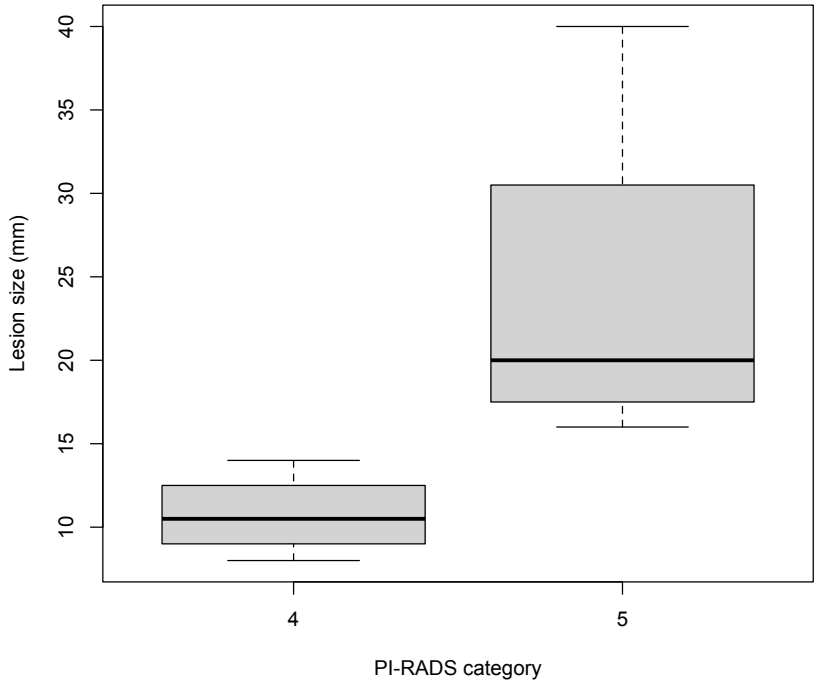

Figure 4. Boxplot of lesion size (mm) according to clinical PI-RADS category. PI-RADS 5 lesions were significantly larger than PI-RADS 4 lesions (p = 0.008).

Median PSA was 8.75 ng/mL in PI-RADS 4 lesions and 11.26 ng/mL in PI-RADS 5 lesions. This difference was not statistically significant (p = 0.368). PSA density was also slightly higher in PI-RADS 5 lesions, but without a significant difference (p = 0.214). Median age was similar in both groups and showed no significant association with PI-RADS category (p = 0.798).

Overall, lesion size was the only variable that differed significantly between PI-RADS 4 and PI-RADS 5 lesions. ADC minimum showed a non-significant trend toward lower values in higher PI-RADS categories. In contrast, PSA, PSA density, and age did not differ significantly between the two MRI-based risk groups. These findings suggest that lesion size was most clearly associated with increasing clinical MRI suspicion in the present cohort.

4.6 CORRELATION ANALYSIS

Spearman correlation analysis was performed to explore the relationship between selected imaging, clinical, and histopathological variables. The strongest positive correlation was found between lesion size and clinical PI-RADS category (Spearman $\rho = 0.821$, $p = 0.001$). This indicates that

larger lesions were more likely to be classified as PI-RADS 5.

