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Systematic Review and Meta-Analysis

Diagnostic Accuracy of Biparametric Versus Multiparametric MRI for Clinically Significant Prostate Cancer: A Systematic Review and Meta-Analysis

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Abstract

Background: Multiparametric MRI (mpMRI) with T2-weighted, diffusion-weighted and dynamic contrast-enhanced sequences is the standard imaging test before prostate biopsy. Biparametric MRI (bpMRI) omits the contrast sequence, which makes the examination shorter, cheaper and free of gadolinium. Whether this costs diagnostic accuracy for clinically significant prostate cancer (csPCa) is uncertain.

Aim: To compare the diagnostic accuracy of bpMRI and mpMRI for csPCa in studies in which both protocols were read in the same patients.

Materials and Methods: PubMed was searched from 1 January 2000 to 31 December 2023 for paired studies that reported, or allowed reconstruction of, 2 × 2 tables for both bpMRI and mpMRI against biopsy or prostatectomy histopathology. Risk of bias was assessed with QUADAS-2. Sensitivity and specificity were pooled separately for each protocol with a bivariate random-effects model and compared on the logit scale.

Results: Nine studies with 2901 patients or lesions (1109 with csPCa) were included. Pooled sensitivity was 91.3% (84.8 to 95.2) for bpMRI and 95.2% (91.3 to 97.4) for mpMRI (p = 0.16). Pooled specificity was 58.3% (41.4 to 73.4) for bpMRI and 48.3% (29.6 to 67.5) for mpMRI (p = 0.45). The areas under the summary receiver operating characteristic curves were 0.91 and 0.94. mpMRI was more sensitive in 9 of 9 studies, and bpMRI was at least as specific in 8. Across all studies, bpMRI missed 38 more cancers and gave 116 fewer false-positive results than mpMRI. Heterogeneity was high for specificity with both protocols.

Conclusion: bpMRI and mpMRI did not differ significantly in sensitivity or specificity for csPCa. mpMRI was slightly more sensitive in every study, while bpMRI gave fewer false-positive results. bpMRI is a reasonable option for biopsy-naive men when image quality and reader experience are high, and mpMRI remains preferable when a missed cancer would matter most.

Keywords: Contrast media; Diagnostic accuracy; Magnetic resonance imaging; Meta-analysis; Prostatic neoplasms; Sensitivity and specificity.

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Introduction

Prostate cancer is the second most commonly diagnosed cancer in men and the fifth leading cause of cancer death in men worldwide [1]. GLOBOCAN estimated 1.4 million new cases in 2020 [1]. Incidence rises steeply with age, and differences between countries partly reflect differences in testing [2].

MRI has changed the diagnostic pathway. In the PROMIS study, multiparametric MRI (mpMRI) had a sensitivity of 93% for csPCa against template mapping biopsy, compared with 48% for transrectal ultrasound biopsy, and its use as a triage test could have allowed 27% of men to avoid biopsy [3]. In the PRECISION trial, an MRI-first pathway with targeted biopsy detected more clinically significant cancers (38% versus 26%) and fewer insignificant cancers than standard biopsy [4]. Similar findings came from the MRI-FIRST study and a Cochrane review [5,6]. European guidelines now recommend MRI before biopsy [7].

The PI-RADS system defines mpMRI as T2-weighted imaging, diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) imaging [8]. DCE has a limited role. It is used mainly to upgrade peripheral zone lesions with an equivocal DWI score of 3 to a score of 4 [9]. Omitting DCE gives a biparametric MRI (bpMRI) that is shorter and cheaper, needs no intravenous cannula and avoids gadolinium, which can deposit in the brain after repeated doses [10]. These advantages matter in India, where MRI capacity is limited and many patients pay out of pocket. The

PI-RADS Steering Committee has accepted bpMRI for selected biopsy-naive men, provided image quality and reader expertise are high, but has advised mpMRI in other settings [11].

