MRI DETECTION OF PROSTATE CANCER

Kamal Mattar MSc MD FRCSC
11th Annual Princess Margaret Cancer Centre
URO-ONCOLOGY DIALOGUE

DISCLOSURE

Advisory board with Astella, Sanofi

Learning Objectives:

- The role of mp-MRI in the diagnosis of prostate cancer
- Update the evaluation of prostate cancer using mp-MRI
- Review published guidelines and recommendations

Prostate Cancer Screening

PSA, DRE and TRUS-GB

Under-treatment: miss clinically significant prostate cancers

- low sensitivity and specificity for PCa
- grey- scale ultrasonography fails to distinguish disease
- repeat biopsy yields a diagnosis in 10 -25% in persistent clinical suspicion
- Gleason upgrading in 36% of radical prostatectomy specimens

Over-treatment: high rate of over-detection of low risk disease

Prostate Cancer Screening

The ideal triage test:

- minimally invasive
- few side effects
- identify men who would benefit from treatment
- overlooks clinically insignificant cancer to minimize over-treatment
- imaging for accurate detection, localization and staging

multiparametric MRI (mp-MRI)

a. *anatomical* T2-weighted image low signal intensity, irregular border, ventral transition zone, anterior to BPH nodule
b. diffusion weighted image, *functional* after iv contrast, cancer shows a lower value, darker than normal tissue
c. diffusion weighted image at high b-values (diffusion effect), prostate cancer demonstrates high signal intensity (white)
d. dynamic contrast enhanced, asymmetric focal enhancement
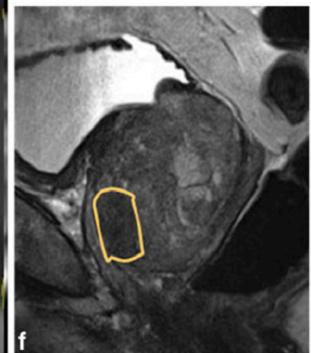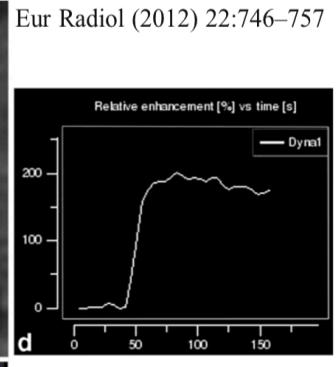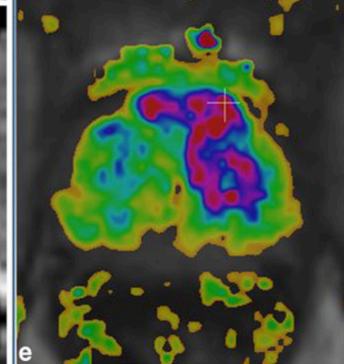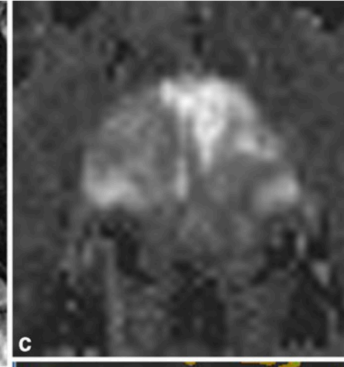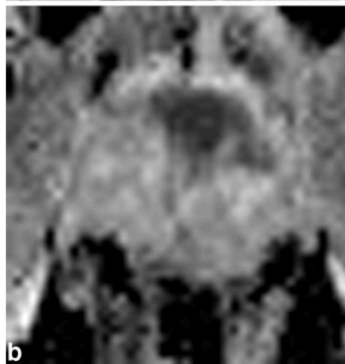
Eur Radiol (2012) 22:746–757

Masoom A. Haider[1]
Theodorus H. van der Kwast[2,3]
Jeff Tanguay[2]
Andrew J. Evans[2]
Ali-Tahir Hashmi[1]
Gina Lockwood[4]
John Trachtenberg[5]

Combined T2-Weighted and Diffusion-Weighted MRI for Localization of Prostate Cancer

Performance Measure	Whole Prostate		
	T2 Alone	T2 + DWI	p
Sensitivity	**81/149 (54) [44–65]**	**120/149 (81) [74–86]**	**< 0.001**
Specificity	**222/243 (91) [86–95]**	**204/243 (84) [77–89]**	**0.003**
PPV	81/102 (79) [69–87]	120/159 (75) [66–83]	0.29
NPV	**222/290 (77) [69–82]**	**204/233 (88) [82–92]**	**< 0.001**
Accuracy	**303/392 (77) [72–82]**	**324/392 (83) [78–86]**	**0.03**

Prostate Cancer: Value of Multiparametric MR Imaging at 3 T for Detection—Histopathologic Correlation[1]
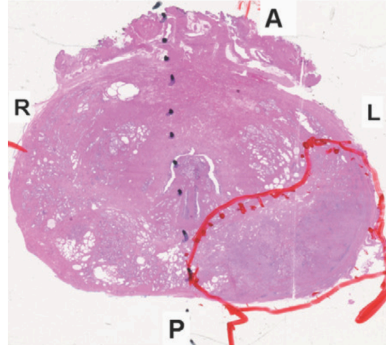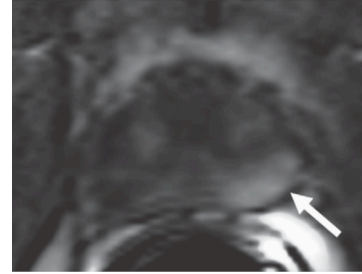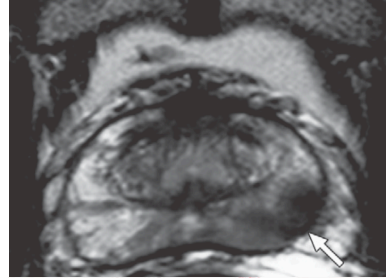
Advance in Knowledge

- With combined use of T2-weighted MR imaging with MR spectroscopy and dynamic contrast-enhanced MR imaging at 3 T, a predictive value of 80% can be achieved for prostate cancer detection ($P < .05$).

