Role of mpMRI: Implication and Implementation

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Decision support system for localizing prostate cancer based on multiparametric magnetic resonance imaging

- Multiparametric (mpMRI) imaging is inherently difficult for observers to interpret correctly and consistently.

Vijay Shah **Med. Phys. 39 (7), July 2012**

Interscanner Comparison of Dynamic Contrast-Enhanced MRI in Prostate Cancer

1.5 Versus 3 T MRI

- The differentiation between PC and the normal tissue is possible with both field strengths.
- *Prostate cancer can be better distinguished from prostatitis at 3T compared with 1.5T.*

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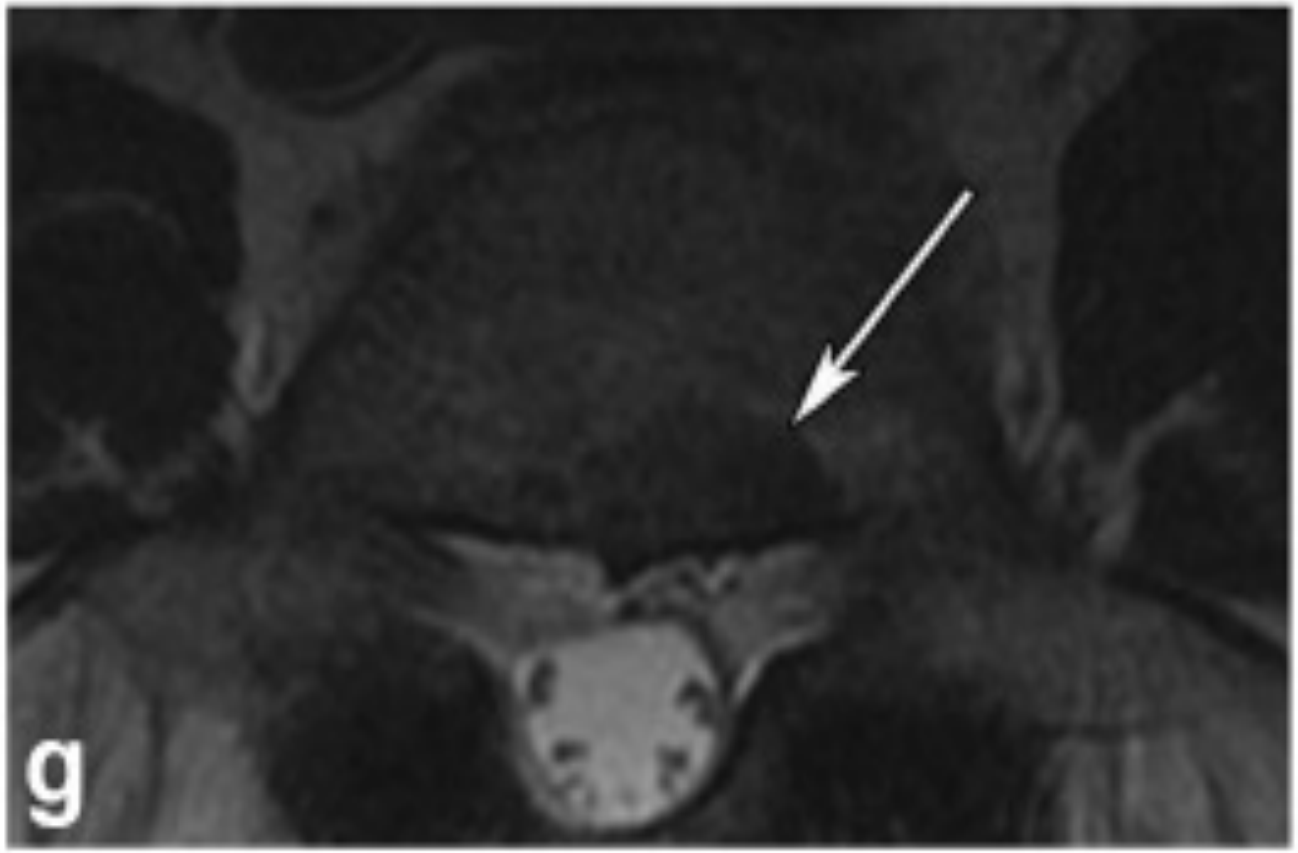
3 Enhancements to MRI