Earlier meta-analyses found similar accuracy for bpMRI and mpMRI [12-16]. However, several pooled single-protocol studies or reported any prostate cancer rather than csPCa, and few were limited to paired head-to-head data. This systematic review and meta-analysis compared the diagnostic accuracy of bpMRI and mpMRI for csPCa using only studies in which both protocols were assessed in the same patients.

Materials and Methods

Protocol and Reporting: The review followed the PRISMA statement for diagnostic test accuracy studies (PRISMA-DTA) [17]. Only published data were used, so ethics committee approval was not required. The protocol was not registered.

Search Strategy: PubMed/MEDLINE was searched from 1 January 2000 to 31 December 2023 with the string: (biparametric OR bpMRI OR bp-MRI OR abbreviated OR non-contrast OR without contrast OR dynamic contrast-enhanced) AND (multiparametric OR mpMRI OR mp-MRI) AND prostate AND (clinically significant OR csPCa) AND (sensitivity OR specificity OR diagnostic accuracy OR diagnostic performance). Targeted searches and the reference lists of included studies and earlier meta-analyses were also checked. Only studies published in English before 2024 were considered.

Eligibility Criteria: Studies were included if (a) bpMRI (T2-weighted imaging and DWI) and mpMRI (T2-weighted imaging, DWI and DCE) were interpreted in the same patients; (b) the target condition was csPCa, as defined by each study, usually Gleason score 3+4 or higher or ISUP grade group 2 or higher; (c) the reference standard was biopsy or prostatectomy histopathology, with or without follow-up; and (d) a 2 × 2 table could be obtained or reconstructed for both protocols. Studies were excluded if the two protocols were assessed in different patients or randomised arms, if only any prostate cancer was reported, if specificity could not be calculated, or if only reader ranges, areas under the curve or lesion visibility were reported. Reviews, case reports, protocols and letters were also excluded.

Data Extraction and Quality Assessment: The following were extracted: first author, year, country, design, setting, unit of analysis, positivity threshold, definition of csPCa, reference standard and the 2 × 2 tables for each protocol. When several readers were reported, the first reader was used. When counts were not given, they were reconstructed from the reported numbers of men with and without csPCa and the reported sensitivity, specificity and predictive values. For two studies the reconstruction was approximate [18,19]. Risk of bias was assessed with QUADAS-2 [20].

Statistical Analysis: For each protocol, sensitivity and specificity were pooled with the bivariate random-effects model fitted by maximum likelihood [21]. Likelihood ratios and diagnostic odds ratios (DOR) were derived from the pooled estimates. Summary receiver operating characteristic (SROC) curves and their areas under the curve (AUC) were obtained from the bivariate parameters. A continuity correction of 0.5 was used for zero cells. Pooled logit sensitivity and logit specificity of the two protocols were compared with a z test. Because the protocols were read in the same patients, treating the estimates as independent makes this test conservative. Within-study differences were also tabulated. Heterogeneity was quantified with I^2 [22]. Sensitivity analyses were limited to patient-level studies, studies using a threshold of PI-RADS or Likert 3 or higher, studies without approximate reconstruction, retrospective studies and studies of men at initial diagnosis, and excluded the study restricted to the transition zone. A leave-one-out analysis was performed. Publication bias was assessed with the Deeks test [23]. Analyses were done in Python 3 (NumPy and SciPy).

Results

Study Selection: The database search found 272 records, and 7 more came from targeted searches and reference lists (Figure 1). After screening of 279 titles and abstracts, 31 full-text articles were assessed. Twenty-two were excluded: 12 did not allow 2 × 2 tables for both protocols, 4 assessed the protocols in separate cohorts or randomised arms, and 6 had an ineligible outcome or population. Nine studies were included [18,19,24-30].

Characteristics of Included Studies: The nine studies were published between 2016 and 2023 and included 2901 patients or lesions, of whom 1109 (38.2%) had csPCa (Table 1). Three were from Germany or Denmark, two each from the United Kingdom, Italy and China.

