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ORIGINAL RESEARCH

Qualitative and Quantitative Assessment of T2-Weighted Imaging Signal Variations in Prostate MRI Following Different Abstinence Periods: A Study in Young Healthy Men

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Objective: This study evaluates the impact of an abstinence period on the image quality of high-field prostate magnetic resonance imaging (MRI).

Methods: Male patients who underwent prostate MRI at Xi'an No.3 hospital between November 2021 and November 2022 were included in this study. The patients were divided into two groups based on whether they had ejaculated within three days prior to the MRI examination. Two radiologists assessed the boundary sharpness of the peripheral zone (PZ) and central gland (CG) using a double-blind 3-Point Likert scale. Regions of interest (ROIs) were marked bilaterally on the PZ and CG in sagittal T2-weighted images (T2WI). The signal intensity (SI) of the ROIs was measured, and the signal intensity ratio (SIR) was subsequently calculated. The Wilcoxon rank-sum test and independent samples *t*-test were employed to compare differences between the two groups.

Results: A total of 50 young male patients participated in the study, with 20 patients having an abstinence period of more than 3 days and 30 patients having an abstinence period of 3 days or less. Qualitative analysis revealed that the prostate structures were more easily identifiable in the abstinence group compared to the ejaculation group ($P \leq 0.05$). Quantitative analysis showed that the SIR of the PZ and CG was lower in the ejaculation group than in the abstinence group ($P \leq 0.05$ for both), with a particularly significant difference observed in the peripheral zone.

Conclusion: To obtain more accurate results in prostate MRI examinations, it is recommended that patients abstain from sexual activity for at least 3 days prior to the examination.

Keywords: image quality, MRI, prostate, T2-weighted imaging

Introduction

Prostate cancer (PCa) is one of the most common cancers that occur in men worldwide.[1,2] In China, the incidence of PCa ranks sixth among male cancers and has shown an increasing trend in recent years.[3,4] Challenges remain in the treatment of prostate cancer, particularly in overcoming resistance to current therapies and improving patient outcomes. The development of novel therapeutic strategies, such as miRNA-based therapies, holds promise for addressing these challenges. MicroRNA-34a (miR-34a) has shown potential as a tumor suppressor and cancer stem cell inhibitor, making it an attractive target for therapeutic development. However, the successful translation of miR-34a-based therapies into clinical practice requires overcoming challenges related to delivery, stability, and specificity.[5,6] MRI plays a crucial role in evaluating PCa and is widely used as a diagnostic, staging, and prognostic tool, providing evidence for clinical

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decision-making.[7–9] The Prostate Imaging Reporting and Data System version 2.1 (PI-RADS v2.1) published in 2019 has been validated in both clinical practice and research.[10] To ensure the management, communication, and multicenter quality of PCa, PI-RADS v2.1 established standardized acquisition techniques and interpretation guidelines for prostate MR images. Multiparametric MRI (mp-MRI), which includes T2-weighted imaging (T2WI), diffusion-weighted imaging (DWI), and dynamic contrast-enhanced MRI (DCE-MRI), is recommended as the first-line MR sequence.

In certain cultures, sexual activity among older adults is viewed as uncommon or even unusual. However, previous studies indicate that sexual activity remains significant for many older men. In Germany, a study on the frequency of sexual activity by age found that, among individuals aged 60 to 79, the frequency in the months preceding the study ranged from 71% to 84%. In Japan, the frequency for the same age group ranged from 55% to 88%. These findings suggest that sexual activity among older adults should not be underestimated.

Previous MRI studies have indicated that the T2 values and apparent diffusion coefficient (ADC) values of the prostate exhibit dynamic changes following ejaculation.[11] The PI-RADS v2.1 guidelines suggest that "some recommend patients refrain from ejaculation for three days before MRI", but also note that "the benefits of abstinence have not been proven".[12] This study, therefore, aims to retrospectively analyze high-field T2WI of the prostate with varying abstinence periods using both qualitative and quantitative methods. The objective is to assess the impact of abstinence on prostate T2WI and to determine whether a 3-day abstinence period should be recommended.