European Society of Urogenital Radiology

Clinically significant disease:
- *Gleason score ≥ 7*
- *tumour volume >0.5 ml*
- *and/or extraprostatic extension*

Prostate Imaging Reporting and Data System (PI-RADS)

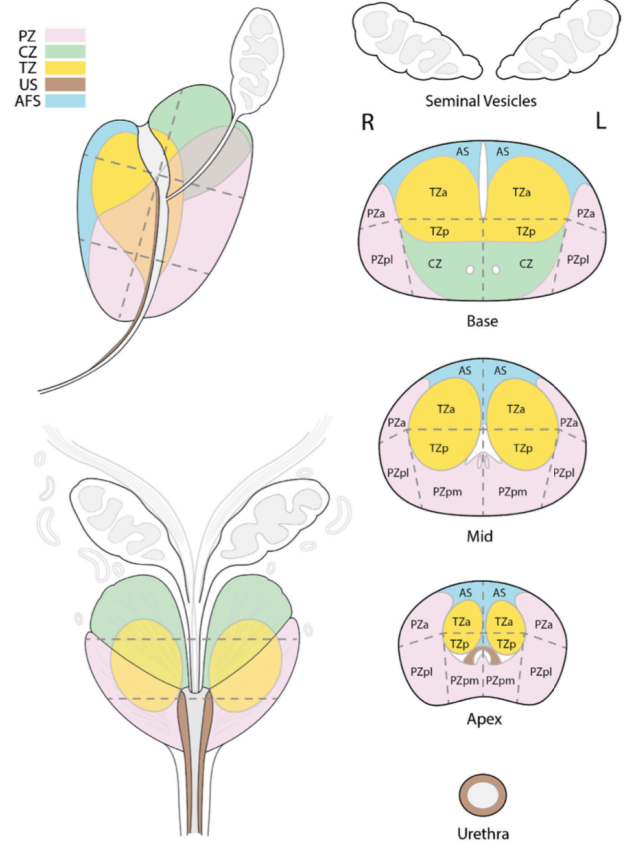2012 - European Society of Urogenital Radiology (ESUR) published guidelines to standardize evaluation

TABLE 7: Forest Plots of Pooled Estimates of All Studies Overall and of Different Subgroups

Studies[a]	Pooled Performance Value (95% CI)		Sensitivity	Specificity
	Sensitivity	Specificity		
All studies	0.74 (0.66−0.81)	0.88 (0.82−0.92)		
Studies that used biopsy as reference standard	0.76 (0.66−0.84)	0.86 (0.79−0.91)		
Studies that used prostatectomy as reference standard	0.69 (0.52−0.82)	0.93 (0.81−0.97)		
Studies that reported data for the whole gland	0.78 (0.65−0.87)	0.88 (0.80−0.94)		
Studies that reported data for the peripheral zone	0.81 (0.75−0.85)	0.91 (0.67−0.98)		
Studies that reported data by region	0.71 (0.63−0.78)	0.89 (0.83−0.94)		

0.0 0.2 0.4 0.6 0.8 1.0   0.0 0.2 0.4 0.6 0.8 1.0

Diagnostic Performance of Prostate Imaging Reporting and Data System Version 2 for Detection of Prostate Cancer: A Systematic Review and Diagnostic Meta-analysis

Sungmin Woo [a,†], Chong Hyun Suh [b,c,†], Sang Youn Kim [a,*], Jeong Yeon Cho [a,d], Seung Hyup Kim [a,d]

Updated PI-RADSv2 in 2015

Meta-analysis of 21 studies, 3,857 patients

- PIRADS ≥ 4: Sensitivity 89% [86% - 92%], Specificity 73% [60% - 83%]
- PIRADS ≥ 3: Sensitivity 95% and poor Specificity of 47%
- all studies used PI-RADSv2 strictly according to guidelines
- use of endorectal coil was not a statistically significant factor
- 3 vs. 1.5 T magnet: Sensitivity 90% vs. 89% (p=0.03)

Prospective Evaluation of PI-RADS^{TM} Version 2 Using the International Society of Urological Pathology Prostate Cancer Grade Group System

339 patients with mpMRI, systematic and targeted biopsy
PIRADS scoring correlates with cancer detection and Gleason Grade

J Urol 2017
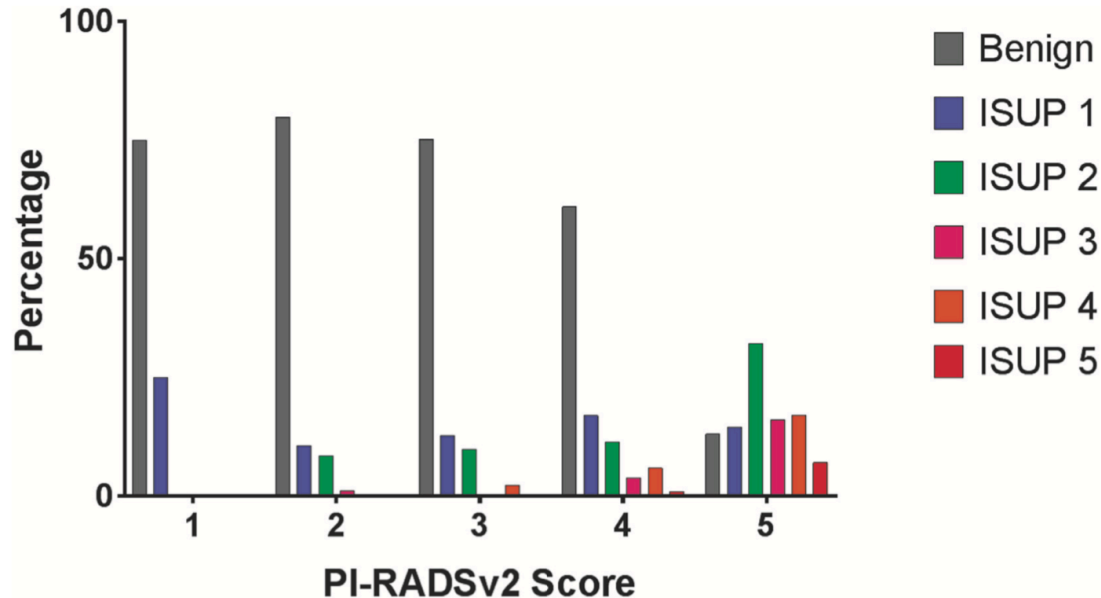
PCa detection rates by mpMRI in radical prostatectomy specimen

ISUP grade group	Tumour volume (mL)		
	< 0.5	0.5-2	> 2
ISUP grade 1	21-29%	43-54%	67-75%
ISUP grade 2-3	63%	82-88%	97%
ISUP grade ≥ 4	80%	93%	100%