Two were prospective [18,29], one was a retrospective analysis of prospectively collected data [25] and six were retrospective. Most studies assessed men with raised PSA or suspicion of cancer before biopsy. One study assessed men after a previous negative biopsy [25], one assessed candidates for active surveillance [29] and one was restricted to transition zone lesions [30]. Eight studies analysed results per patient and one per lesion [27]. Eight used PI-RADS or Likert 3 or higher as positive, and one used 4 or higher.

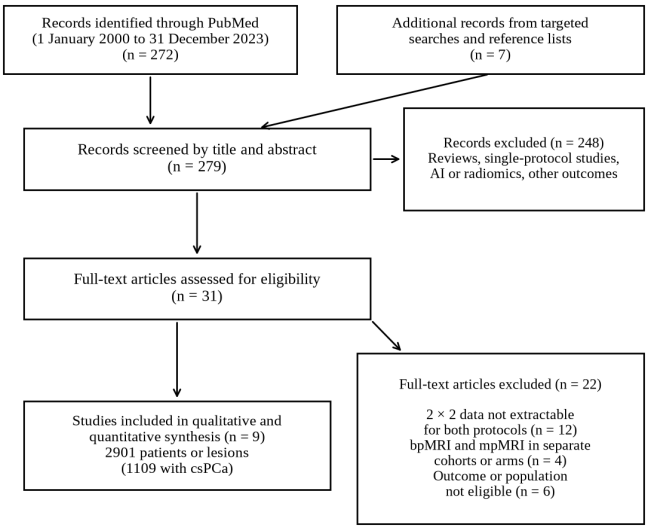


Figure 1: Flow diagram of study identification, screening and inclusion

The diagram follows the PRISMA-DTA statement. csPCa: clinically significant prostate cancer.

Table 1: Characteristics of the included studies

Study	Country	Design	Setting	Unit	Score cut-off	n (csPCa)	bpMRI TP/FP/FN/TN	mpMRI TP/FP/FN/TN
Thestrup 2016 [24]	Denmark	Retro	Elevated PSA, biopsy	Patient	≥3	204 (71)	67/113/4/20	71/128/0/5
Kuhl 2017 [25]	Germany	Retro*	Prior negative TRUS biopsy	Patient	≥3	542 (139)	138/58/1/345	139/69/0/334
Xu 2019 [26]	China	Retro	Suspected prostate cancer	Patient	≥3	235 (99)	83/45/16/91	87/50/12/86
Bosaily 2020 [18]	UK	Pro	Biopsy-naive men (PROMIS)	Patient	L≥3	497 (200)	188/186/12/111	190/186/10/111
Zawaideh 2020 [19]	UK	Retro	Suspected prostate cancer	Patient	L≥3	264 (93)	87/56/6/115	88/44/5/127
Brancato 2020 [27]	Italy	Retro	Lesions referred for biopsy	Lesion	≥4	117 (41)	29/18/12/58	38/37/3/39
Thaiss 2022 [28]	Germany	Retro	Biopsy-naive men	Patient	≥3	563 (308)	299/99/9/156	305/134/3/121
Zattoni 2023 [29]	Italy	Pro	Active surveillance candidates	Patient	≥3	54 (12)	10/29/2/13	11/29/1/13
Zhang 2023 [30]	China	Retro	Transition zone lesions	Patient	≥3	425 (146)	121/70/25/209	131/113/15/166

Retro: retrospective; Retro*: retrospective analysis of prospectively collected data; Pro: prospective. Score cut-off is PI-RADS unless marked L (Likert). csPCa: clinically significant prostate cancer; TP: true positive; FP: false positive; FN: false negative; TN: true negative. Counts were reconstructed from reported sensitivity, specificity, predictive values and patient numbers when not given directly; the reconstruction was approximate for Bosaily 2020 and Zawaideh 2020. First reader shown when several readers were reported.