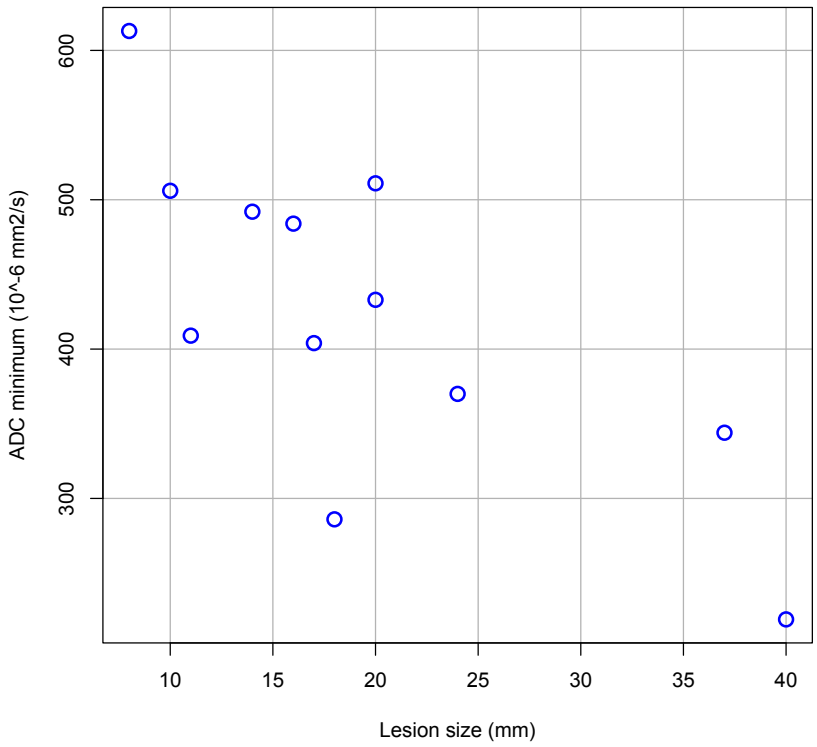

Figure 5. Scatterplot of lesion size and ADC minimum.

A statistically significant moderate negative correlation was observed between ADC minimum and lesion size (Spearman $\rho = -0.694$, $p = 0.012$). Lower ADC minimum values were therefore associated with larger lesions. ADC minimum also showed a moderate negative correlation with PI-RADS category (Spearman $\rho = -0.563$, $p = 0.057$), which approached but did not reach statistical significance, suggesting that lesions with higher MRI suspicion tended to have lower diffusion values. PSA showed only weak to moderate, non-significant correlations with the investigated variables. The correlation with lesion size was positive but limited (Spearman $\rho = 0.392$, $p = 0.207$), and the correlation with PI-RADS category was also weak (Spearman $\rho = 0.307$, $p = 0.331$). PSA showed a moderate negative correlation with ADC minimum, which did not reach statistical significance (Spearman $\rho = -0.455$, $p = 0.138$).

No meaningful correlation was found between Gleason grade group and the other analysed variables. Correlation coefficients for Gleason grade group with lesion size (Spearman $\rho = -0.123$, $p = 0.704$), PI-RADS category (Spearman $\rho = -0.239$, $p = 0.454$), ADC minimum (Spearman $\rho = 0.171$, $p = 0.594$), and PSA (Spearman $\rho = -0.269$, $p = 0.397$) were all weak and statistically non-significant. This is consistent with the group comparisons, which also did not show clear separation between Gleason score groups.

Overall, the correlation analysis suggests that lesion size and ADC minimum were more closely related to MRI-based lesion suspicion than to histopathological tumour grade in this cohort. Of the ten correlations examined, two reached statistical significance (lesion size with PI-RADS category, $p = 0.001$; ADC minimum with lesion size, $p = 0.012$), while the negative correlation between ADC minimum and PI-RADS category showed a non-significant trend ($p = 0.057$). The strongest relationship was observed between lesion size and PI-RADS category, while histopathological grade showed only weak associations with the available imaging and clinical variables.

4.7 EXPLORATORY IMAGING FINDINGS

Several exploratory findings emerged from the cohort analysis. Most lesions were located in the peripheral zone, and lesion laterality showed a statistically significant association with clinical PI-RADS category. Left-sided and bilateral lesions were more often classified as PI-RADS 5, whereas right-sided lesions were more often classified as PI-RADS 4 (Fisher's exact test, $p = 0.030$). Because of the very small sample size, this finding should be interpreted cautiously.

Another notable observation concerned lesion size and histopathological grade. Although lesion size was significantly higher in PI-RADS 5 lesions, larger lesions were not consistently associated with higher Gleason scores. In particular, some relatively large lesions were still classified as Gleason score 6. This indicates that lesion size alone did not reliably reflect biological aggressiveness in the present cohort.

ADC minimum showed a non-significant trend toward lower values in lesions with higher PI-RADS categories. At the same time, ADC minimum was not clearly associated with Gleason score group. This suggests that diffusion restriction may be more closely related to MRI-based lesion suspicion than to histopathological separation between Gleason score 6 and 7 in this small sample.

Taken together, these exploratory findings support a cautious interpretation of isolated MRI parameters. In the present cohort, lesion size and ADC minimum contributed to imaging-based suspicion, but neither parameter alone was sufficient to explain histopathological tumor grade. These observations may be relevant for the interpretation of discordant cases and for the later discussion of large lesions with relatively low Gleason score.

