

Chinese Journal of Cancer Prevention and Treatment

eISSN: None / ISSN: 1673-5269 **Open Access**

Research Article

Comparative Evaluation of High b-Value Diffusion-Weighted MRI (b1500 vs b2000 s/mm^2) for Prostate Lesion Assessment at 1.5 Tesla: A Prospective Observational Study

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Article History
Received: 22. 09. 2026
Revised: 01. 10. 2026
Accepted: 20. 10. 2026
Published: 05. 11. 2026

Citations:
Rakshitha, Sahana, Rajitha D. Comparative evaluation of high b-value diffusion-weighted MRI (b1500 vs b2000 s/mm^2) for prostate lesion assessment at 1.5 Tesla: a prospective observational study. Chin. J. Cancer Prev. Treat, 33(11) 01-08, 2026.

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Abstract: Prostate cancer is among the most commonly diagnosed malignancies in men worldwide, and diffusion-weighted imaging (DWI) is a core component of multiparametric MRI (mpMRI) for detecting and characterizing prostate lesions. Higher b-values improve the visualization of restricted diffusion in malignant tissue but lower the signal-to-noise ratio (SNR), and the optimal high b-value for 1.5 Tesla (T) systems remains uncertain. Objective: To compare directly acquired DWI at b-values of 1500 and 2000 s/mm^2 in terms of lesion conspicuity and overall image quality, and to identify the more suitable high b-value for prostate lesion evaluation at 1.5 T. ***Materials and Methods***: This prospective, cross-sectional observational study was conducted between February and May 2026 at Mangala Hospital and Kidney Foundation, Mangaluru, India, on a 1.5 T MRI system. Of 30 planned prostate MRI examinations, 23 met the inclusion criteria and were analyzed. Images at b1500 and b2000 were scored for lesion conspicuity and overall image quality on 5-point Likert scales by a single reader, blinded to b-value, in consultation with a radiologist, and mean scores were compared using paired analysis. ***Results***: Lesion conspicuity was significantly higher at b2000 than at b1500 (4.1 ± 0.6 vs 2.9 ± 0.5; $p < 0.05$), whereas overall image quality was significantly higher at b1500 (4.2 ± 0.4 vs 3.0 ± 0.5; $p < 0.05$), reflecting greater noise and lower SNR at the higher b-value. ***Conclusion***: At 1.5 T, b2000 DWI improved subjective lesion conspicuity compared with b1500, at the cost of increased noise and lower overall image quality. Because the assessment was qualitative and lacked quantitative SNR/contrast-to-noise ratio (CNR) measurement, standardized quality scoring and histopathological confirmation, these findings are hypothesis-generating. They support further evaluation of high b-value optimization strategies, including synthesized DWI and deep learning reconstruction, for prostate MRI at 1.5 T.

Keywords: Prostate cancer; Diffusion-weighted imaging; b-value; Magnetic resonance imaging; Lesion conspicuity; PI-RADS

INTRODUCTION

Prostate cancer is one of the most frequently diagnosed malignancies in men and a leading cause of cancer-related mortality worldwide, and its incidence continues to rise as populations age (1,2). Early and accurate detection of clinically significant disease is therefore a priority, and mpMRI has become the reference imaging technique for lesion detection, localization and risk stratification, outperforming earlier protocols based on T2-weighted imaging alone (3–5).

DWI is one of the three core sequences of the Prostate Imaging–Reporting and Data System (PI-RADS), together with T2-weighted and dynamic contrast-enhanced imaging, and it is the dominant sequence for scoring peripheral zone lesions (6). Malignant prostate tissue typically shows increased cellularity and restricted water diffusion, which appears as high signal on high b-value DWI. Increasing the b-value improves lesion-to-background contrast by further suppressing signal from normal, freely diffusing tissue, but it also lowers the SNR of the acquisition, which can degrade anatomical clarity and introduce artifacts (7,8). Several studies, mostly performed at 3 T, have shown that acquired or computed high b-value images (b ≥ 1500–2000 s/mm^2) improve lesion conspicuity compared with lower b-value acquisitions, albeit with some loss of image quality (7,8), and inter-reader reproducibility of DWI-based PI-RADS scoring remains only moderate even among experienced readers (9). Evidence at 1.5 T, where intrinsic SNR is

lower than at 3 T, is comparatively limited, and the optimal high b-value for routine 1.5 T protocols has not been firmly established (10–12).