Risk of Bias: Risk of bias is shown in Figure 2. Patient selection was at low risk in 3 studies with consecutive or prospective enrolment, unclear in 5 retrospective studies and high in one lesion-level study that selected biopsied lesions [27]. The index test was at low risk in 4 studies in which bpMRI was read separately from mpMRI and blinded to histopathology; in the others, the bpMRI read was

taken from the same session as the mpMRI read or blinding was unclear. The reference standard was at low risk in 5 studies in which all men had a thorough histological reference (template, saturation, or systematic plus targeted biopsy), and unclear in the rest.

Flow and timing was at high risk in one study in which men received different reference standards [24].

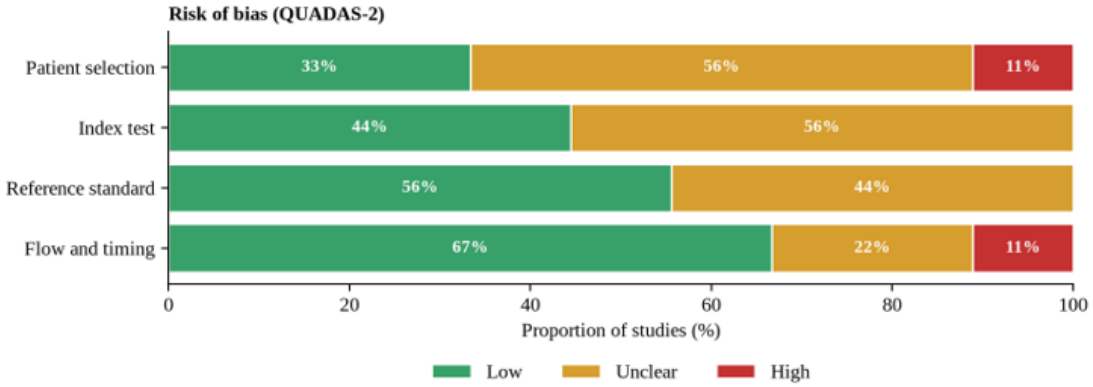


Figure 2: Risk of bias in the included studies (QUADAS-2)

Bars show the proportion of the nine studies judged at low, unclear or high risk of bias in each QUADAS-2 domain.

Pooled Diagnostic Accuracy: Study sensitivity ranged from 70.7% to 99.3% for bpMRI and from 87.9% to 100% for mpMRI; specificity ranged from 15.0% to 85.6% and from 3.8% to 82.9% (Figures 3 and 4). Pooled sensitivity was 91.3% (95% CI 84.8 to 95.2) for bpMRI and 95.2% (95% CI 91.3 to 97.4) for mpMRI, a difference of 3.9 percentage points (p = 0.16). Pooled specificity was 58.3% (95% CI 41.4 to 73.4) for bpMRI and 48.3% (95% CI 29.6 to 67.5) for mpMRI, a difference of 10.0 percentage points in favour of bpMRI (p = 0.45) (Table 2). The negative likelihood ratio was 0.15 for bpMRI and 0.10 for mpMRI.

The SROC AUC was 0.91 for bpMRI and 0.94 for mpMRI, and the summary points and confidence regions overlapped (Figure 5). Heterogeneity in specificity was high for both protocols (I^2 97% and 97%).