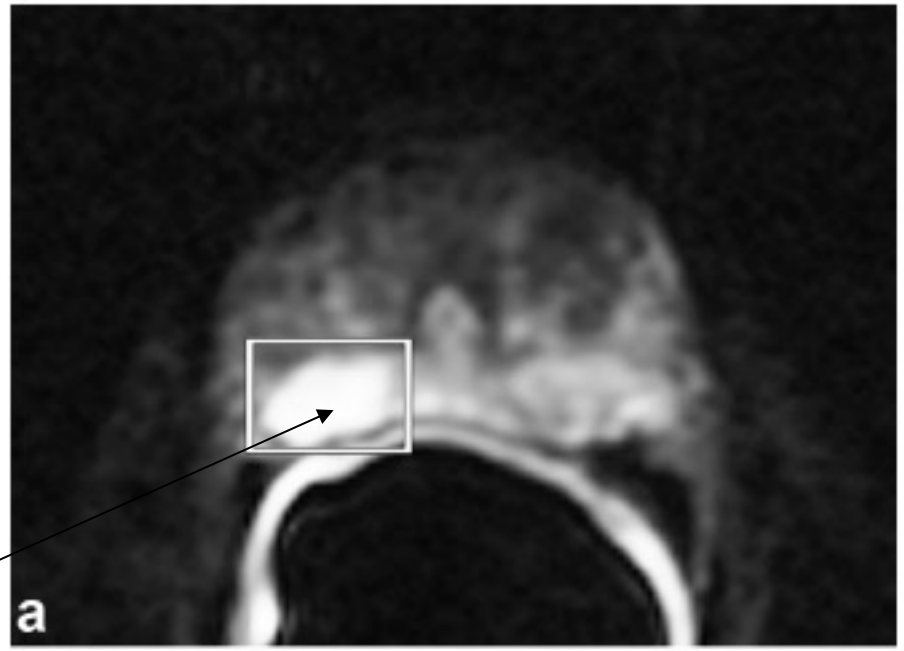
- T1-weigted imaging (T1W)
  - Dynamic contrast enhancement (DCE)
- T2-weighted imaging (T2W)
  - Apparent diffusion coefficient (ADC) on diffusion weighted imaging (DWI)
- MR spectroscopic imaging (MRSI)

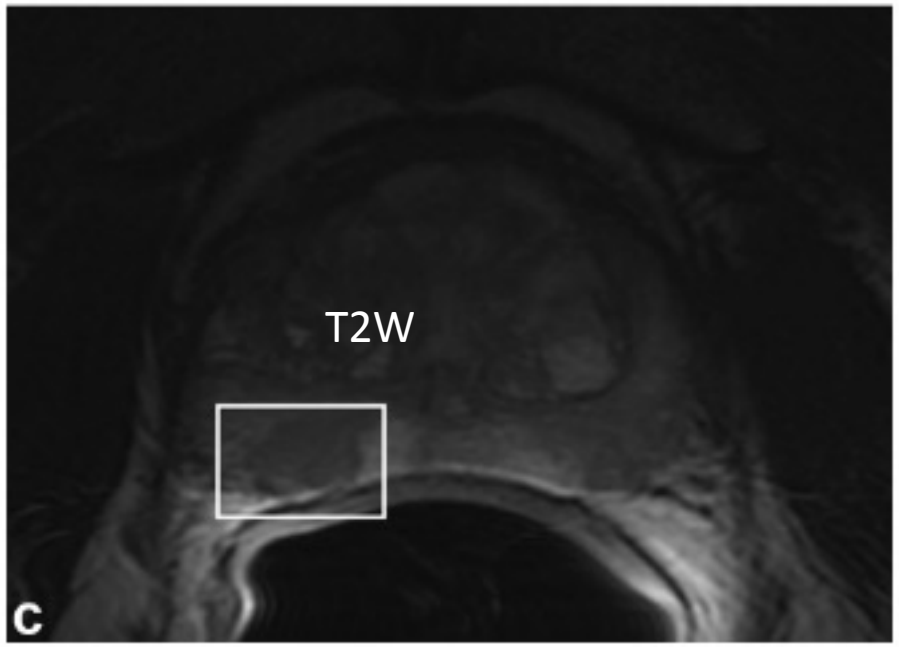
Interpretation Difficulties

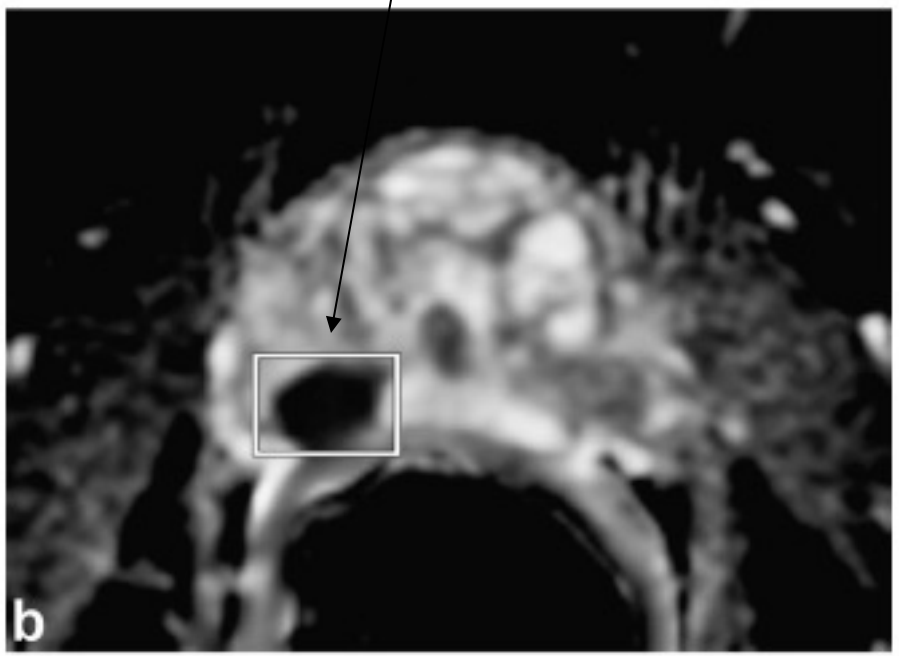
- No standard way of weighting findings as “low”, “intermediate” or “high” suspicion of cancer
  - Number of suspicious sequences (three=high)
  - Graded scoring system with sequences summed and ROC cutoffs created based on correlation with Gleason 7
  - Score 1-5 based on subjective and objective criteria
  - Linear discrimination and logistic regression to assign probability