PI-RADS permits high b-value DWI to be either directly acquired or synthesized (computed) by extrapolation from lower b-value acquisitions (6). Synthesized high b-value DWI has been proposed as a way of preserving lesion contrast while avoiding the SNR penalty of direct high b-value acquisition, and its performance has recently been compared directly with that of acquired high b-value imaging (13). Deep learning-based reconstruction offers a further approach to this trade-off, with early evidence that it can improve DWI image quality without prolonging acquisition time (14). Objective, standardized tools for grading prostate MRI quality, such as the Prostate Imaging Quality (PI-QUAL) score, have also been developed to supplement purely subjective assessment (15). The present study evaluated only directly acquired b1500 and b2000 DWI using subjective Likert scoring; synthesized DWI, deep learning reconstruction and objective quality metrics were not applied, and these approaches are considered further in the Discussion (16–18).

This study therefore aimed to prospectively compare DWI acquired at b-values of 1500 and 2000 s/mm^2 on a 1.5 T MRI system, using lesion conspicuity and overall image quality as endpoints, in order to identify the more suitable high b-value for prostate lesion evaluation in routine clinical practice.

MATERIALS AND METHODS

Study Design and Setting

This prospective, cross-sectional, observational study was conducted between February 1 and May 25, 2026, at Mangala Hospital and Kidney Foundation, Mangaluru, Karnataka, India. The study was approved by the Mangala Institutional Ethics Committee (approval no. MIEC/8.1/133, dated 27 February 2025), and written informed consent was obtained from all participants.

Study Population

Patients with clinically suspected prostate cancer who were referred for MRI were considered for inclusion. Exclusion criteria were severe motion artifacts, hip prosthesis causing image distortion, incomplete imaging sequences and previously treated prostate cancer. A sample of 30 examinations was planned; 23 met the inclusion criteria and were analyzed. The remaining seven were excluded because of artifacts or inadequate lesion visualization, most often in patients with prostatomegaly.

Patient Positioning and Coil Set-up

Patients were positioned supine with the body aligned straight and parallel to the central alignment light. A pelvic phased-array coil was placed over the pelvis and secured with immobilization devices, and the centering point was set at the pubic symphysis. Patients were instructed to remain still throughout the examination, and earplugs were provided for hearing protection. The complete set-up is summarized in Table 1 (Part A).

MRI Protocol

All examinations were performed on a 1.5 T MRI system (MAGNETOM Essenza, Siemens Healthineers, Erlangen, Germany) using the institutional standard prostate protocol supplemented by high b-value DWI. Representative DWI parameters were TR/TE of approximately 3500/85 ms, slice thickness of 3.0 mm, matrix of 128 × 128 and b-values of 0, 100, 1500 and 2000 s/mm^2, with 1–2 excitations (NEX) for b0 and b1500 and 5–8 for b2000. Four spatial saturation bands were placed around the field of view, one in each in-plane direction. The full acquisition parameters are listed in Table 1 (Part B).

Image Analysis

Images at b1500 and b2000 s/mm^2 were acquired directly with the scanner's native diffusion sequence; no synthesized (computed) high b-value images and no deep learning-based denoising or reconstruction were used. For each case, both image sets were reviewed and scored for lesion conspicuity and overall image quality on 5-point Likert scales (Table 2) by a single reader in consultation with a radiologist with one year of experience. The reader was blinded to b-value, and image sets were reviewed in random order. Quantitative SNR and CNR were not measured, a standardized quality instrument such as PI-QUAL was not applied (12,15), and multi-reader scoring for interobserver agreement was not performed. No histopathological or biopsy reference standard was available; conspicuity scores therefore represent visual detectability on imaging rather than confirmed diagnostic accuracy.

Statistical Analysis

Lesion conspicuity and image quality scores are presented as mean ± standard deviation (SD). Scores at b1500 and b2000 were compared using a paired test, and the mean difference (b2000 − b1500) was calculated for each parameter. A p-value < 0.05 was considered statistically significant.