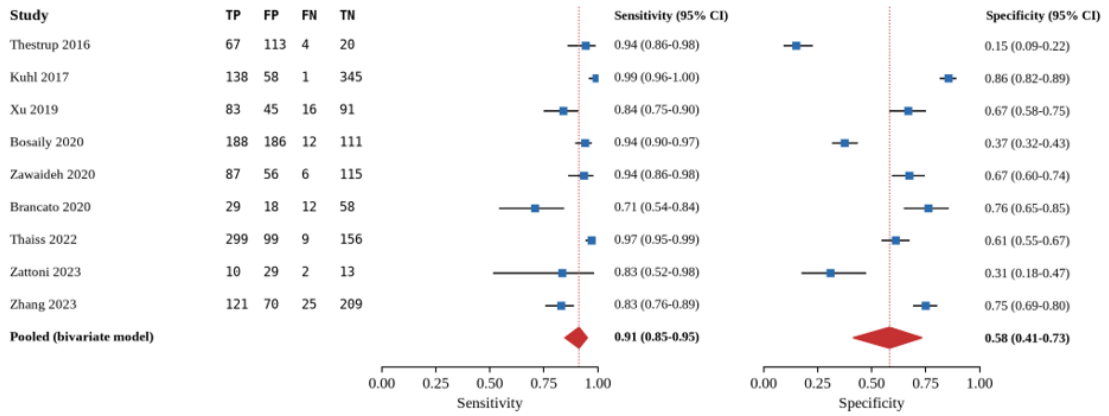


Figure 3: Forest plot of the sensitivity and specificity of biparametric MRI for clinically significant prostate cancer

Squares show study estimates with exact 95% confidence intervals; diamonds show pooled estimates from the bivariate random-effects model. TP: true positive; FP: false positive; FN: false negative; TN: true negative.

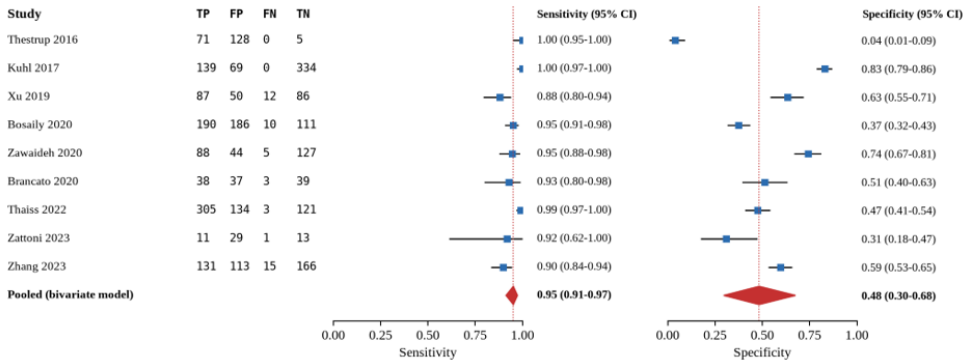


Figure 4: Forest plot of the sensitivity and specificity of multiparametric MRI for clinically significant prostate cancer

Squares show study estimates with exact 95% confidence intervals; diamonds show pooled estimates from the bivariate random-effects model. TP: true positive; FP: false positive; FN: false negative; TN: true negative.

Table 2: Pooled diagnostic accuracy of biparametric and multiparametric MRI (9 studies)

Measure	bpMRI (95% CI)	mpMRI (95% CI)	p value
Sensitivity (%)	91.3 (84.8 to 95.2)	95.2 (91.3 to 97.4)	0.16
Specificity (%)	58.3 (41.4 to 73.4)	48.3 (29.6 to 67.5)	0.45
Positive likelihood ratio	2.19 (1.55 to 3.40)	1.84 (1.36 to 2.89)	-
Negative likelihood ratio	0.15 (0.08 to 0.28)	0.10 (0.06 to 0.18)	-
Diagnostic odds ratio	14.6 (6.1 to 34.9)	18.4 (8.1 to 41.3)	-
Area under the SROC curve	0.91	0.94	-
I^2 sensitivity / specificity (%)	85 / 97	71 / 97	-
Total false negatives / false positives	87 / 674	49 / 790	-

p values are from a z test on the logit scale that treats the two pooled estimates as independent, which is conservative for paired data. bpMRI: biparametric MRI; mpMRI: multiparametric MRI; SROC: summary receiver operating characteristic.