Eur Radiol 2013

MRI-TRUS fusion biopsy
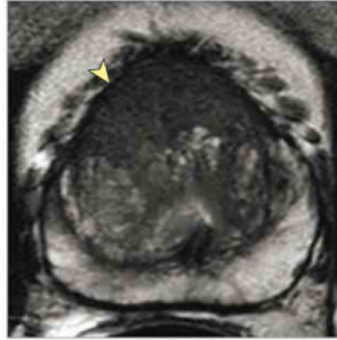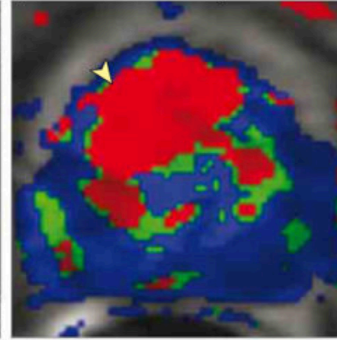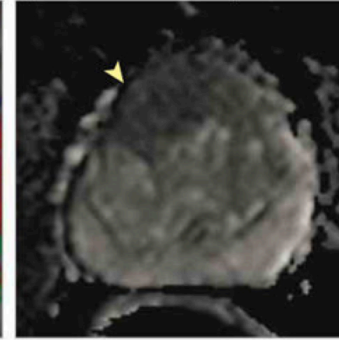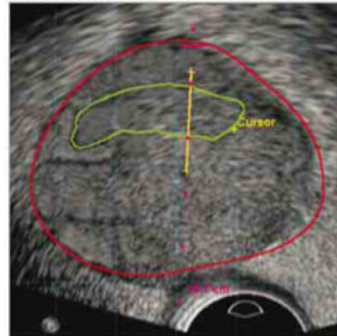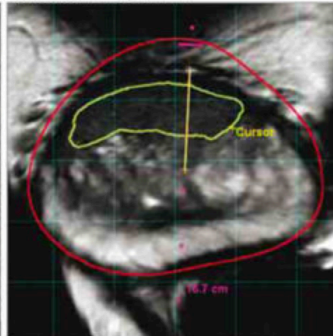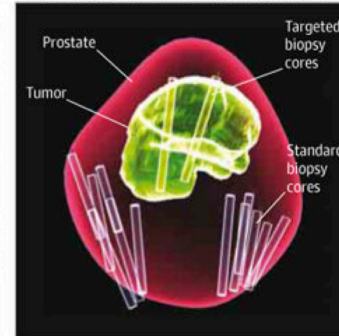
Comparison of MR/Ultrasound Fusion–Guided Biopsy With Ultrasound-Guided Biopsy for the Diagnosis of Prostate Cancer

Prospective cohort at NCI of patients with elevated PSA and prior negative biopsy underwent targeted and standard 12 core biopsy

Comparison of MR/Ultrasound Fusion–Guided Biopsy With Ultrasound-Guided Biopsy for the Diagnosis of Prostate Cancer

690 patients (69%) demonstrated agreement between targeted and standard biopsy

Targeted: 30% more high risk & 17% fewer low risk disease

Targeted MR/Ultrasound Fusion Biopsy Results		No Cancer	Standard Extended-Sextant Biopsy Results				Totals
			Low-Risk Cancer		Intermediate-Risk Cancer	High-Risk Cancer	
			Gleason 6	Gleason 3+4 Low Volume[a]	Gleason 3+4 High Volume[b]	Gleason ≥4+3	
No cancer		439	74	12	12	5	542
Low-Risk Cancer	Gleason 6	38	84	12	10	3	147
	Gleason 3+4 Low volume[c]	17	14	9	19	7	66
Intermediate-Risk Cancer	Gleason 3+4 High volume[d]	14	21	7	29	4	75
High-Risk Cancer	Gleason ≥4+3	26	13	12	19	103	173
Totals		534	206	52	89	122	1003

Comparison of MR/Ultrasound Fusion–Guided Biopsy With Ultrasound-Guided Biopsy for the Diagnosis of Prostate Cancer

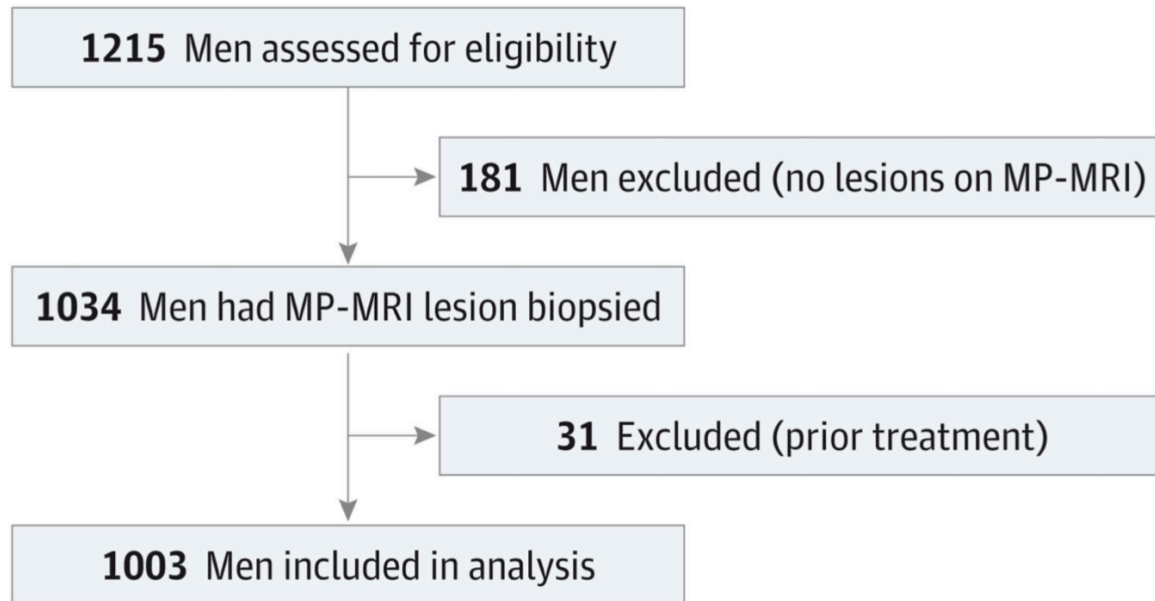| Targeted MR/Ultrasound Fusion Biopsy Results	Whole-Mount Pathology (Prostatectomy)			Totals
	Low-Risk Cancer	**Intermediate-Risk Cancer**	**High-Risk Cancer**	
No cancer	Standard biopsy results No cancer 0 Low 6 Intermediate 7 High 1	Standard biopsy results No cancer 0 Low 0 Intermediate 1 High 0	Standard biopsy results No cancer 0 Low 0 Intermediate 1 High 1	17
Low-risk cancer	Standard biopsy results No cancer 4 Low 27 Intermediate 7 High 0	Standard biopsy results No cancer 2 Low 9 Intermediate 2 High 0	Standard biopsy results No cancer 1 Low 2 Intermediate 1 High 2	57
Intermediate-risk cancer	Standard biopsy results No cancer 3 Low 8 Intermediate 8 High 1	Standard biopsy results No cancer 2 Low 7 Intermediate 4 High 0	Standard biopsy results No cancer 0 Low 2 Intermediate 2 High 1	38
High-risk cancer	Standard biopsy results No cancer 1 Low 1 Intermediate 0 High 2	Standard biopsy results No cancer 0 Low 3 Intermediate 2 High 3	Standard biopsy results No cancer 7 Low 9 Intermediate 4 High 26	58
Totals	76	35	59	170