RESULTS

Of the 30 planned examinations, 23 met the inclusion criteria and were analyzed, and paired b1500 and b2000 assessment was completed in all 23 cases.

Lesion conspicuity was significantly higher at b2000 than at b1500 (4.1 ± 0.6 vs 2.9 ± 0.5; mean difference +1.2; $p < 0.05$) (Table 3, Fig. 1). In contrast, overall image quality was significantly higher at b1500 (4.2 ± 0.4 vs 3.0 ± 0.5; mean difference −1.2; $p < 0.05$) (Table 3, Fig. 2), consistent with greater noise and lower SNR at the higher b-value.
Qualitatively, b2000 images showed stronger suppression of background prostatic signal and more confident depiction of diffusion-restricted lesions, whereas b1500 images retained better anatomical clarity with less perceptible noise. Despite the noise penalty, lesions suspicious for malignancy were more readily identified on b2000 images. Representative cases are shown in Figures 3 and 4: a 60-year-old man with clinically suspected prostate carcinoma and a PI-RADS 3 index lesion (Fig. 3), and a 66-year-old man with benign prostatic enlargement, likely prostatitis and a probably benign pelvic cyst (PI-RADS 1) (Fig. 4).

Table 1. Patient positioning and diffusion-weighted imaging (DWI) acquisition protocol at 1.5 T

Component	Specification	Purpose / note
A. Patient preparation and positioning		
Patient position	Supine on the MRI table	Stable, comfortable position that limits motion
Body alignment	Body straight and parallel to the central alignment light	Places the prostate near the magnet isocenter
Receiver coil	Pelvic phased-array coil placed over the pelvis	Maximizes local signal reception
Coil fixation	Coil secured with immobilization devices	Reduces coil movement and respiratory motion
Centering point	Pubic symphysis	Centers the field of view on the prostate
Patient instruction	Remain still throughout the examination	Minimizes motion artifacts, to which DWI is sensitive
Hearing protection	Earplugs	Noise protection and patient comfort
B. DWI acquisition parameters		
MRI system	1.5 T MAGNETOM Essenza (Siemens Healthineers)	—
Imaging plane	Axial	—
TR / TE	≈ 3500 / 85 ms	Approximate; varied slightly between examinations
Slice thickness	3.0 mm	—
Acquisition matrix	128 × 128	—
b-values	0, 100, 1500 and 2000 s/mm²	b1500 and b2000 compared in this study
NEX	b0 and b1500: 1–2; b2000: 5–8	More averages at high b-value offset the SNR loss
Saturation bands	b2000-Four bands, one in each in-plane direction Band thickness - 76mm	Suppress signal from tissue outside the field of view, reducing aliasing and motion artifacts
High b-value images	Directly acquired with the native diffusion sequence	No synthesized (computed) DWI or deep learning reconstruction

NEX, number of excitations; SNR, signal-to-noise ratio; TE, echo time; TR, repetition time.

Table 2. Five-point Likert scales used for lesion conspicuity and overall image quality scoring

Score	Lesion conspicuity	Overall image quality
1	Not visible	Non-diagnostic
2	Poorly visible	Severe noise
3	Moderately visible	Acceptable quality
4	Clearly visible	Good quality
5	Highly conspicuous	Excellent quality

Table 3. Comparison of mean lesion conspicuity and overall image quality scores between b1500 and b2000 DWI (n = 23)

Parameter	b1500 (mean ± SD)	b2000 (mean ± SD)	Mean difference (b2000 – b1500)	p-value*
Lesion conspicuity	2.9 ± 0.5	4.1 ± 0.6	+1.2	< 0.05
Overall image quality	4.2 ± 0.4	3.0 ± 0.5	−1.2	< 0.05

SD, standard deviation. Scores on 5-point Likert scales (Table 2). *Paired comparison.

FIGURE LEGENDS

Fig. 1. Mean lesion conspicuity scores at b1500 and b2000 DWI (n = 23). Error bars indicate standard deviation.