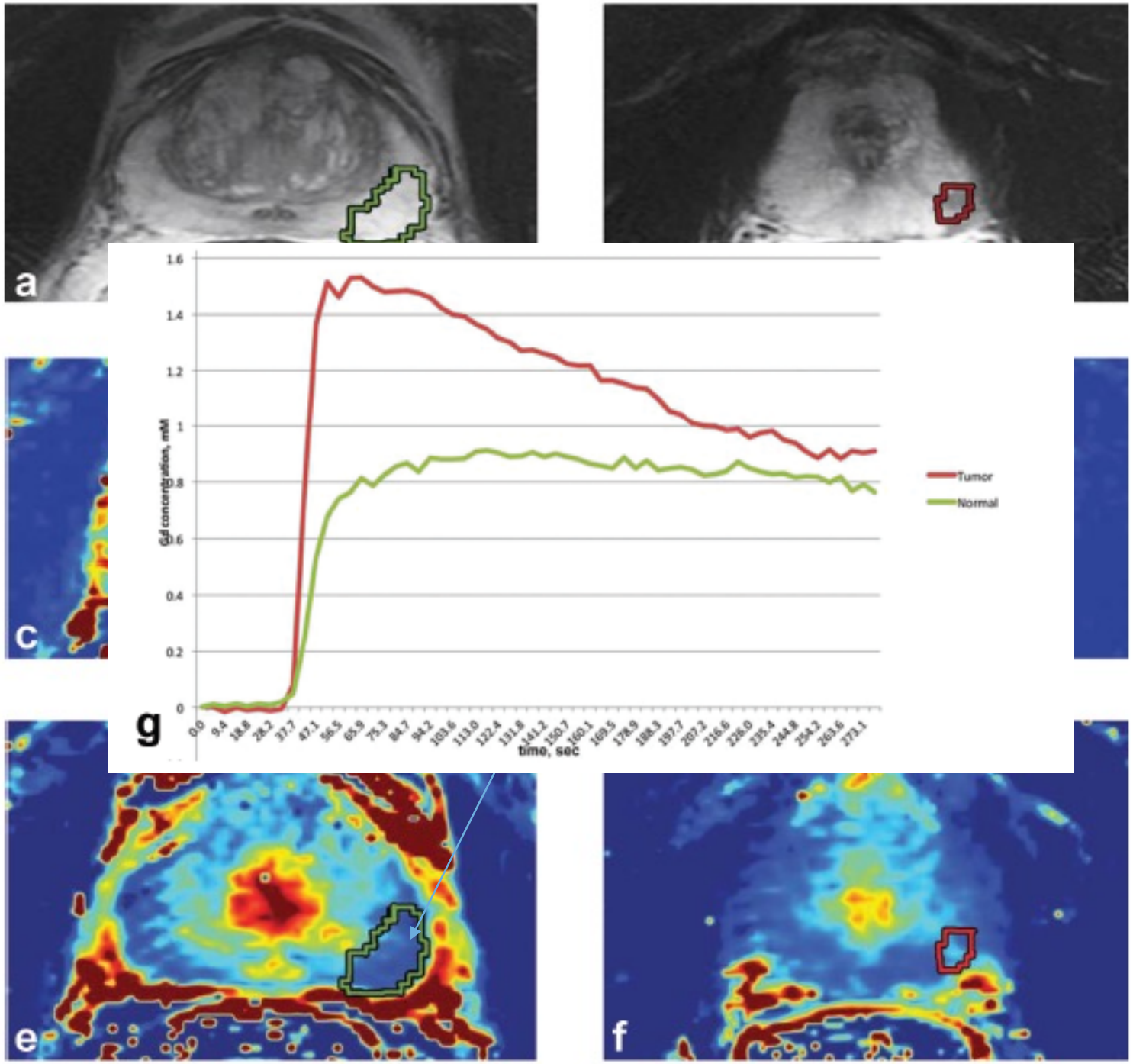
T2: hypointense

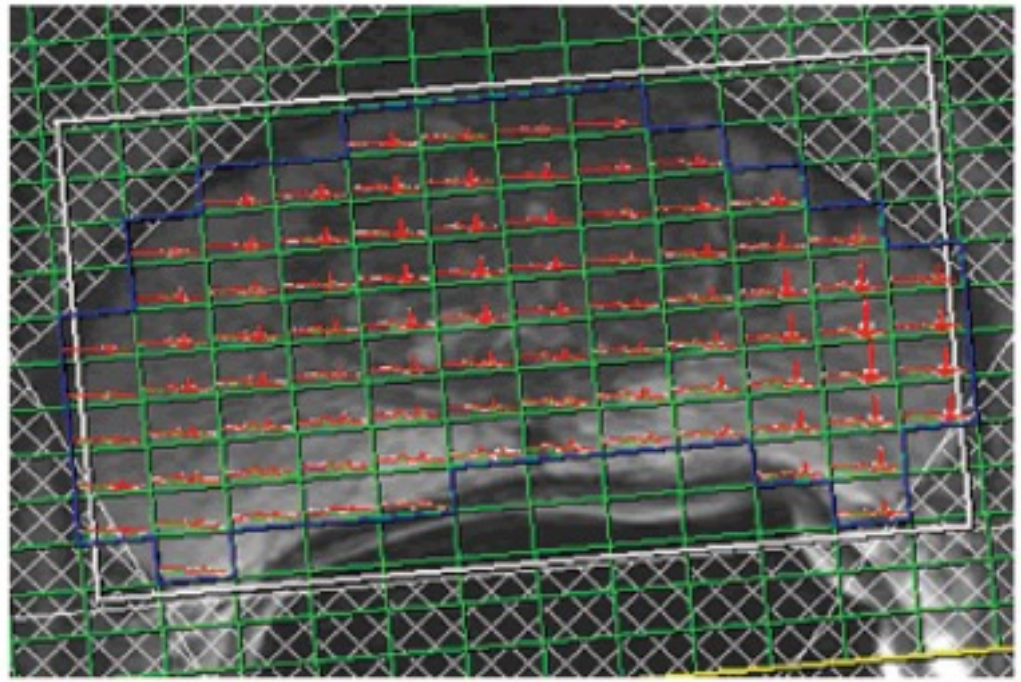


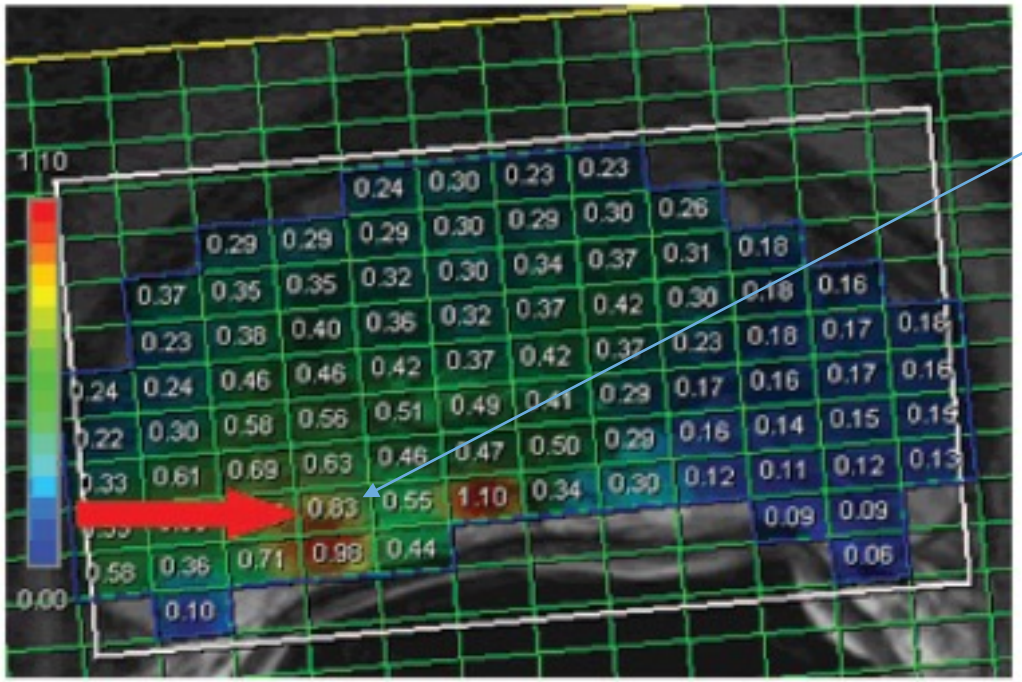

DWI
a

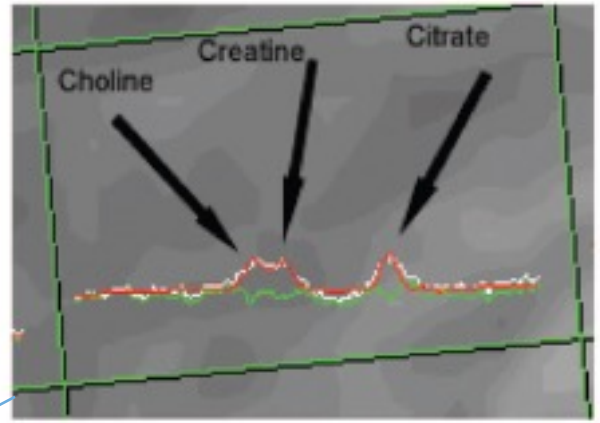

T2W
c


ADC map
b


a
c
g
e
f
Gd concentration, mM
time, sec
Tumor
Normal







D

E

Gleason 6

(*Invest Radiol* 2011;46: 301–306)