5. DISCUSSION

5.1 PRINCIPAL FINDINGS

The present study explored the relationship between clinical prostate MRI findings and histopathological tumor grade in a small retrospective cohort of 12 patients with biopsy-proven prostate cancer. The analysis was descriptive and exploratory. It focused on clinical mpMRI findings, lesion size, ADC minimum, PSA, PSA density, and simplified lesion location variables.

Several principal findings emerged from the analysis. First, the cohort was characterized by a predominance of high-suspicion MRI findings. Two-thirds of lesions were classified as PI-RADS 5, while one third were classified as PI-RADS 4. Histopathologically, the cohort was limited to Gleason score 6 and 7, corresponding to Grade Group 1 and 2. This reflects a relatively narrow spectrum of tumor grade.

Second, lesion size showed the clearest association with MRI-based lesion suspicion. PI-RADS 5 lesions were significantly larger than PI-RADS 4 lesions. In contrast, ADC minimum showed only a non-significant trend toward lower values in higher PI-RADS categories. PSA, PSA density, and age did not differ significantly between PI-RADS groups.

Third, no clear separation was found between Gleason score 6 and 7 for the analyzed imaging and clinical variables. ADC minimum, lesion size, PSA, PSA density, and age did not differ significantly between the two histopathological groups. Likewise, correlation analysis showed only weak associations between Gleason grade group and the available MRI-derived variables. This suggests that, within this small cohort, MRI-based lesion suspicion was more closely related to lesion size than to histopathological grade.

Fourth, lesion location analysis showed that most lesions were located in the peripheral zone. Exploratory testing did not demonstrate significant associations between zonal location and Gleason score or PI-RADS category. However, lesion laterality showed an association with clinical PI-RADS category, with left-sided and bilateral lesions more often classified as PI-RADS 5, whereas right-sided lesions were more often classified as PI-RADS 4. Given the very small sample size, this finding should be interpreted with caution.

Finally, an important case-based observation was that relatively large lesions were not always associated with higher tumor grade. Some large lesions were still classified as Gleason score 6. This finding is relevant because it suggests that lesion size alone may not reflect biological aggressiveness. Additional imaging features, such as diffusion characteristics or qualitative lesion morphology, may be needed for a more complete interpretation.

5.2 INTERPRETATION OF RESULTS

The findings of this study should be interpreted in the context of a small and histopathologically narrow cohort. Within these limits, the results suggest that MRI-based lesion suspicion was more closely related to lesion size than to histopathological tumour grade. The clearest result was the significant difference in lesion size between PI-RADS 4 and PI-RADS 5 lesions, which indicates that larger lesions were more likely to be classified as highly suspicious on clinical mpMRI.

ADC minimum showed a trend toward lower values in PI-RADS 5 lesions, but this did not reach statistical significance. This direction is plausible from an imaging perspective, since stronger

diffusion restriction is associated with greater lesion suspicion. However, the absence of significance in the present cohort suggests that ADC minimum alone did not provide clear discrimination between MRI categories. This may be related to the small sample size, but it may also reflect biological overlap between lesions with different MRI-based suspicion levels.

An important observation was that the imaging and clinical variables did not separate Gleason score 6 from Gleason score 7. Neither lesion size nor ADC minimum, PSA, PSA density, nor age showed significant differences between the two groups. The size finding is relevant. According to the PI-RADS framework, a lesion diameter of ≥ 15 mm is one of the criteria that may upgrade a peripheral zone lesion from PI-RADS 4 to PI-RADS 5 (15). The cohort followed this pattern, with PI-RADS 5 lesions reaching a median size of 20 mm and PI-RADS 4 lesions a median size of 10.5 mm ($p = 0.008$). When the same comparison was repeated by Gleason score, however, no meaningful difference was found, with a median lesion size of 17 mm in Gleason 6 lesions and 18 mm in Gleason 7 lesions ($p = 0.745$). This shows that within the present cohort, lesion size reflects MRI-based suspicion rather than tumour grade. The narrow histopathological range likely contributed to this finding: since the cohort included only Gleason 6 and 7 disease, the biological contrast was limited from the start, and a broader distribution including Grade Group 3 and higher would have allowed more informative comparisons of MRI parameters as markers of tumour aggressiveness.