Comparison of MR/Ultrasound Fusion–Guided Biopsy With Ultrasound-Guided Biopsy for the Diagnosis of Prostate Cancer

Performance of Different Biopsy Approaches in the Detection of Intermediate- toHigh-Risk Prostate Cancer on Whole-Gland Prostatectomy Specimen

	Targeted MR/Ultrasound Fusion Biopsy	Standard Extended-Sextant Biopsy	Combined Biopsy
Sensitivity, % (95% CI)	77 (67-84)	53 (43-63)	85 (76-91)
Specificity, % (95% CI)	68 (57-78)	66 (54-76)	49 (37-60)
Negative predictive value, % (95% CI)	70 (58-80)	53 (43-63)	73 (58-84)
Positive predictive value, % (95% CI)	75 (65-83)	66 (54-76)	67 (58-75)
Accuracy, % (95% CI)	73 (70-76)	59 (55-63)	69 (65-72)
AUC (95% CI)	0.73 (0.66-0.79)	0.59 (0.52-0.67)	0.67 (0.60-0.74)
P value of comparison with targeted MR/ultrasound biopsy		.005	.04

Comparison of MR/Ultrasound Fusion–Guided Biopsy With Ultrasound-Guided Biopsy for the Diagnosis of Prostate Cancer

The utility of standard biopsy in addition to targeted biopsy was limited

- The number needed to biopsy (standard template) to diagnose 1 additional high-risk tumor was 200 men

- For every 1 high-risk tumor diagnosed, 17 additional low-risk tumors would also be diagnosed

Limitation: referral bias, patients with MRI lesions **and** prior -ve biopsy

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

J Urol Dec 2016

Andrew B. Rosenkrantz,*,† Sadhna Verma, Peter Choyke, Steven C. Eberhardt, Scott E. Eggener,‡ Krishnanath Gaitonde, Masoom A. Haider, Daniel J. Margolis, Leonard S. Marks, Peter Pinto, Geoffrey A. Sonn and Samir S. Taneja§

QUALITY ASSURANCE

- Experienced radiologists and biopsy operators
- Ongoing case review, comparing prospective interpretations with histological results

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

MRI Targeted Biopsy Methods

1. Cognitive targeting involves estimating the location of a lesion

- unreliable for lesions that are small or anterior

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

J Urol Dec 2016

MRI Targeted Biopsy Methods

2. MR in-bore target biopsy

- time-consuming (60 minutes) and labor-intensive
- concurrent systematic biopsies are not obtained

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

MRI Targeted Biopsy Methods

3. MRI/ultrasound fusion guided prostate biopsy

- familiar approach easily incorporated into existing workflow

Comparing Three Different Techniques for Magnetic Resonance Imaging-targeted Prostate Biopsies: A Systematic Review of In-bore versus Magnetic Resonance Imaging-transrectal Ultrasound fusion versus Cognitive Registration.
Is There a Preferred Technique?
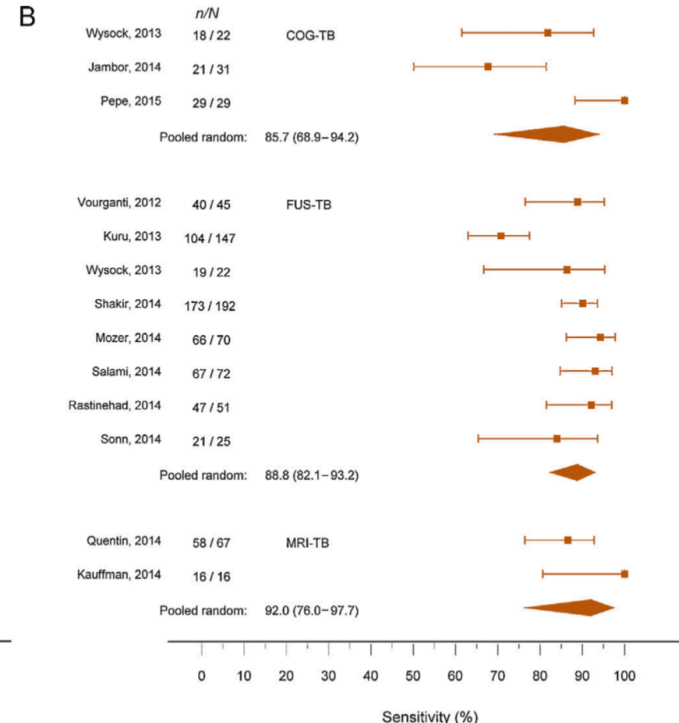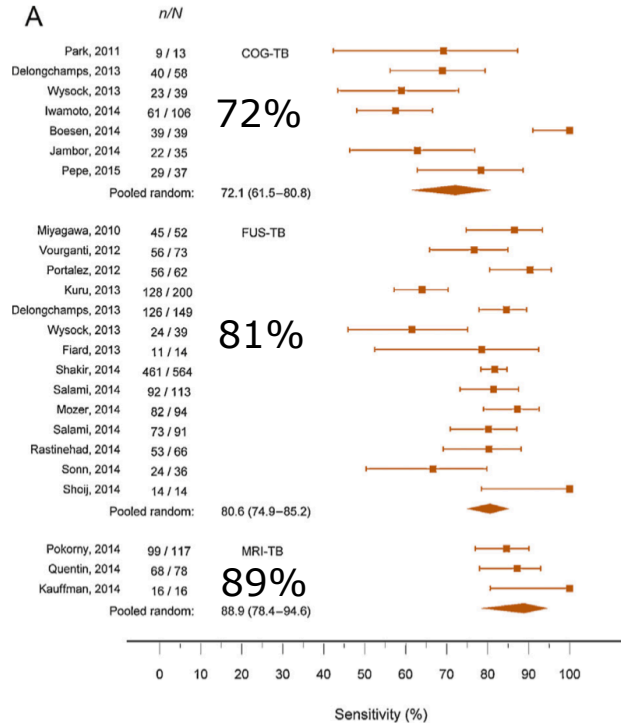
Comparing Three Different Techniques for Magnetic Resonance Imaging-targeted Prostate Biopsies: A Systematic Review of In-bore versus Magnetic Resonance Imaging-transrectal Ultrasound fusion versus Cognitive Registration. Is There a Preferred Technique?