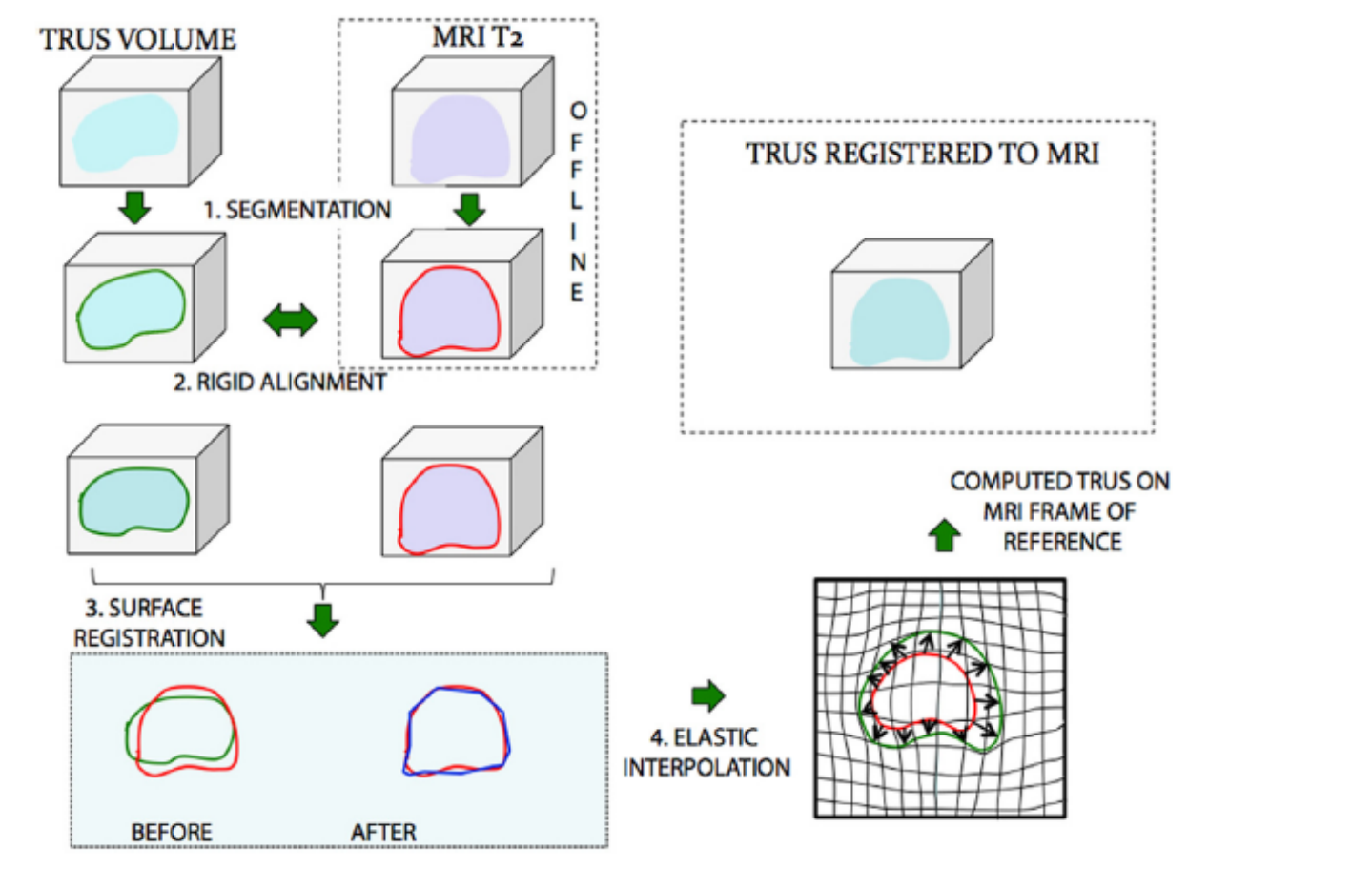
Performance of mpMRI

- Utilizing three different imaging parameters, Futterer et al concluded from T2W, DCE, and MRS imaging that the modalities separately yielded AUC values of 0.68, 0.91, and 0.80.
  - tumor localization accuracy with DCE imaging was significantly better than with MRSI
  - the combination of DCE and MRSI was significantly better for reader accuracy compared to T2WI alone.

Findings of MRI Sequence				mpMRI Suspicion Level
T2W MRI	ADC map of DW MRI	MR Spectroscopy	DCE MRI	
-	-	-	-	Negative
+	-	-	-	Low
+	+	-	-	Low
-	+	-	-	Low
-	-	+	-	Low
-	-	-	+	Low
+	-	+	-	Moderate
+	-	-	+	Moderate
-	+	+	-	Moderate
-	+	-	+	Moderate
+	+	+	-	Moderate
+	+	-	+	Moderate
-	-	+	+	Moderate
+	+	+	+	High


tracking assembly
monitor
workstation

Target detection: Magnetic resonance imaging-ultrasound fusion–guided prostate biopsy