The location analysis also requires cautious interpretation. Most lesions were located in the peripheral zone, which is in line with the known distribution of prostate cancer. No significant associations were found between lesion location and Gleason score, PSA density, or ADC minimum. The association between lesion laterality and PI-RADS category was statistically significant, but this finding should be treated as exploratory. In a cohort of only 12 patients, even small shifts in category distribution can have a marked effect on p-values, and the result may therefore reflect a dataset-specific pattern rather than a stable biological effect.

One of the most relevant interpretative points concerns the relationship between MRI-based lesion suspicion and histopathological grade. In the present cohort, several PI-RADS 4 and 5 lesions were classified as Grade Group 1 disease. This shows that high MRI suspicion does not always translate into clinically significant cancer. Several factors may explain this finding. First, biopsy sampling error and the risk of undergrading must be considered. Targeted biopsy can underestimate the highest-grade component of a heterogeneous tumour, in cases where only a limited number of cores is taken or when the most aggressive area within the lesion is not sampled (2).

Second, non-malignant conditions can mimic the imaging features of prostate cancer. Granulomatous or chronic prostatitis, post-biopsy haemorrhage, and dense stromal fibrosis can produce focal areas of low ADC and abnormal T2 signal that resemble malignant lesions on both bpMRI and mpMRI, and may lead to false-positive PI-RADS 4 or 5 classifications (4,14).

Third, the present analysis was based on ADC minimum, lesion size, and clinical PI-RADS category alone, without additional parameters such as ADC mean, lesion contour, structured T2 hypointensity grading, capsular contact, or signs of extracapsular extension. These features have been described as further discriminators between Grade Group 1 and Grade Group ≥ 2 disease and may help to explain cases of apparent imaging–pathology mismatch (4,14). Their absence in the current dataset is a relevant interpretative limitation, above all in cases where high MRI suspicion is combined with limited histopathological aggressiveness.

Taken together, MRI-based suspicion, lesion extent and histopathological grade are related but do not measure the same aspect of disease. A large lesion may appear suspicious on imaging and still show limited histopathological aggressiveness, while a smaller lesion may already contain clinically relevant adverse features. In this cohort, lesion size was the clearest correlate of PI-RADS category, whereas histopathological grade was not strongly reflected by the available quantitative MRI and clinical parameters. These findings underline the complexity of linking imaging appearance to tumour biology and provide the basis for comparison with the published literature in the following section.

5.3 COMPARISON WITH PREVIOUS LITERATURE

In the systematic review and meta-analysis by Woo et al., which pooled data from multiple comparative studies of bpMRI and mpMRI, the two protocols showed comparable diagnostic performance for the detection of prostate cancer, and the choice of MRI protocol was not identified as a significant source of heterogeneity (7). Comparative studies by Xu et al. and Iacob et al. similarly concluded that omission of the dynamic contrast-enhanced sequence did not lead to a clinically relevant reduction in diagnostic accuracy, particularly in the detection of clinically significant disease in biopsy-naive men (5,6). Feng et al. additionally reported that ADC-based parameters were among the strongest independent predictors of csPCa in both bpMRI and mpMRI protocols (9). At the same time, mpMRI remains the guideline-based standard and may still offer added value in equivocal or more complex cases, where the dynamic contrast-enhanced sequence can support lesion characterisation (2,14). The present cohort does not allow a formal head-to-head comparison between bpMRI and mpMRI. However, several observations are in line with the published literature. In particular, the association between higher PI-RADS category and larger lesion size is plausible and consistent with the general concept that more suspicious lesions tend to be morphologically more conspicuous. The non-significant trend toward lower ADC minimum values in PI-RADS 5 lesions is also compatible with prior reports showing that diffusion restriction is related to lesion suspicion and may correlate inversely with tumor aggressiveness (9,14).

At the same time, the lack of a clear association between the available MRI-derived variables and histopathological separation between Gleason score 6 and 7 deserves attention. In larger studies,

ADC-based parameters and structured MRI assessment have shown some value in distinguishing clinically significant from non-significant disease. In the present study, this relationship was much weaker. The most likely explanation is the limited sample size and the narrow histopathological range of the cohort. Since only Gleason score 6 and 7 lesions were included, the study design offered only limited biological contrast. This makes it difficult to reproduce stronger associations described in larger comparative cohorts (9,10).