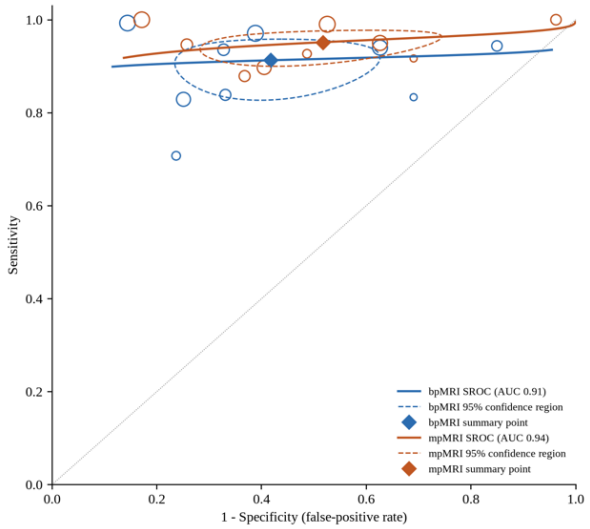


Figure 5: Summary receiver operating characteristic curves for biparametric and multiparametric MRI

Circles show individual studies, sized by sample size; diamonds show summary points, dashed lines their 95% confidence regions and solid lines the SROC curves. AUC: area under the curve; bpMRI: biparametric MRI; mpMRI: multiparametric MRI; SROC: summary receiver operating characteristic.

Within-study Comparison: Within studies, mpMRI had higher sensitivity than bpMRI in 9 of 9 studies, with differences ranging from 0.7 to 22.0 percentage points. The largest difference was in the lesion-level study, which used a threshold of 4 or higher, so lesions upgraded from score 3 to 4 by DCE counted as positive only with mpMRI [27]. bpMRI had higher specificity in 6 studies, equal specificity in 2 and lower specificity in one [19]. The largest specificity gains with bpMRI were in the transition zone study (15.4 points) [30] and in biopsy-naive men undergoing fusion biopsy (13.7

points) [28]. In absolute terms, bpMRI missed 38 more of 1109 cancers (3.4%) and avoided 116 false-positive results.

Sensitivity Analyses and Publication Bias: The results were similar in all sensitivity analyses (Table 3). The same eight studies were analysed per patient and used a threshold of 3 or higher, so these two analyses coincide. No analysis showed a significant difference between protocols, although mpMRI was always more sensitive by 3 to 6 percentage points and bpMRI always more specific by 8 to 14 points. In the leave-one-out analysis, pooled bpMRI sensitivity ranged from 89.5% to 92.7% and mpMRI sensitivity from 93.0% to 95.9%. The Deeks test showed no evidence of small-study effects for bpMRI (p = 0.24) or mpMRI (p = 0.34), although the test has little power with nine studies.

Table 3: Sensitivity analyses

Analysis	Studies	bpMRI sensitivity, %	mpMRI sensitivity, %	P	bpMRI specificity, %	mpMRI specificity, %	p
All studies	9	91.3 (84.8 to 95.2)	95.2 (91.3 to 97.4)	0.16	58.3 (41.4 to 73.4)	48.3 (29.6 to 67.5)	0.45
Patient-level studies (threshold ≥3)	8	92.7 (87.4 to 95.8)	95.6 (91.3 to 97.8)	0.27	55.7 (37.6 to 72.4)	47.8 (27.0 to 69.4)	0.59
Excluding approximate reconstructions	7	90.6 (80.7 to 95.7)	95.7 (90.0 to 98.3)	0.18	59.8 (39.2 to 77.5)	45.7 (24.0 to 69.2)	0.39
Retrospective studies	6	89.8 (81.0 to 94.8)	95.8 (89.3 to 98.4)	0.13	60.3 (41.2 to 76.7)	46.2 (23.4 to 70.7)	0.38
Initial diagnosis or biopsy-naive	6	91.5 (84.1 to 95.7)	96.1 (91.2 to 98.4)	0.15	53.6 (34.8 to 71.4)	42.3 (20.9 to 67.2)	0.49
Excluding transition zone study	8	92.3 (85.4 to 96.0)	95.9 (92.0 to 97.9)	0.19	55.8 (37.6 to 72.6)	46.8 (26.3 to 68.4)	0.54

Values are pooled estimates (95% CI) from the bivariate random-effects model. bpMRI: biparametric MRI; mpMRI: multiparametric MRI.