Materials and Methods

Subjects

Between November 2021 and November 2022, a total of 128 healthy men underwent prostate magnetic resonance imaging (MRI). However, 78 patients were excluded from the study as 34 patients lacked detailed clinical records or did not have T2WI, 31 patients were younger than 20 years or older than 35 years, and 13 patients were excluded due to poor image quality. Ultimately, 50 patients were included in the study. All patients underwent T2WI (both axial and sagittal images) and had reliable abstinence periods. Patients were categorized into two groups based on their abstinence period: the abstinence group (with an abstinence period of more than 3 days) comprised 20 patients (60%), while the ejaculation group (who had ejaculated within 3 days) included 30 patients (40%). The duration of abstinence was determined according to the PI-RADS guidelines. This retrospective study was approved by the Ethics Committee of Xi'an No.3 hospital. All patients provided informed consent and signed the informed consent form. All subjects should maintain normal hydration levels and avoid excessive fluid intake in the hours prior to the MRI. Maintaining the usual diet for a few days prior to the test is sufficient to ensure that the patient's diet is not affecting the prostate in any way. Avoid strenuous activity for 24 hours after the test.

MRI Acquisition

Prostate MRI was conducted using a 3T MRI scanner (Philips Ingenia, Philips Healthcare, Best, Netherlands) with an 18-channel phased-array body coil and a 32-channel phased-array spinal coil. Three-dimensional (3D) high-resolution T2WI were obtained through a 3D turbo spin echo (TSE) sequence, with the following parameters: TR/TE = 3556/113 ms, field of view (FOV) = 180×180 mm^2, slice thickness = 3 mm, and no inter-slice gap.

MRI Image Analysis

The images were stored and transmitted in the DICOM (Digital Imaging and Communications in Medicine) format, ensuring patient anonymity. All high-resolution T2WI were then transferred to a post-processing workstation for display as both axial and sagittal prostate views.

Qualitative Analysis

The patient images were randomly reviewed by two genitourinary radiologists, each with 5 to 7 years of experience in prostate MRI. They independently evaluated the boundaries of the central gland and peripheral zone on axial and sagittal T2WI using a 3-point Likert scale (3 points for well-defined; 2 points for indistinct; 1 point for poorly defined). All evaluations were overseen by a senior radiologist. In the event of discrepancies, the final rating was determined after a discussion with the senior radiologist.

Quantitative Analysis

A radiologist with 5 years of experience in prostate MRI delineated and analyzed the regions of interest (ROIs) using ITK-SNAP software (ITK-SNAP v.3.6.0, http://www.itksnap.org), with supervision from a senior radiologist. To measure the T2-weighted signal intensity, four circular ROIs, each with a diameter of 1 cm, were drawn on sagittal prostate images, representing the symmetrical layers of the peripheral zone (PZ) and central gland (CG). Similarly, ROIs of the same size were placed within the obturator internus muscle. The signal intensity ratio (SIR) for each ROI was then calculated using the signal intensity of the obturator internus muscle as the denominator.

Statistical Analysis

Statistical analysis were conducted using R version 3.1 (R Foundation for Statistical Computing). Likert scale scores were presented as means along with the corresponding maximum and minimum values. The Wilcoxon rank-sum test was used to compare differences in Likert scale scores between the two groups. SIR values were presented as means with standard deviation (SD). The Shapiro–Wilk test was employed to assess the normality of the data distribution. Independent samples t-tests were applied for normally distributed data, while the Wilcoxon rank-sum test was used for non-normally distributed data. A $p < 0.05$ was considered statistically significant.

Results

Patient Characteristics

The abstinence group consisted of 20 male patients (40%), with an average age of 27.55 years (range: 22.7–34.6 years) and an average abstinence period of 9.13 days (range: 5–15 days). The ejaculation group included 30 males (60%), with an average age of 28.15 years (range: 22.5–34.9 years) and an average abstinence period of 2.13 days (range: 1–3 days). A significant difference was observed in the abstinence periods between the two groups ($P = 0.000$), while no significant difference was found in age ($P = 0.772$) (Table 1).

Qualitative Analysis

A significant difference was observed in the clarity of the boundary between the central gland and the peripheral zone between the two groups ($P = 0.000$). In the abstinence group, 50.00% (10/20) of the T2WI exhibited clear boundaries, while only 10.00% (2/20) showed unclear boundaries. In contrast, the majority (70.00%, 21/30) of T2WI in the ejaculation group displayed indistinct boundaries between the two structures, with only 3.33% (1/30) showing clear boundaries (Table 2).

Quantitative Analysis

No significant differences were observed in the SIR of the CG and PZ between the left and right sides within the same group (Table 3, Figure 1). However, significant differences were found in the SIR of the CG, PZ, and the PZ-CG ratio between the two groups (all $P < 0.05$) (Figure 2).

Discussion

Our study shows that through qualitative analysis of the T2WI, the prostate structures were more clearly identifiable in the abstinence group. Quantitative analysis further revealed that the signal intensity of the PZ and CG was higher in the abstinence group, leading to a more pronounced contrast between the PZ and CG.