The observation that some relatively large lesions were still classified as Gleason score 6 is also relevant in light of the literature. Published work generally supports the view that lesion size contributes to MRI suspicion, but lesion extent alone does not fully reflect histopathological aggressiveness. The current cohort illustrates this point clearly. Large lesions were more often classified as PI-RADS 5, yet this did not necessarily translate into higher Gleason score. This finding supports a more differentiated interpretation of MRI, in which lesion size, diffusion characteristics, zonal anatomy, and histopathological grading are understood as related but not interchangeable parameters (4,14).

The present study also relates conceptually to the current debate addressed in the PRIME protocol. The PRIME trial protocol was designed to assess whether bpMRI is non-inferior to mpMRI for the detection of csPCa in biopsy-naive men, with Gleason score ≥ 3+4 or Grade Group ≥ 2 as the primary endpoint. Although the present work is much smaller, retrospective, and not a true paired non-inferiority design, it addresses a similar clinical question at a descriptive level: which MRI-derived findings appear most relevant when interpreted against biopsy results, and how much useful information may already be contained in the non-contrast components of prostate MRI. At the time of writing, the PRIME protocol publication (8) outlines the design but the full trial results were not yet integrated into this thesis.

Overall, comparison with the literature suggests that the present findings are directionally plausible but methodologically limited. They support the general view that MRI-based lesion suspicion is influenced by lesion size and diffusion-related features, while the relationship with histopathological grade may be less straightforward in small real-world cohorts. The study therefore does not challenge the current literature, but rather illustrates, on a small scale, some of the same interpretative tensions that underlie the broader bpMRI versus mpMRI debate (2,8,14).

5.4 CLINICAL RELEVANCE AND PRACTICAL IMPLICATIONS

The clinical relevance of the present findings lies mainly in their contribution to the interpretation of prostate MRI in routine practice. In this cohort, lesion size showed the clearest association with MRI-based lesion suspicion, whereas the available quantitative and clinical variables did not separate

Gleason score 6 from Gleason score 7. This indicates that clinical MRI assessment reflects lesion conspicuity and extent, but does not predict histopathological grade in every individual case.

This observation is relevant for everyday decision-making. Prostate MRI is used to identify lesions that are likely to represent clinically significant disease and to guide biopsy, but it is not a substitute for histopathological confirmation. Even lesions with high MRI suspicion or large size may show limited histopathological aggressiveness, and MRI findings should therefore always be interpreted together with biopsy results and the broader clinical context.

The study also has practical relevance for the discussion of simplified MRI protocols. In this cohort of patients with biopsy-proven prostate cancer, MRI-derived parameters including lesion size, ADC minimum, PI-RADS classification, and PSA density did not reliably differentiate between Gleason score 6 and Gleason score 7 disease within PI-RADS 4 and PI-RADS 5 lesions. These findings suggest that both biparametric imaging features and multiparametric MRI-based lesion classification have limited value for distinguishing low- from intermediate-grade prostate cancer once a lesion has been classified as suspicious for clinically significant disease.

The majority of lesions in this cohort were located in the peripheral zone (10 of 12), where diffusion-weighted imaging and ADC are the dominant PI-RADS sequences and dynamic contrast-enhanced imaging has only a secondary role. The findings are therefore relevant to the role of bpMRI in peripheral-zone lesion assessment. For peripheral-zone lesions classified as PI-RADS 4 or 5 with adequate DWI quality, T2-weighted imaging and ADC may provide sufficient information for lesion detection and targeted biopsy planning (2,7,14). However, this does not mean that bpMRI can reliably determine tumour grade, since lesion size, ADC minimum, PI-RADS category, and PSA density did not distinguish Gleason 6 from Gleason 7 in the present series. For many peripheral-zone lesions with good-quality DWI and ADC, bpMRI may therefore be sufficient for detection and biopsy guidance, while final assessment of tumour grade must rely on histopathology.

A further practical implication concerns the interpretation of large lesions with low Gleason score. In the present cohort, some of the larger lesions were classified as Gleason score 6, which underlines that lesion extent alone should not be equated with higher-grade disease. In clinical practice, such cases warrant careful correlation between MRI appearance, biopsy findings, and, where available, additional qualitative imaging features such as lesion morphology, contour, T2 appearance, and diffusion characteristics.

Overall, the present findings support a cautious and integrated use of prostate MRI in routine care. MRI is valuable for lesion detection, risk stratification, and biopsy guidance, but its interpretation remains probabilistic. Histopathology remains essential for final grading. The study therefore reinforces the practical view that MRI should guide clinical decision-making, but not replace tissue-based diagnosis.