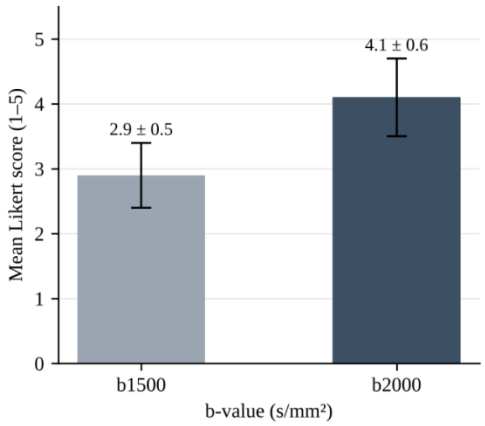


Fig. 1

Fig. 2. Mean overall image quality scores at b1500 and b2000 DWI (n = 23). Error bars indicate standard deviation.

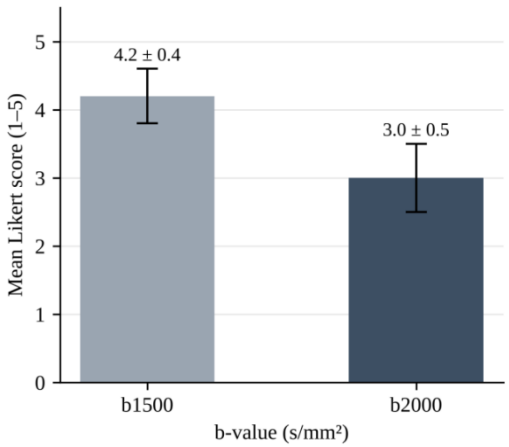


Fig. 2

Fig. 3. Axial DWI in a 60-year-old man with clinically suspected prostate carcinoma (index lesion, PI-RADS 3). (a) b1500 and (b) b2000 images, show the same images with the lesion outlined in red.

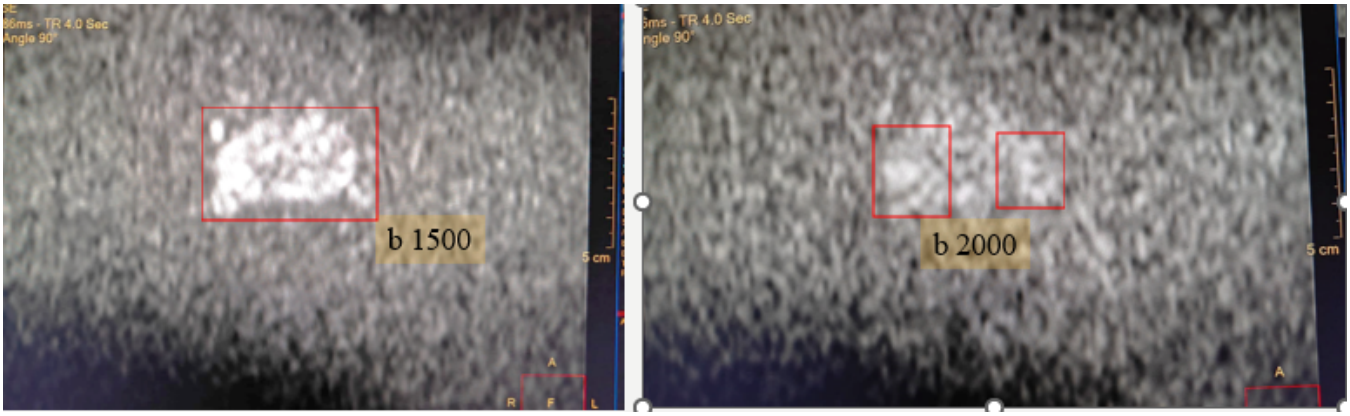


Fig. 3

Fig. 4. Axial DWI in a 66-year-old man with benign prostatic enlargement, likely prostatitis and a probably benign pelvic cyst (PI-RADS 1), acquired at b1500 (left) and b2000 (right). Note the stronger background suppression and higher noise at b2000.