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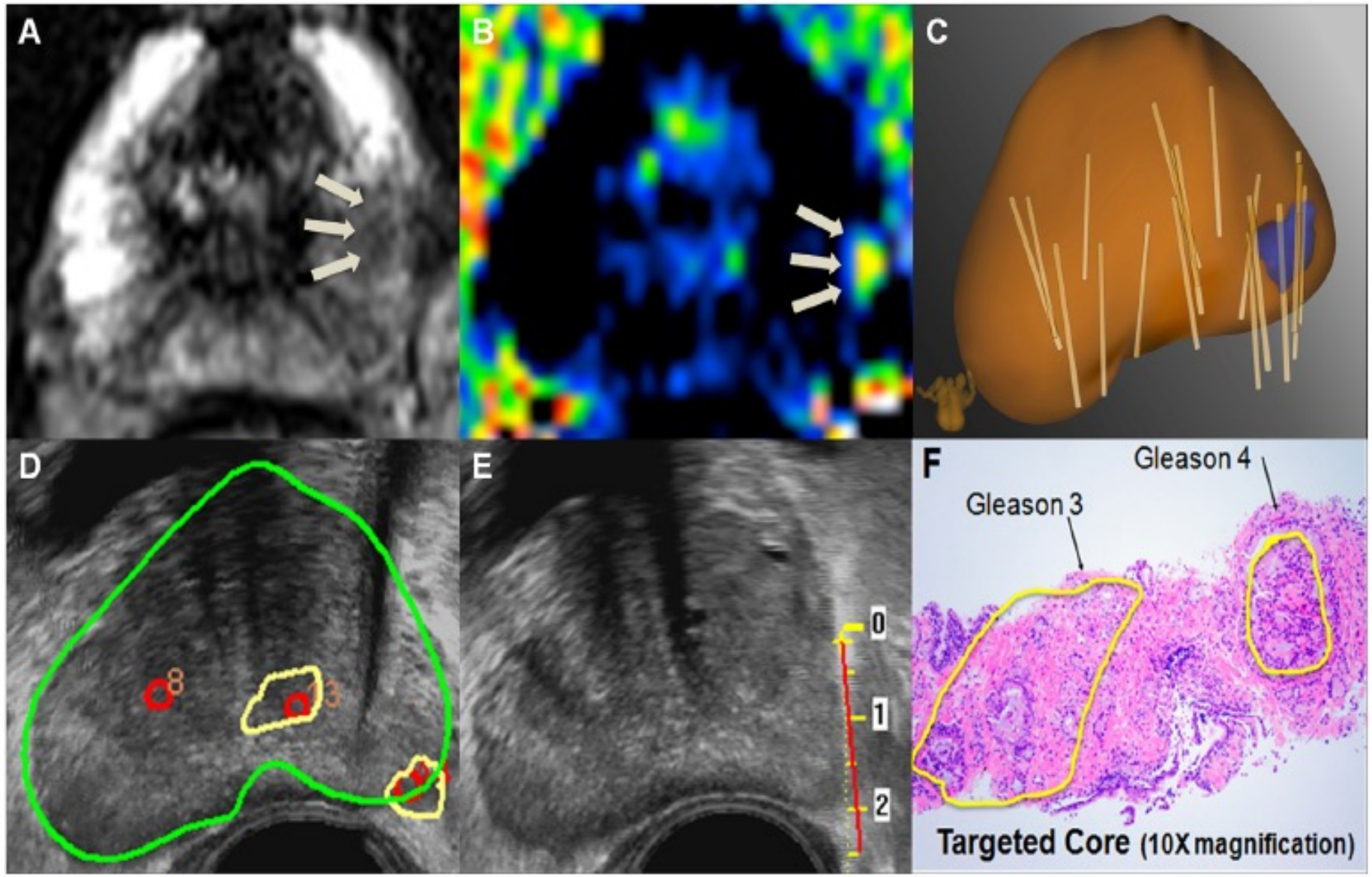