5.5 STRENGTHS AND LIMITATIONS

The present study has several strengths. First, it was based on real-world clinical data from patients who underwent prostate MRI as part of routine diagnostic work-up. This gives the analysis practical relevance and reflects everyday clinical conditions rather than an artificial study environment. Second, histopathological verification was available in all included cases, which allowed MRI-derived variables to be interpreted against biopsy-proven tumour grade. Third, the study included both quantitative and descriptive MRI-related parameters, including lesion size, ADC minimum, PI-RADS category, and simplified lesion location variables. This made it possible to examine different aspects of MRI-based lesion assessment within the same cohort.

At the same time, the study has important limitations. The most relevant limitation is the very small sample size. With only 12 cases, the statistical power was low and all results must be interpreted with caution. Small differences between groups may not have reached statistical significance, and isolated significant findings may also be unstable. The second major limitation is the narrow histopathological range. Only Gleason score 6 and 7 lesions were included, which restricted biological variation and limited the ability to detect stronger associations between imaging variables and tumour grade.

A further limitation is the retrospective study design. The analysis depended on parameters that were available in the existing records and dataset. Several additional MRI features proposed as relevant in the literature, such as ADC mean, ADC maximum, structured T2 signal grading, lesion contour, lesion shape, and DWI signal intensity grading, were not available for all patients. The same applies to the intended comparison between bpMRI and mpMRI. Because a full paired re-reading dataset was not available, the study could not perform a formal head-to-head comparison of both protocols. Conclusions regarding biparametric MRI are therefore based on the published literature, while the original data analysis remains exploratory and focused on mpMRI-derived parameters.

Another limitation concerns the use of clinical mpMRI reports as the imaging basis. No central or blinded re-reading of MRI examinations was performed, and all imaging variables were derived from the original clinical radiology reports. While this reflects routine radiological assessment, it may introduce reporter bias and limits direct comparability with study designs that use standardised central image review and formal assessment of interobserver variability. In addition, simplified lesion location variables had to be derived from the original sector-based descriptions. Although this was reasonable for exploratory analysis, some anatomical detail was lost during recoding.

A final limitation is that the study cohort consisted only of biopsy-proven prostate cancer cases. This means that the dataset was suitable for exploratory analysis of MRI–pathology relationships within cancer-positive patients, but not for evaluation of the full diagnostic pathway in men with and without cancer. The study therefore cannot provide robust estimates of sensitivity, specificity, or negative predictive value.

Overall, the strengths of the study lie in its real-world clinical relevance, biopsy verification, and focused exploratory analysis. Its main limitations are the small sample size, restricted tumour grade spectrum, retrospective design, the absence of independent bpMRI reassessment, and the lack of central image review. These factors should be kept in mind when interpreting the results.

5.6 FUTURE PERSPECTIVES

Future research should build on the present findings in larger and methodologically stronger cohorts. The most important next step would be inclusion of a greater number of patients with a broader histopathological spectrum. This would allow more robust analysis of the relationship between MRI-derived variables and tumour aggressiveness. Inclusion of higher Grade Groups would improve assessment of whether lesion size, ADC-related parameters, and PI-RADS category can distinguish lower-risk from more aggressive disease.

A second step would be a more detailed and standardised imaging analysis. Additional MRI features proposed as clinically relevant should be recorded systematically. These include ADC mean, ADC maximum, structured T2 hypointensity, lesion contour, lesion shape, and DWI signal intensity on high b-value images. Such parameters may help explain cases in which lesion size and histopathological grade do not correspond, and they are above all relevant for large lesions with low Gleason score.

Future studies should also revisit the original comparative question. A paired design with structured reassessment of bpMRI and mpMRI in the same patients would be preferable. This would allow evaluation of whether omission of DCE changes lesion classification, clinical suspicion, or association with biopsy findings. A design concept similar to the current bpMRI versus mpMRI literature, including paired image interpretation, would provide a stronger basis for comparison.

Another relevant perspective concerns image quality and standardisation. Simplified MRI protocols can only be useful if technical quality remains high and image interpretation is reliable. Future work should therefore not only compare protocols, but also consider reader experience, acquisition quality, and reproducibility of structured reporting. This is important for studies aiming to transfer abbreviated MRI protocols into routine practice.