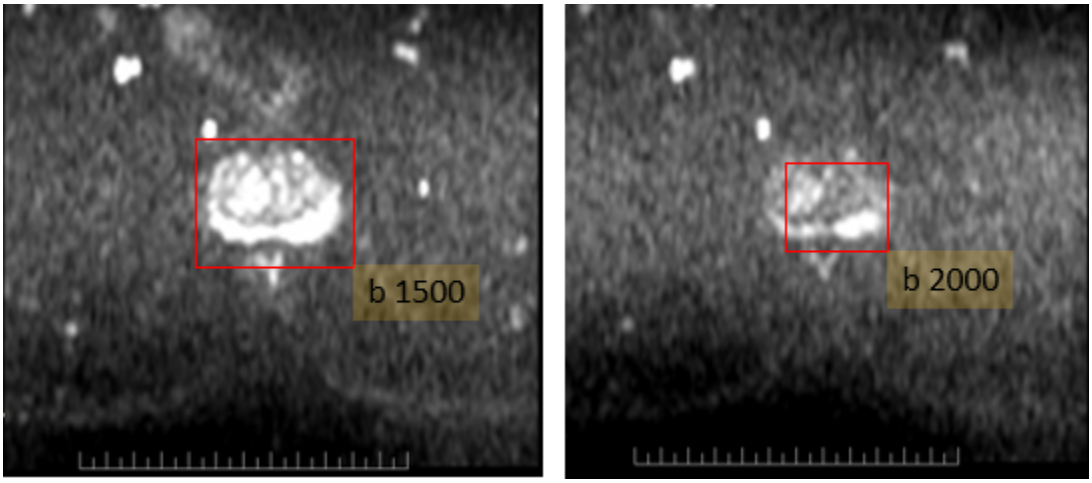


Fig. 4

DISCUSSION

DWI characterizes prostate tissue by measuring the restriction of water motion; malignant tissue typically has higher cellular density and therefore greater diffusion restriction, which produces high signal on high b-value images (6,19,20). In the present study, lesion conspicuity was significantly better at b2000 than at b1500, in keeping with the principle that increasing the b-value progressively suppresses signal from normal, freely diffusing tissue and so improves lesion-to-background contrast (7,8). This agrees with previous, predominantly 3 T studies showing that acquired or computed high b-value DWI (b ≥ 1500–2000 s/mm²) improves lesion conspicuity compared with lower b-values (8,21) and extends the observation to 1.5 T, where lower intrinsic SNR makes the trade-off between lesion contrast and noise more pronounced.

The higher b-value was also associated with lower overall image quality, driven by increased noise and reduced SNR, reflecting the recognized physical trade-off of high b-value DWI (7,8). While b1500 images preserved better anatomical clarity, diffusion restriction was better appreciated on b2000 images. Neither b-value was therefore optimal for both endpoints, which supports protocols that acquire both, or that derive a computed high b-value series from lower b-value data, when scanner time permits (8).

An important caveat is that much of the foundational evidence on high b-value DWI, including the direct comparison of b1000 and b2000 image sets that informed the present study design, comes from 3 T systems (7). Because intrinsic SNR scales approximately with field strength, the noise penalty of high b-value acquisition is expected to be greater at 1.5 T, and 3 T findings should be extrapolated to 1.5 T protocols with caution. This is the

setting in which synthesized high b-value DWI is most attractive: because it is extrapolated from lower, higher-SNR b-value acquisitions rather than acquired directly, it can preserve lesion contrast while limiting additional noise, and its performance relative to acquired high b-value DWI has been evaluated in recent comparative work (8,13). Only acquired b1500 and b2000 sequences were evaluated here; a head-to-head comparison with synthesized high b-value DWI on the same 1.5 T platform is an important next step, particularly as the two approaches can differ in diagnostic performance (13). Deep learning-based reconstruction is a further option, having been shown to improve prostate DWI quality without prolonging acquisition time (14); it was not applied in this study.