MRI-GB vs. TRUS-GB

- Equivalent overall PCa detection

- MRI-GB detects more CS-PCa (16%)

- MRI-GB has a lower yield of insignificant PCa (0.47)

- Omitting TRUS-GB would miss 19% of all PCa cases, 10% of CS-PCa, and decrease the over diagnosis of insignificant PCa by 50%

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

Additional Considerations for MRI Targeted Biopsy

1. At least 2 cores from each MRI target

Minimum number of MRI ultrasound fusion targeted biopsy cores needed for prostate cancer detection: Multivariable retrospective lesion-based analyses of patients treated with radical prostatectomy

Leyh-Bannurah SR, Kachanov M, Beyersdorff D, Tian Z, Karakiewicz PI, Tilki D, Fisch M, Maurer T, Graefen M, Budäus L

Table 2. Lesion based cumulative percentage of prostate cancer detection per each additional targeted biopsy core that was sampled within 1,459 mpMRI lesions (PI-RADS ≥3) of 771 radical prostatectomy patients

number of targeted biopsy cores sampled per MRI lesion	overall		systematic biopsy naïve (n = 886)		≥ 1 prior negative systematic biopsy (n = 573)		PI-RADS 3 (n=110)		PI-RADS 4 (n=1055)		PI-RADS 5 (n=294)	
	n	%	n	%	n	%	n	%	n	%	n	%
1	1159	79	741	84	418	73	74	67	830	79	255	87
2	187	92	97	95	90	89	21	86	142	92	24	95
3	84	98	35	99	49	97	10	95	65	98	9	98
≥4	29	100	13	100	16	100	5	100	18	100	6	100

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

Additional Considerations for MRI Targeted Biopsy

2. Systematic and MRI targeted cores be separately labeled

- pathologist to report the presence of inflammation, HGPIN and ASAP
- correlative histological abnormality may provide assurance that targeting was accurate when the lesion is benign

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

Concurrent Systematic Sampling when Performing MRI Targeting

- CS-PCa detected by systematic biopsies and missed by targeted biopsy (0% to 23%)
  - ☀ repeat biopsies vs. biopsy-naive

MRI-Targeted or Standard Biopsy for Prostate-Cancer Diagnosis

Quality of Life and Safety

- no difference between groups
- no difference WRT discomfort or pain
- better in the MRI-targeted group at 30 days:
    - hematuria (30% vs. 63%)
    - hematospermia (32% vs. 60%)
    - rectal bleeding (14% vs. 22%)
    - pain (13% vs. 23%)
    - erectile dysfunction (11% vs. 16%)
    - serious adverse events (2% vs. 2%)

Infections and hospitalizations

the lower incidence among patients undergoing MRI-targeted prostate biopsy appears related to trans-perineal access rather than the number of cores taken

Prostate Magnetic Resonance Imaging and Magnetic Resonance Imaging Targeted Biopsy in Patients with a Prior Negative Biopsy: A Consensus Statement by AUA and SAR

Role of Immediate Re-biopsy after MRI

- Target biopsy PIRAD 4 or 5 lesions, and likely 3
  - ⁕ continue followup, as 5% - 15% of CS-PCa remain undetected on MRI
  - ⁕ serial PSA, DRE and repeat MRI

Active Surveillance Magnetic Resonance Imaging Study (ASIST): Results of a Randomized Multicenter Prospective Trial

Laurence Klotz [a,*], Andrew Loblaw [a], Linda Sugar [b], Madeline Moussa [c], David M. Berman [d], Theo Van der Kwast [e], Danny Vesprini [a], Laurent Milot [b], Marlene Kebabdjian [b], Neil Fleshner [f], Sangeet Ghai [f], Joe Chin [c], Gregory R. Pond [g], Masoom Haider [b]

Under-treatment: AS may miss clinically significant prostate cancers
- 25% harbour aggressive tumor at radical prostatectomy
- high risk disease often located anteriorly

Over-treatment and morbidity of repeat biopsy

Active Surveillance Magnetic Resonance Imaging Study (ASIST): Results of a Randomized Multicenter Prospective Trial

Randomized (n = 273)

PSA <5:5–10 (n = 69:67)
Age <65:≥65 (n = 75:61)
Centre London:Sunnybrook:UHN (n = 35:73:28)

PSA <5:5–10 (n = 70:67)
Age <65:≥65 (n = 76:61)
Centre London:Sunnybrook:UHN (n = 34:75:28)

TRUS-guided biopsy (n = 136)

MRI-guided biopsy (n = 137)

Withdrew (n = 3)
Pathology upgraded (n = 1)

Withdrew (n = 2)
Pathology upgraded (n = 2)
Protocol deviation (n = 1)
Noncompliance (n = 1)
Subject request (n = 2)
Unable to tolerate MRI (n=2)

Confirmatory biopsy (n = 132)

Confirmatory biopsy (n = 127)

Primary outcome
≥GG 2: 31 (22.8%)

Primary outcome
≥GG 2s: 29 (21.2%)

Progressed or had a radical intervention post-confirmatory biopsy (not upgraded), n = 11

Progressed or had a radical intervention post-confirmatory biopsy (not upgraded), n = 6

mp-MRI Health Economics

Cost savings over standard TRUS-guided biopsy may emerge:
- earlier detection of clinically significant cancers
- fewer cases of insignificant cancer diagnosed
- fewer repeat biopsies

Full PI-RADS-compliant protocol

1. T2- weighted imaging (T2WI) in 3 orthogonal planes
2. after iv contrast, diffusion-weighted imaging (DWI)
3. and dynamic contrast-enhanced (DCE), reserved for the clarification of equivocal abnormalities in the peripheral zone