Overall, future research should aim to clarify in which clinical settings bpMRI can be used without relevant loss of information and in which situations mpMRI remains preferable. The present study cannot answer this question, but it highlights several variables and patterns that may be useful for more detailed investigation in larger prospective studies.

6. CONCLUSION

6.1 SUMMARY OF KEY FINDINGS

This thesis examined the diagnostic role of biparametric and multiparametric MRI in prostate cancer detection. The literature review showed that bpMRI is a promising alternative to mpMRI in many diagnostic settings, above all when the main aim is detection of csPCa. At the same time, the review confirmed that mpMRI remains the current standard, as it provides the most complete imaging assessment and may offer advantages in selected equivocal or more complex cases.

The original cohort analysis explored the relationship between clinical MRI findings and histopathological tumour grade in a small retrospective series of 12 patients with biopsy-proven prostate cancer. Within this cohort, lesion size showed the clearest association with MRI-based lesion suspicion: PI-RADS 5 lesions were significantly larger than PI-RADS 4 lesions, and ADC minimum showed a non-significant trend toward lower values in higher PI-RADS categories. In contrast, MRI-derived parameters including lesion size, ADC minimum, PI-RADS classification, and PSA density did not reliably differentiate between Gleason score 6 and Gleason score 7 disease within PI-RADS 4 and 5 lesions.

Additional exploratory analyses of lesion location showed that most lesions were located in the peripheral zone (10 of 12). Lesion laterality showed an association with clinical PI-RADS category, while zonal location was not associated with Gleason score, PI-RADS category, PSA density, or ADC minimum. Overall, MRI-based lesion suspicion in this cohort showed a stronger relationship with lesion size and diffusion-related features than with histopathological separation between Gleason score 6 and 7.

6.2 FINAL CONCLUSION

The findings of this thesis support the view that biparametric MRI can provide clinically useful diagnostic information in prostate cancer assessment, above all in settings where a shorter and less invasive protocol is desirable. However, the present study also underlines that MRI findings must be interpreted with caution and always together with histopathology.

Within the analysed cohort, MRI-derived parameters including lesion size, ADC minimum, PI-RADS classification, and PSA density did not reliably differentiate Gleason score 6 from Gleason score 7 disease within PI-RADS 4 and 5 lesions. Both biparametric imaging features and multiparametric MRI-based lesion classification therefore appear to have limited value for distinguishing low- from intermediate-grade prostate cancer once a lesion has been classified as suspicious for clinically significant disease.

Since most lesions in this cohort were located in the peripheral zone, where diffusion-weighted imaging and ADC are the dominant PI-RADS sequences, the findings further support the role of

bpMRI for detection and biopsy guidance in peripheral-zone PI-RADS 4 and 5 lesions with adequate DWI quality. Final assessment of tumour grade, however, must rely on histopathology.

Although limited by its small retrospective design, this thesis contributes to the ongoing discussion on simplified prostate MRI protocols. It suggests that bpMRI has substantial diagnostic potential, while mpMRI remains the more comprehensive approach in current practice. Larger studies are needed to clarify in which clinical situations bpMRI can replace mpMRI without clinically relevant loss of information.

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8. APPENDIX

8.1 TABLES

Table 1. Risk-adapted biopsy decision matrix based on PI-RADS category and PSA density for csPCa detection (adapted from the EAU Guidelines 2025).

Table 2. Dominant MRI sequences and structured PI-RADS assessment in prostate MRI according to prostate zone (adapted from published PI-RADS reviews and guidelines).

Table 3. Relationship between Gleason score, Grade Group, and clinical relevance in prostate cancer (adapted from published grading reviews and guidelines).

8.2 FIGURES

Figure 1. Bar chart showing the distribution of clinical PI-RADS categories in the study cohort. PI-RADS 5 lesions were more frequent than PI-RADS 4 lesions.

Figure 2. Bar chart showing the distribution of histopathological Grade Group in the study cohort. Grade Group 2 was more frequent than Grade Group 1.

Figure 3. Boxplot showing ADC minimum according to clinical PI-RADS category. PI-RADS 5 lesions tended to show lower ADC minimum values than PI-RADS 4 lesions, although the difference did not reach statistical significance ($p = 0.073$).

Figure 4. Boxplot showing lesion size (mm) according to clinical PI-RADS category. PI-RADS 5 lesions were significantly larger than PI-RADS 4 lesions ($p = 0.008$).