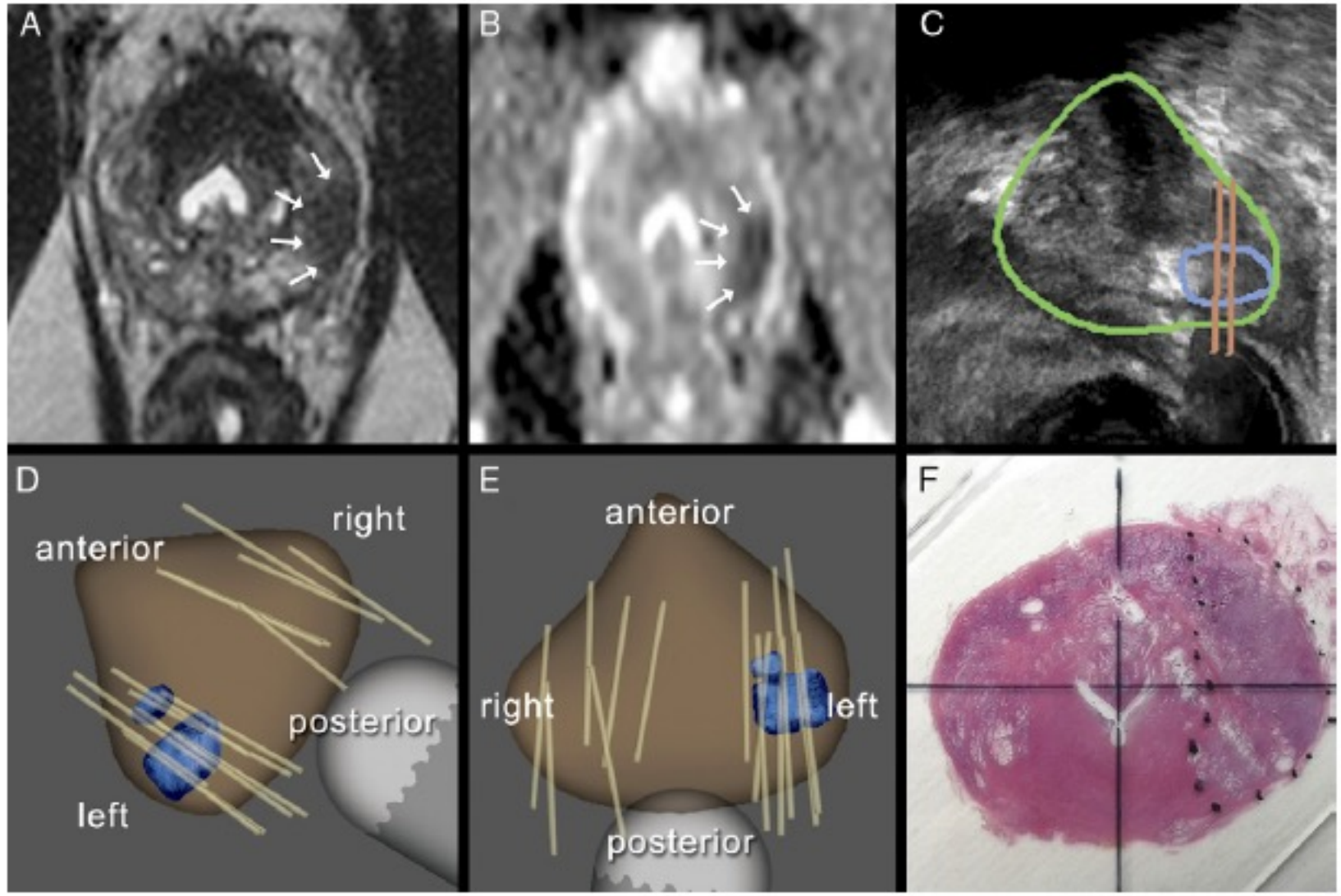
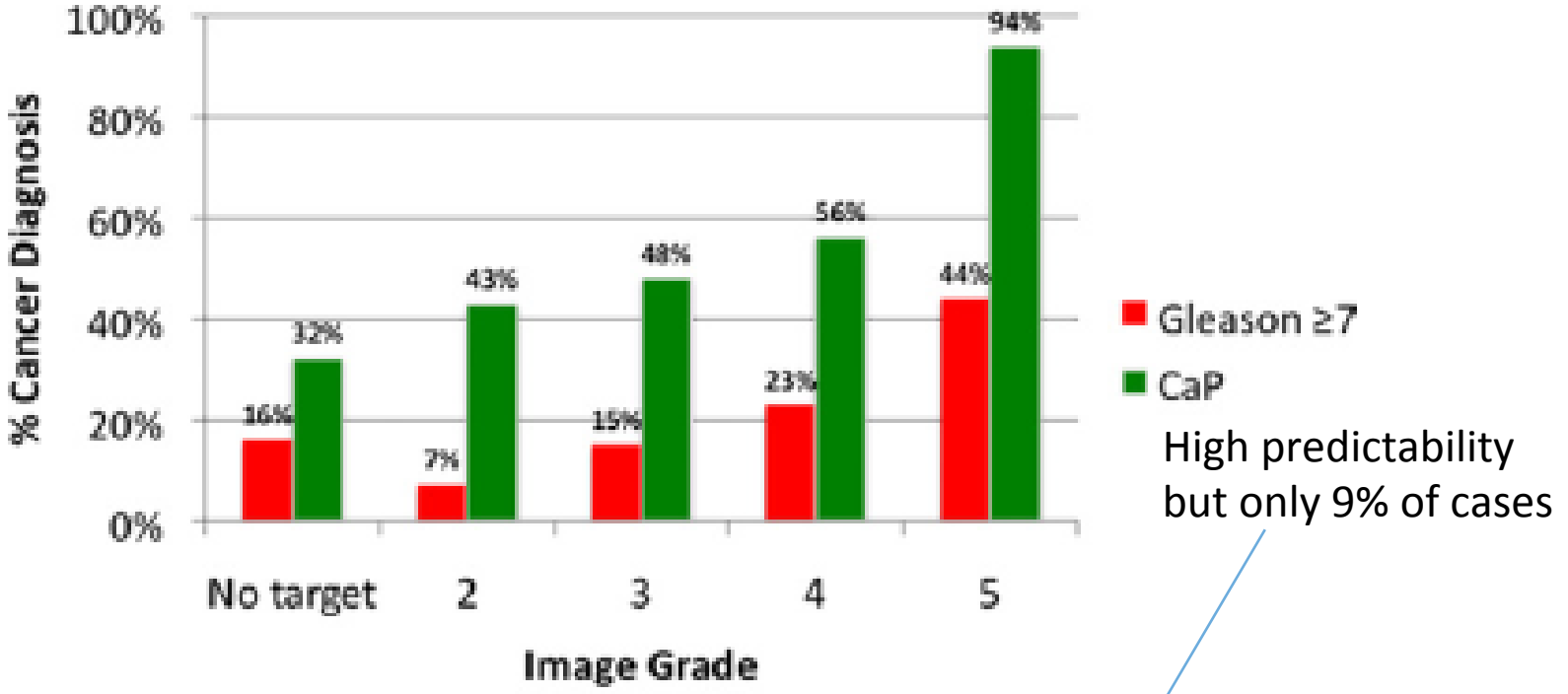