Short, non-contrast bi-parametric MRI (bp-MRI) may be safer, faster, cheaper and expand usage:
1. T2WI
2. DWI

High Diagnostic Performance of Short Magnetic Resonance Imaging Protocols for Prostate Cancer Detection in Biopsy-naïve Men: The Next Step in Magnetic Resonance Imaging Accessibility

Marloes van der Leest [a,†,*], Bas Israël [a,b,†], Erik Bastiaan Cornel [c], Patrik Zámecnik [a], Ivo G. Schoots [d], Hans van der Lelij [e], Anwar R. Padhani [f], Maroeska Rovers [g], Inge van Oort [b], Michiel Sedelaar [b], Christina Hulsbergen-van de Kaa [h], Gerjon Hannink [g], Jeroen Veltman [i,‡], Jelle Barentsz [a,‡]

| Sequence	mp-MRI	bp-MRI	"Fast" bp-MRI
T2WI localizers	0:00:51	0:00:51	0:00:26
T2WI localizer (sagittal)	0:00:07	0:00:07	0:00:00 *
T2WI sagittal	0:02:31	0:02:31	0:00:00
T2WI coronal	0:02:15	0:02:15	0:00:00 *
T2WI transversal	0:02:33	0:02:33	0:02:33
DWI	0:04:50	0:04:50	0:04:50
DCE imaging	0:02:50	0:00:00	0:00:00
Total sequence time	0:15:57	0:13:07	0:07:49

bp = biparametric; DCE = dynamic contrast enhanced; DWI = diffusion weighted imaging; mp = multiparametric; MRI = magnetic resonance imaging; T2WI = T2-weighted imaging.

High Diagnostic Performance of Short Magnetic Resonance Imaging Protocols for Prostate Cancer Detection in Biopsy-naïve Men: The Next Step in Magnetic Resonance Imaging Accessibility

	Sensitivity % (95% CI)	Specificity % (95% CI)	NPV % (95% CI)	PPV % (95% CI)	LR− (95% CI)	LR+ (95% CI)
mp-MRI	95 (91–97)	69 (64–73)	97 (94–98)	57 (51–62)	0.077 (0.042–0.14)	3.0 (2.6–3.5)
bp-MRI	95 (91–97)	69 (64–73)	97 (94–98)	57 (51–62)	0.077 (0.042–0.14)	3.0 (2.6–3.5)
"Fast" bp-MRI	95 (91–97)	65 (61–70)	97 (94–98)	54 (49–60)	0.081 (0.044–0.15)	2.7 (2.4–3.1)

bp = biparametric; LR− = negative likelihood ratio; LR+ = positive likelihood ratio; mp = multiparametric; MRI = magnetic resonance imaging; NPV = negative predictive value; PPV = positive predictive value.
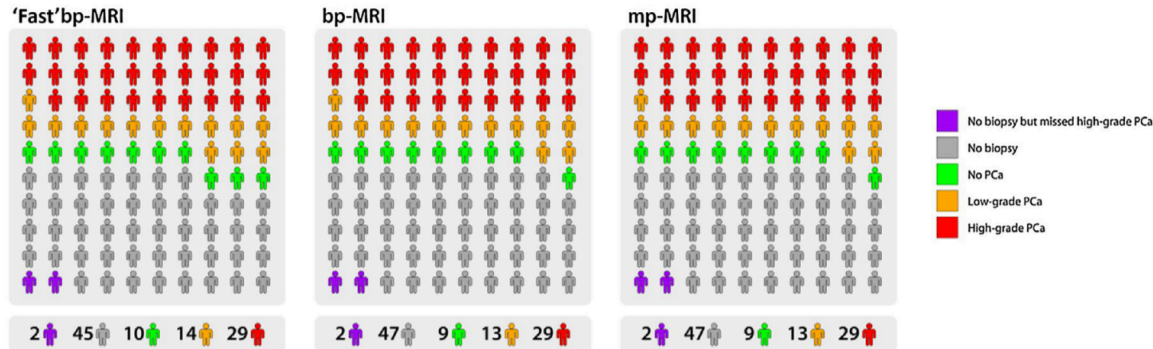
Prostate MRI, with or without MRI-targeted biopsy, and systematic biopsy for detecting prostate cancer (Review)

Drost FJH, Osses DF, Nieboer D, Steyerberg EW, Bangma CH, Roobol MJ, Schoots IG

Evidence up to July 2018, 43 studies, 13,770 men

- Out of 1000 men at risk for PCa, MRI will correctly identify 273 out of 300 who actually have CS-PCa (Sn 91%), but miss 27 men
- Of the remaining 700 men, MRI will correctly identify 259 as not having PCa, but will misclassify 441 men as having CS-PCa (Sp 37%)

Cochrane Library

Cochrane Database of Systematic Reviews

Prostate MRI, with or without MRI-targeted biopsy, and systematic biopsy for detecting prostate cancer (Review)

Drost FJH, Osses DF, Nieboer D, Steyerberg EW, Bangma CH, Roobol MJ, Schoots IG

In the same population MR-targeted biopsy,

- Out of 300 men with CS-PCa, will correctly identify 240 (Sn 80%), but miss 60

- Of the remaining 700 men without CS-PCa, will correctly identify 658 (Sp 94%), but misclassify 42 as having CS-PCa

Cochrane
Library

Prostate MRI, with or without MRI-targeted biopsy, and systematic biopsy for detecting prostate cancer (Review)

Drost FJH, Osses DF, Nieboer D, Steyerberg EW, Bangma CH, Roobol MJ, Schoots IG

In the same population systematic biopsy,

- Out of 300 men with CS-PCa, will correctly identify 189 (Sn 63%), but miss 111
- Of the 700 men without CS-PCa, all will be correctly identified (Sp 100%)

Cochrane Library

Prostate MRI, with or without MRI-targeted biopsy, and systematic biopsy for detecting prostate cancer (Review)

Drost FJH, Osses DF, Nieboer D, Steyerberg EW, Bangma CH, Roobol MJ, Schoots IG

mp-MRI performance compared to systematic biopsy (detection ratio)

- 1.12 for ISUP grade ≥ 2
  - ☀ 1.44 in patients with prior negative biopsy
  - ☀ 1.05 in biopsy-naive
- 1.2 for ISUP grade ≥ 3
  - ☀ 1.64 in patients with prior negative biopsy
  - ☀ 1.09 in biopsy-naive