Figure 5. Scatterplot showing the relationship between lesion size and ADC minimum. Larger lesions tended to show lower ADC minimum values, indicating an inverse association between lesion extent and diffusion restriction (Spearman rho = −0.694).

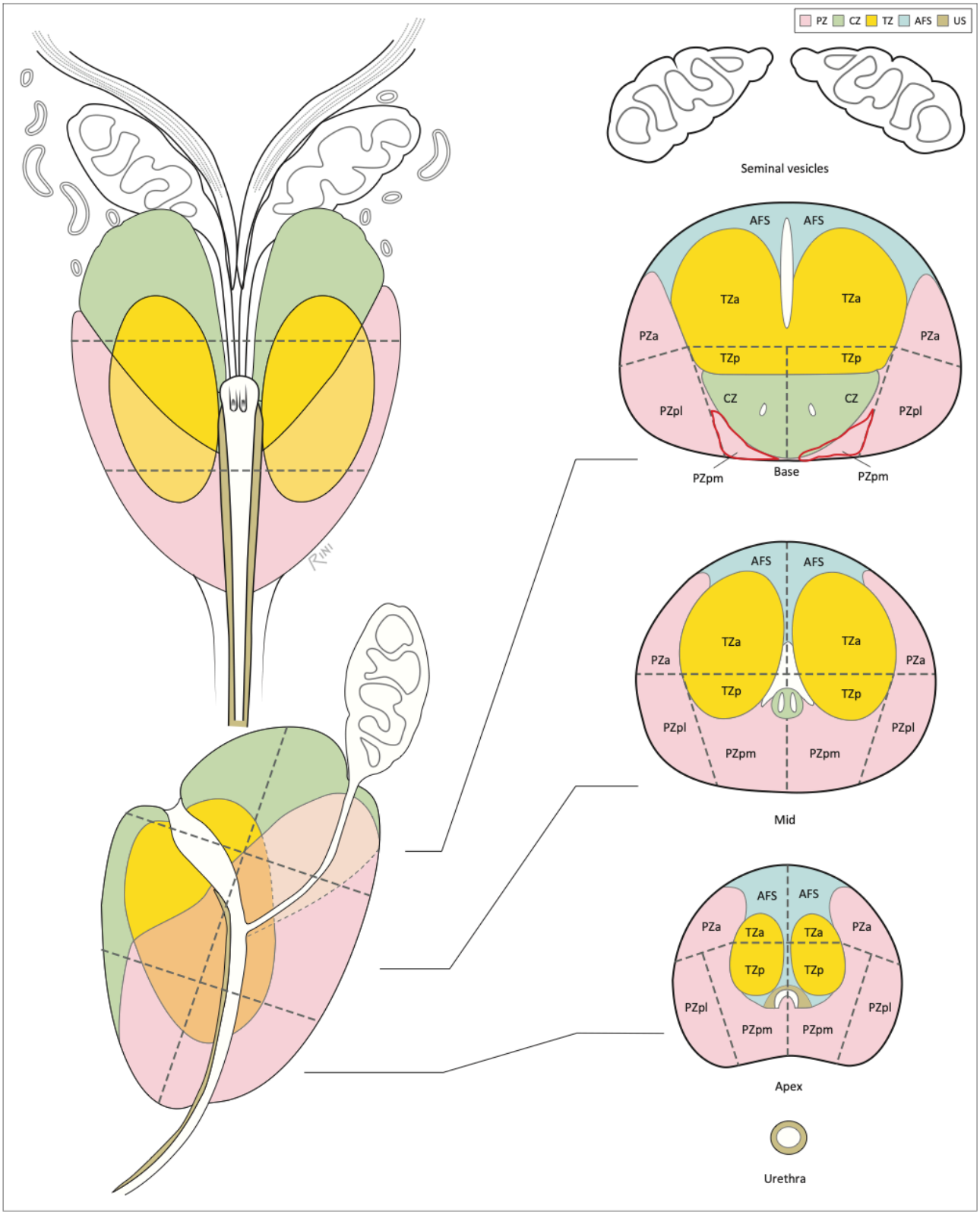

Figure 6. Schematic illustration of prostate zonal anatomy and sector-based lesion localization, including peripheral zone, transition zone, central zone, anterior fibromuscular stroma, and anatomical levels from base to apex.