DWI interpretation, even at high b-values, remains partly subjective. This study relied on 5-point Likert scoring by a single reader in consultation with one radiologist, without quantitative SNR or CNR measurement or a standardized instrument such as PI-QUAL (12,15). Likert scoring reflects routine qualitative clinical assessment but cannot replace objective metrics, and without multi-reader scoring, interobserver agreement could not be assessed. This is relevant because inter-reader reproducibility of DWI-based PI-RADS scoring is only moderate, even among experienced radiologists (9). Importantly, no histopathological or biopsy reference standard was available. The higher conspicuity at b2000 therefore reflects visual detectability on imaging rather than confirmed diagnostic accuracy, and part of it may reflect noise-related signal change rather than true tumor-related diffusion restriction. The findings should accordingly be regarded as hypothesis-generating rather than as evidence of improved cancer detection. Nonetheless, despite the reduced sample size, the study produced a consistent comparative signal and shows that high b-value DWI protocols can be evaluated systematically in a resource-constrained 1.5 T clinical setting.

LIMITATIONS

This study has several limitations. The sample was small (n = 23), and the single-center, single-scanner design limits generalizability to other centers and MRI vendors. Excluding examinations with artifacts or inadequate lesion visualization may have introduced selection bias. Assessment relied on subjective Likert scoring by a single reader, in consultation with a radiologist of limited (one year) experience, rather than quantitative apparent diffusion coefficient (ADC), SNR or CNR measurement, or a standardized instrument such as PI-QUAL. No histopathological reference standard was available, and only acquired, not synthesized or deep learning-reconstructed, high b-value DWI was evaluated. Comparison with the predominantly 3 T literature must allow for the difference in intrinsic SNR between field strengths. Resource constraints limited the extent of radiologist consultation and image analysis, and patient cooperation and scan duration were practical constraints of high b-value acquisition. Future work should include larger multicenter cohorts on different scanner platforms, with histopathological or biopsy correlation; multi-reader validation with formal interobserver agreement analysis; quantitative SNR, CNR and ADC analysis alongside PI-QUAL or similar standardized scoring; and head-to-head comparison of synthesized high b-value DWI and deep learning reconstruction with the acquired b1500 and b2000 protocols evaluated here.

CONCLUSION

In this prospective study at 1.5 T, directly acquired DWI at b2000 s/mm^2 provided significantly better subjective lesion conspicuity and depiction of diffusion restriction than b1500 s/mm^2, whereas b1500 provided better overall image quality with less noise. Because these observations are based on single-reader qualitative assessment without quantitative SNR/CNR measurement, standardized quality scoring or histopathological confirmation, they should be regarded as hypothesis-generating. They nonetheless provide real-world clinical evidence from a 1.5 T setting that warrants further evaluation, incorporating synthesized high b-value DWI, deep learning reconstruction, objective quality metrics such as PI-QUAL, multi-reader reliability analysis and histopathological correlation, before specific high b-value recommendations can be made for routine 1.5 T prostate MRI.

DECLARATIONS

Ethics approval and consent to participate: The study was approved by the Mangala Institutional Ethics Committee (approval no. MIEC/8.1/133, dated 27 February 2025). Written informed consent was obtained from all participants.

Consent for publication: Written informed consent for publication of anonymized images was obtained from the patients whose images are shown in Figures 3 and 4.

Availability of data and materials: The datasets analyzed during the current study are available from the corresponding author upon reasonable request.

Conflict of interest: The authors declare no conflicts of interest.

Funding: This study was supported by an Undergraduate Research Grant (Project Code: UG25AHS0047) from Rajiv Gandhi University of Health Sciences (RGUHS), Karnataka, India.

Author contributions: Conceptualization and supervision: Rakshitha; data curation, investigation and formal analysis: Sahana; methodology: Sahana, D. Rajitha and Rakshitha; writing – original draft: Sahana; writing –

review and editing: D. Rajitha and Rakshitha. All authors have read and approved the final manuscript.

Acknowledgements: The authors thank the MRI and radiology staff of Mangala Hospital and Kidney Foundation, Mangaluru, and the consulting radiologist for their contribution to image interpretation, and Rajiv Gandhi University of Health Sciences for funding support under the Undergraduate Research Grant scheme.

Generative AI use disclosure: AI-assisted tools were used for language editing and reference formatting support during manuscript preparation; all scientific content, data and conclusions were generated and verified by the authors, who take full responsibility for the accuracy of the manuscript. AI tools are not listed as authors.

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