Discussion

In this meta-analysis of nine paired studies, bpMRI and mpMRI did not differ significantly in sensitivity or specificity for csPCa. Pooled sensitivity was 91.3% with bpMRI and 95.2% with mpMRI, and pooled specificity was 58.3% and 48.3%. The pattern was consistent: adding DCE caught a few more cancers in every study but at the cost of more false-positive findings. Over 2901 men or lesions, omitting DCE would have missed 38 cancers (3.4% of all csPCa) and avoided 116 false-positive results.

These findings agree with earlier reviews. Alabousi and colleagues found pooled sensitivity of 90% and specificity of 70% for bpMRI, against 86% and 73% for mpMRI, with no significant difference [15]. Woo and colleagues found near-identical accuracy in 20 head-to-head studies [13], and Kang and colleagues reported AUCs of 0.89 and 0.88 [14]. A larger review of bpMRI reported a pooled sensitivity of 87% and specificity of 72% for csPCa, with no difference from mpMRI on meta-regression [16]. By contrast, Niu and colleagues found that mpMRI was significantly more sensitive in head-to-head comparison, 85% versus 80%, with similar specificity [12]. Our estimate of the sensitivity difference, about 4 percentage points, lies between these results. Our pooled specificities were lower than in some earlier reviews because most included studies used a threshold of 3 or higher and a thorough biopsy reference, as did PROMIS [3] and the Cochrane review [6]. The extra cancers found with mpMRI came mainly from peripheral zone lesions scored 3 on DWI, where positive DCE upgrades the score to 4 under PI-RADS [9,27]. When the threshold for biopsy is 3 or higher, such lesions are biopsied anyway, so DCE changes management less often [25,28]. This explains why the sensitivity loss was smaller in patient-level studies with a threshold of 3. In the transition zone, DCE added false positives from enhancing benign nodules without improving sensitivity much [30]. DCE may matter more where DWI is degraded by artefacts, after a previous negative biopsy and in men on active surveillance [11,29].

For Indian practice, bpMRI could make prostate MRI faster and more affordable. It removes the need for contrast, cannulation and post-contrast imaging time, avoids gadolinium exposure and allows more examinations per day on each scanner [10,11]. Its gains depend on high-quality DWI and experienced readers, and the PI-RADS Steering

Committee advises that bpMRI be used only where these conditions are met, with mpMRI available when the biparametric images are inadequate [11].

Strengths and Limitations: This review included only paired studies in which both protocols were assessed in the same patients, used csPCa as the target condition and used the bivariate model. It also has limitations. Only PubMed was searched, only English-language studies published before 2024 were included, and the number of studies was small, which limits the power of the comparison and of the Deeks test.

Most 2 × 2 tables were reconstructed from reported percentages, and two reconstructions were approximate. The comparison treated the two pooled estimates as independent, which is conservative because the data were paired. In most studies the bpMRI read was a separate reading of the same examination, which may not match a true bpMRI workflow. Definitions of csPCa, reference standards and thresholds varied, and heterogeneity in specificity was high. No study came from India.

Conclusion

bpMRI and mpMRI did not differ significantly in diagnostic accuracy for clinically significant prostate cancer. mpMRI was slightly more sensitive in every study, and bpMRI produced fewer false-positive results. bpMRI is a reasonable, faster and contrast-free option for biopsy-naive men when image quality and reader expertise are high, while mpMRI remains preferable after a negative biopsy, in active surveillance and when DWI is of poor quality. Prospective multicentre studies, including Indian centres, are needed.

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