Cochrane Library

Cochrane Database of Systematic Reviews

2019 EAU Guidelines

Recommendations in patients with prior negative biopsy	LE	Strength rating
Perform mpMRI before prostate biopsy	1a	Strong
When mpMRI is positive (i.e. PI-RADS ≥ 3), perform targeted biopsy only.	2a	Weak
When mpMRI is negative (PI-RADS ≤ 2), and clinical suspicion of prostate cancer is high, perform systematic biopsy	2a	Strong

2019 EAU Guidelines

Recommendations in men on active surveillance	LE	Strength rating
Perform mpMRI before a confirmatory prostate biopsy, if not done before the first biopsy.	1a	Strong
Perform the combination of targeted biopsy (of any PI-RADS ≥ 3 lesion) and systematic biopsy at confirmatory biopsy.	2a	Weak

Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study

Hashim U Ahmed*, Ahmed El-Shater Bosaily*, Louise C Brown*, Rhian Gabe, Richard Kaplan, Mahesh K Parmar, Yolanda Collaco-Moraes, Katie Ward, Richard G Hindley, Alex Freeman, Alex P Kirkham, Robert Oldroyd, Chris Parker, Mark Emberton, and the PROMIS study group†

The reference test was template prostate mapping (TPM):

- core biopsies of the entire prostate taken every 5 mm
- centrally reported by expert uropathologists
- blinded to MR images and TRUS-biopsy findings

Clinically significant prostate cancer:

- Gleason ≥4 + 3
- or core length ≥6 mm

Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study

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PIRAD (n)

PIRAD	(n)
MRI 1	23
MRI 2	135
MRI 3	163
MRI 4	120
MRI 5	135

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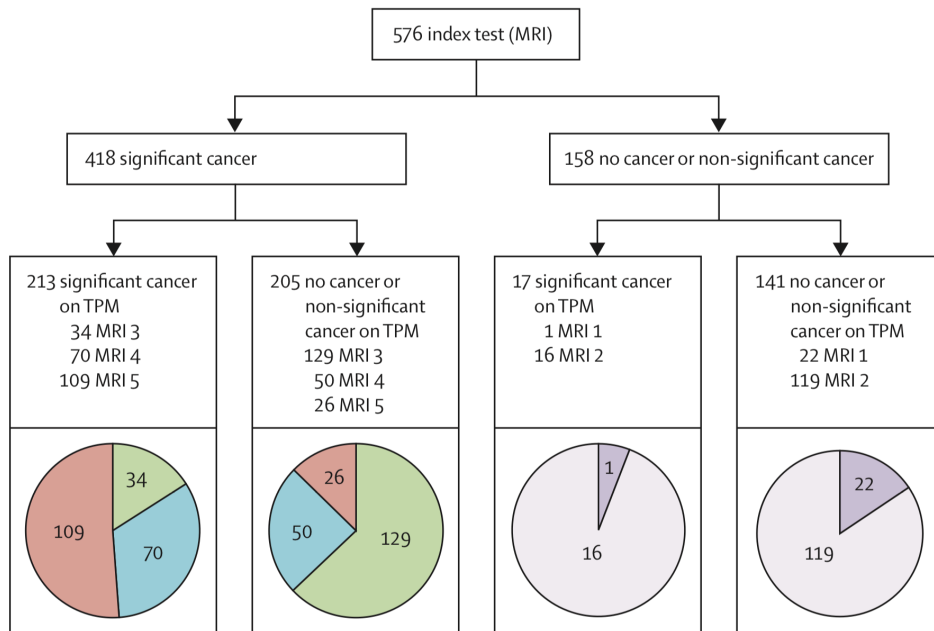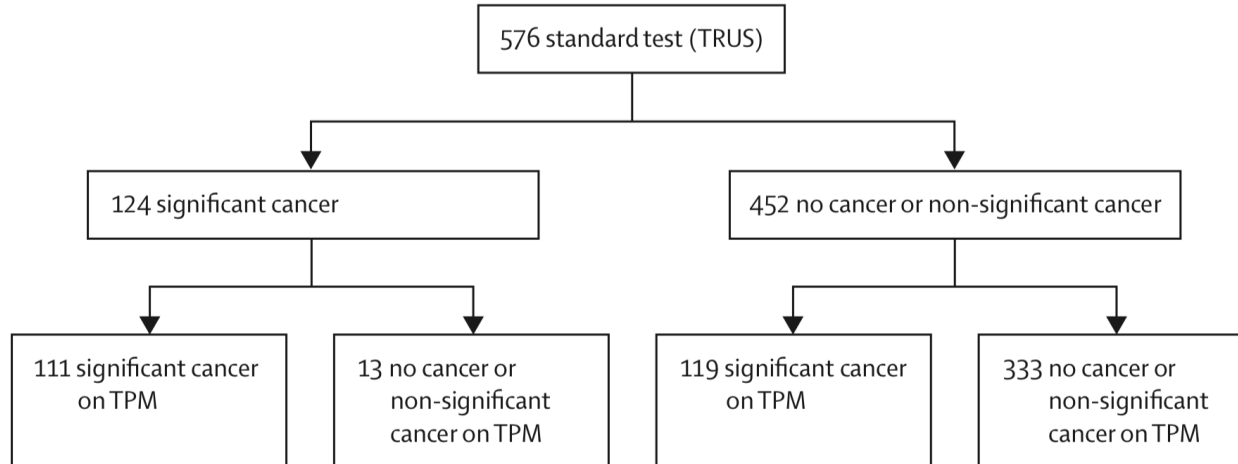
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	MP-MRI, % (95% CI)	TRUS-biopsy, % [95% CI]	Test ratio* [95% CI]	p value
Primary definition (Gleason score ≥4+3 or cancer core length ≥6 mm), prevalence of clinically significant cancer 230 (40%, 36–44%)				
Sensitivity test	93 (88–96)	48 (42–55)	0·52 (0·45–0·60)	p<0·0001
Specificity test	41 (36–46)	96 (94–98)	2·34 (2·08–2·68)	p<0·0001
PPV	51 (46–56)	90 (83–94)	8·2 (4·7–14·3)	p<0·0001
NPV	89 (83–94)	74 (69–78)	0·34 (0·21–0·55)	p<0·0001
Any Gleason score 7 (≥3+4), prevalence of clinically significant cancer 308 (53%, 49–58%)				
Sensitivity test	88 (84–91)	48 (43–54)	0·55 (0·49–0·62)	p<0·0001
Specificity test	45 (39–51)	99 (97–100)	2·22 (1·94–2·53)	p<0·0001
PPV	65 (60–69)	99 (95–100)	40·8 (10·2–162·8)	p<0·0001
NPV	76 (69–82)	63 (58–67)	0·53 (0·38–0·73)	p<0·0001

Is MRI The Ideal Triage Test

mpMRI has a high negative predictive value (NPV):

- one-quarter of men would avoid prostate biopsy

- minimize over-diagnosis

- side-effects of over-treatment

- burden of active surveillance on patients and system

Low specificity and PPV means that biopsy is still needed
target or systematic?