Table 1 Patient Characteristic of Two Groups

Group	n	Age	Time
Abstinence	20	27.55(4.27)	9.13(3.52)
Ejaculation	30	28.15(3.85)	2.13(0.83)
P-value	——	0.772	0.000

Note: Data are presented as mean (SD).

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Table 2 The Sharpness of Boundary Between the Central Gland and Peripheral Zone in Two Groups

Group	Score		
	Ill-defined	Obscure	Well-defined
Abstinence	2	8	10
Ejaculation	21	8	1
X^2	21.937		
P-value	0.000		

Table 3 The SIR at Different ROI of Both Side in Two Groups

	Left			Right		
	PZ-CG	CG-MUS	PZ-MUS	PZ-CG	CG-MUS	PZ-MUS
Abstinence	1.60 (0.31)	3.77 (0.76)	5.88 (0.56)	1.63 (0.35)	3.65 (0.66)	5.82 (0.95)
Ejaculation	1.26 (0.20)	3.04 (0.54)	3.76 (0.56)	1.24 (0.21)	2.94 (0.50)	3.57 (0.51)
P-value	0.000	0.000	0.000	0.000	0.000	0.000

Note: Data are presented as mean (SD).

Previous studies have indicated that ejaculation may influence the T2WI and ADC signals of the prostate. Medved et al and Shin et al manually delineated ROIs on typical slices and fully segmented the CG and PZ of the prostate based on their clinical experience.[13,14] However, the relatively small volume of the transitional zone (TZ) in young men makes segmentation challenging, especially after ejaculation, when prostate signals change. These factors present difficulties in manual segmentation. Consequently, Barrett et al chose not to segment different regions, instead using the entire prostate as a single ROI. However, distinct characteristics exist within different prostate structures on T2WI, which may impact results.[15] To mitigate these effects, a full segmentation of the prostate into CG and PZ was not attempted. Instead, ROIs of the same size were drawn on both sides of the prostate, placing one ROI in the left CG and the other in the right PZ. Quantitative analysis of the SIR between the left and right sides within the same group showed no statistically significant differences, indicating that the ROIs drawn at contralateral positions represent the same prostate structure. This suggests that our ROI delineation method is more reasonable.

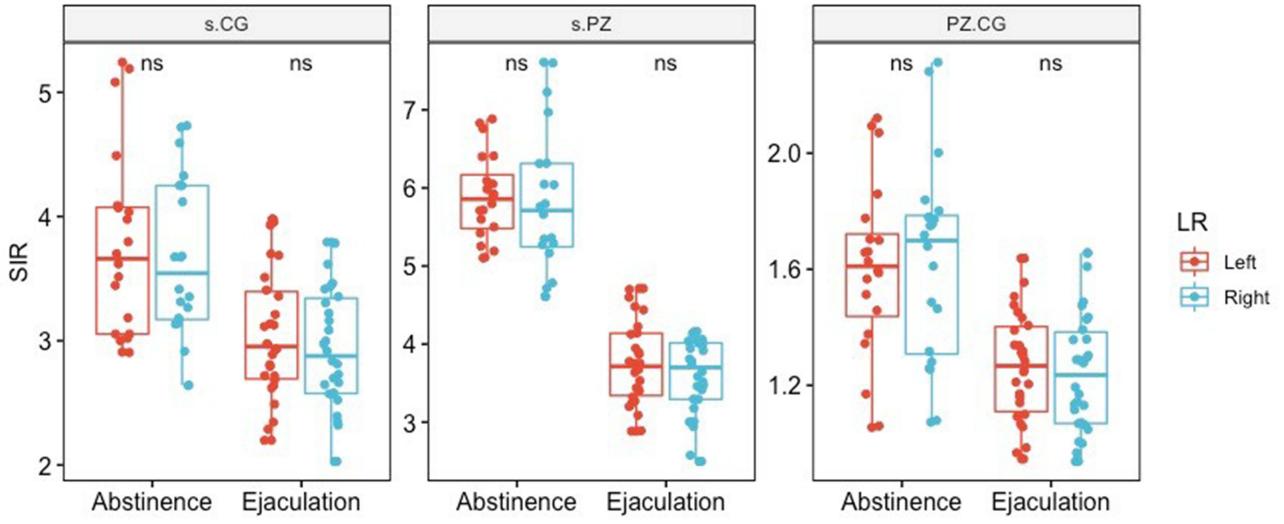

Figure 1 The SIR of the CG, PZ, and the PZ-CG between left and right sides. There are no difference between the left and right sides in the same group, *P*>0.05.
Abbreviations: s.CG, signal ratio of the central gland; s. PZ, SIR of the peripheral zone; ns, No significant.