MR-Targeted Biopsy Alone

A Randomized Controlled Trial To Assess and Compare the Outcomes of Two-core Prostate Biopsy Guided by Fused Magnetic Resonance and Transrectal Ultrasound Images and Traditional 12-core Systematic Biopsy

Diagnostic Pathway with Multiparametric Magnetic Resonance Imaging Versus Standard Pathway: Results from a Randomized Prospective Study in Biopsy-naïve Patients with Suspected Prostate Cancer

MRI-Targeted or Standard Biopsy for Prostate-Cancer Diagnosis

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PRECISION

PRostate **E**valuation for **C**linically **I**mportant disease: **S**ampling using **I**mage guidance **O**r **N**ot

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Screening population:
- no prior biopsy
- elevated PSA (≤20) &/or +ve DRE (≤T2)

Table 1. Characteristics of the Participants at Baseline.*

Characteristic	MRI-Targeted Biopsy Group (N = 252)	Standard-Biopsy Group (N = 248)
Age — yr	64.4±7.5	64.5±8.0
PSA level — ng/ml		
Median	6.75	6.50
Interquartile range	5.16–9.35	5.14–8.65
Family history of prostate cancer — no. (%)	48 (19)	40 (16)
Abnormal digital rectal examination — no. (%)	36 (14)	38 (15)

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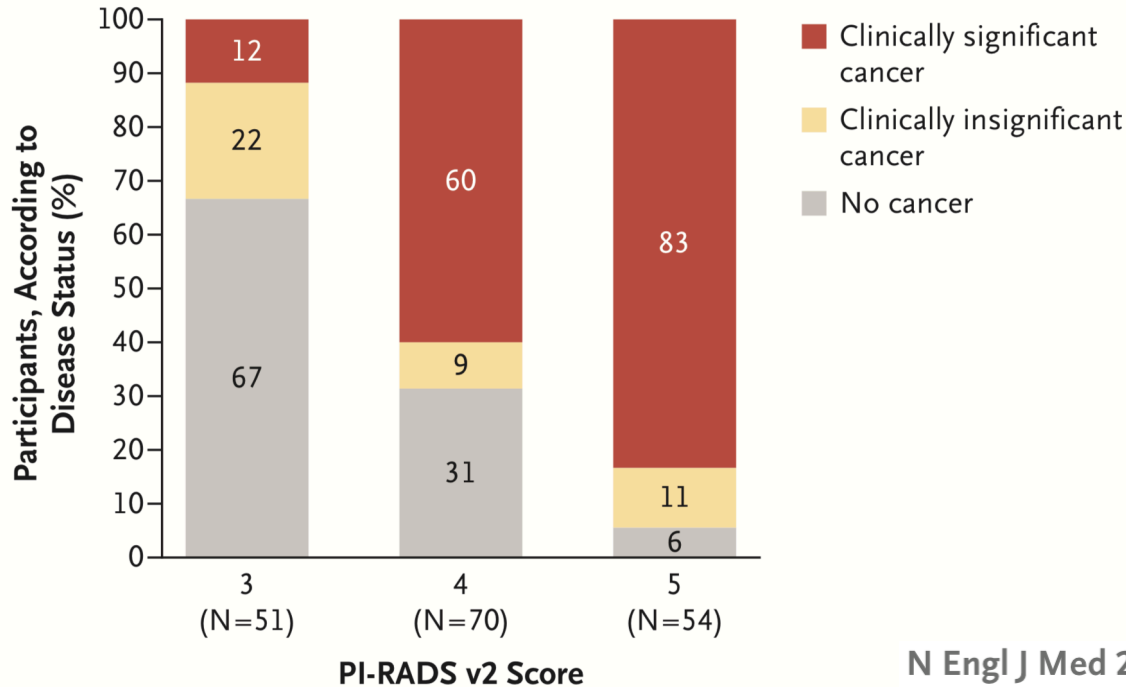| Characteristic	MRI-Targeted Biopsy Group (N = 252)	Standard-Biopsy Group (N = 248)
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Outcome	MRI-Targeted Biopsy Group (N=252)	Standard-Biopsy Group (N=248)
Biopsy outcome — no. (%)		
No biopsy because of negative result on MRI	71 (28)	0
Benign tissue	52 (21)	98 (40)
Atypical small acinar proliferation	0	5 (2)
High-grade prostatic intraepithelial neoplasia	4 (2)	10 (4)
Gleason score		
3+3	23 (9)	55 (22)
3+4	52 (21)	35 (14)
3+5	2 (1)	1 (<1)
4+3	18 (7)	19 (8)
4+4	13 (5)	6 (2)
4+5	7 (3)	2 (1)
5+5	3 (1)	1 (<1)
No biopsy‡	4 (2)	3 (1)
Withdrawal from trial§	3 (1)	13 (5)

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Clinically significant prostate cancer defined as Gleason score ≥ 3+4

Outcome	MRI-Targeted Biopsy Group (N=252)	Standard-Biopsy Group (N=248)	Difference†	P Value
Clinically significant cancer¶				
Intention-to-treat analysis — no. (%)	95 (38)	64 (26)	12 (4 to 20)	0.005
Modified intention-to-treat analysis — no./total no. (%)	95/245 (39)	64/235 (27)	12 (3 to 20)	0.007
Per-protocol analysis — no./total no. (%)	92/235 (39)	62/227 (27)	12 (3 to 20)	0.007
Clinically insignificant cancer — no. (%)	23 (9)	55 (22)	−13 (−19 to −7)	<0.001
Maximum cancer core length — mm	7.8±4.1	6.5±4.5	1.0 (0.0 to 2.1)	0.053
Core positive for cancer — no./total no. of cores (%)	422/967 (44)	515/2788 (18)	—	—
Men who did not undergo biopsy — no. (%)‖	78 (31)	16 (6)	—	—

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Further management

- standard group 39 (16%) >> 38 (15%) mp-MRI

  >> repeat biopsy 9 >> 3 clinically significant cancer

- MRI group 7 (3%) >> 3 (1%) standard biopsy

  >> all negative