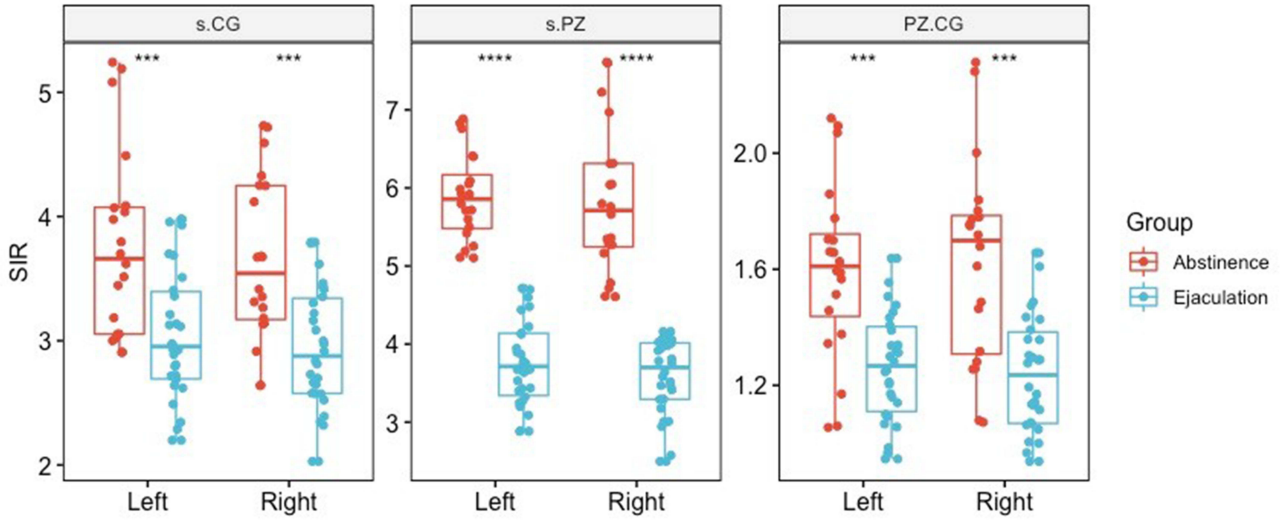

Figure 2 The signal ratio of CG, PZ and PZ-CG on the same side between the two groups. The SIR of CG, PZ and PZ-CG on the same side between the abstinence group and ejaculation group were statistically different, all *P*=0.000. ***: *P*<0.001; ****: *P*<0.0001.
Abbreviations: s.CG, SIR of the central gland; s. PZ, SIR of the peripheral zone.

Our study found that the SIR of the PZ and CG was lower in the ejaculation group compared to the abstinence group. This suggests that the prostate structures are less distinguishable in the ejaculation group, which could potentially affect the accuracy of prostate MRI in detecting and characterizing prostate lesions. Prostate cancer often appears as low-signal lesions on T2WI, and a lower SIR might make it more challenging to differentiate between normal prostate tissue and potential cancerous lesions. This finding supports the PI-RADS v2.1 guidelines, which recommend a 3-day abstinence period before prostate MRI to ensure optimal image quality. By highlighting the impact of ejaculation on MRI image quality, our study underscores the importance of patient preparation protocols in improving the reliability and accuracy of prostate MRI. Ensuring that patients follow the recommended abstinence period can enhance diagnostic confidence and reduce the likelihood of false-negative results, ultimately leading to better patient outcomes.

In this study, it was observed that the SIR of the PZ and CG was lower in the ejaculation group compared to the abstinence group, with a more significant decrease in the SIR of the PZ. This suggests that PZ and CG are more distinguishable in the abstinence group. Approximately 70% of the prostate is comprised of the PZ, while 25% is occupied by the central zone (CZ). The prostate glands gradually secrete prostatic fluid, which is stored within the glands, contributing to the high density of the prostate. These fluids, which make up around 30% of semen, are released into the urethra during ejaculation. In this study, a reduction in prostate signal intensity following ejaculation was observed. Given that the PZ stores more prostatic fluid, the decrease in signal intensity in the PZ after ejaculation is more pronounced than in the CG.

Due to the destruction of glandular structures, It prostate cancer appears as low-signal lesions on T2WI.[16] It was speculated that the reduction in prostate signal intensity after ejaculation may impact the detection of prostate malignant tumors, particularly when using certain quantitative methods. Therefore, it is important for patients to abstain from sexual activity for a specific period before undergoing an MRI examination. However, PI-RADS explicitly notes that the recommendation for a 3-day abstinence period is grounded in clinical experience with insufficient evidence to back this practice at present. In this retrospective study, patients were categorized into two groups based on whether they abstained for 3 days, and the observed results support the recommendation for abstinence prior to the examination. However, further research is necessary to determine the ideal abstinence period by comparing MRI images taken at different time points.

This study has several limitations. First, the study population consisted entirely of healthy young men, whereas clinical scenarios are more complex. Specifically, as men age, both prostate volume and the T2-weighted signal intensity of the PZ increase. The effects of ejaculation on the hyperplastic prostate have not yet been studied. In particular, the changes in signal intensity following ejaculation in patients with prostate cancer require further investigation and analysis. Our study only focused on young healthy men (20–35 years), where the prostate anatomy is relatively uniform

and less complex. In this population, the PZ and CG are more easily distinguishable, and the signal intensity variations are more consistent. However, in elderly men, age-related changes such as benign prostatic hyperplasia (BPH) can lead to significant enlargement of the prostate and increased signal heterogeneity. These changes can complicate the interpretation of T2WI signals and may affect the impact of abstinence on MRI image quality. Future studies should investigate whether the same abstinence period is equally effective in elderly men and explore the use of multiparametric MRI (mp-MRI) sequences to differentiate between normal age-related changes and pathological conditions.

Additionally, manually outlining ROIs completely and accurately is challenging. ROIs were delineated by selecting points on both sides of the region in this study, and this may introduce some bias into the results. With the advancement of artificial intelligence, machine learning methods could fully automate prostate segmentation, thus mitigating biases introduced by manual delineation. Furthermore, while PI-RADS recommends using multiparametric MRI (mp-MRI) sequences, including T2WI, DWI, and DCE for prostate cancer detection, this study was limited to analyzing only T2WI differences due to data constraints. Thus, further research is required to assess the impact of ejaculation on other imaging sequences.

Based on the above reasons, we have put forward the following assumptions for future research directions: Automated Segmentation Techniques: Future studies should explore the use of AI and machine learning to automate the segmentation of prostate structures, thereby reducing the need for manual ROI delineation and minimizing bias; Multiparametric MRI Analysis: Future research should include a comprehensive evaluation of all components of mp-MRI to determine the impact of abstinence on different imaging sequences. This will provide a more complete picture of how sexual activity affects prostate MRI results; Broader Patient Populations: Future studies should include a broader range of patient populations, including older men and those with prostate conditions such as BPH or prostate cancer, to validate our findings and ensure their clinical relevance.

Conclusion

In summary, our study found that the T2-weighted signal intensity ratio (T2WI-SIR) of both the CG and PZ in the prostate decreases after ejaculation in healthy young men. Furthermore, the decrease in the SIR of the PZ is more pronounced than that of the CG, which complicates the identification of internal prostate structures. Based on these findings, the recommendation for abstinence before prostate MRI examinations is supported. In accordance with PI-RADS guidelines, at least 3 days of abstinence prior to prostate MRI is recommended. Our study provides evidence for the recommendation of abstinence for 3 days prior to prostate MRI. This finding has direct application to clinical practice as it helps to ensure the highest quality of MRI images, thereby increasing diagnostic accuracy and improving patient prognosis. Moreover, the results of this study provide baseline data for understanding T2WI signal changes in young healthy men. These data may provide a basis for future exploration of the effects of abstinence on older men and men with prostate disease such as BPH or prostate cancer.

Abbreviations

MRI, magnetic resonance imaging; PZ, peripheral zone; CG, central gland; ROIs, region of interests; SI, signal intensity; SIR, SI ratio; PCa, Prostate cancer; mp-MRI, Multi-parameter MRI; T2WI, T2-weighted imaging; DWI, diffusion-weighted imaging; DCE-MRI, dynamic contrast-enhanced MRI; ADC, apparent diffusion coefficient; 3D, Three-dimensional; TSE, turbo spin echo; FOV, field of view; DICOM, Digital Imaging and Communications in Medicine; SD, standard deviation.

Data Sharing Statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethics Approval and Consent to Participate

This study was conducted with approval from the Ethics Committee of Xi'an No.3 hospital, The Affiliated Hospital of Northwest University (SYLL-2023-067). This study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants.

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Disclosure

The authors declare that they have no competing interests in this work.

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