A
B
C
D
E
F
Gleason 4
Gleason 3
0
1
2
Targeted Core (10X magnification)


A
B
C
D
right
anterior
posterior
left
E
anterior
right
left
posterior
F



# Patients	19	14	61	61	16
# Any CaP	6	6	29	34	15
# Gleason ≥7 CaP	3	1	9	14	7

Figure 2. Prostate cancer detection rate in 171 men undergoing MR-US fusion biopsy.

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

M. Minhaj Siddiqui, MD; Soroush Rais-Bahrami, MD; Baris Turkbey, MD; Arvin K. George, MD; Jason Rothwax, BS; Nabeel Shakir, BS; Chinonyerem Okoro, BS; Dima Raskolnikov, BS; Howard L. Parnes, MD; W. Marston Linehan, MD; Maria J. Merino, MD; Richard M. Simon, DSc; Peter L. Choyke, MD; Bradford J. Wood, MD; Peter A. Pinto, MD

Figure 3. Comparison of Pathology From Standard Extended-Sextant Biopsy and Targeted MR/Ultrasound Fusion Biopsy for Prostate Cancer

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				542
Low-Risk Cancer	Gleason 6	38	84			3	147
Low-Risk Cancer	Gleason 3+4 Low volume[c]	17	14	9	19		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

5% intermediate-high risk

17% intermediate-high risk

11% high risk

JAMA. 2015;313(4):390-397. doi:10.1001/jama.2014.17942

Can Clinically Significant Prostate Cancer Be Detected with Multiparametric Magnetic Resonance Imaging? A Systematic Review of the Literature

Jurgen J. Fütterer [a,], Alberto Briganti [b], Pieter De Visschere [c], Mark Emberton [d], Gianluca Giannarini [e], Alex Kirkham [f], Samir S. Taneja [g], Harriet Thoeny [h], Geert Villeirs [c], Arnauld Villers [i]*

EUROPEAN UROLOGY 68 (2015) 1045–1053

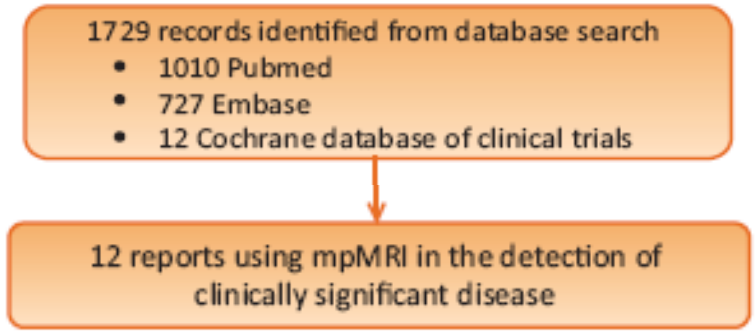


Table 5 – Performance characteristics of multiparametric magnetic resonance imaging for detection and ruling out of clinically significant cancer

Study (year)	Patients	Overall cancer detection rate, *n*/*N* (%)	Reference	Analysis	Clinically significant disease								
					Accuracy, *n*/*N* (%)	TP (*n*)	TN (*n*)	FN (*n*)	FP (*n*)	Sens (%)	Spec (%)	PPV (%)	NPV (%)
[25] (2014) [a]	129	141/258 [b] (55)	Biopsy	Region	114/258 (44)	72	42	5	139	94	23	34	89
[26] (2014)	115	All	RP	Patient	75/104 (72)	52	23	2	27	96	46	66	92
[27] (2013)	105	36/105 (34)	Biopsy	Patient	24/48 (50)	NR	NR	NR	NR	NR	NR	NR	NR
[28] (2014) [a,c]	54	34/54 (63)	Biopsy	Region	57/108 (53)	26	31	8	43	76	42	38	79
[22] (2013) [a,c]	64	54/64 (84)	Biopsy	Region	183–201/256 (72–82)	41–51	132–154	20–30	29–53	58–73	71–84	49–63	84–89
[29] (2013) [a]	182	144/182 (79)	Biopsy	Patient	103/182 (57)	103	45	27	7	79	87	93	63
[30] (2012)	265	108/265 (41)	Biopsy	Patient	94/265 (35)	NR	NR	NR	NR	NR	NR	NR	NR
[31] (2013)	538	316/538 (59)	Biopsy	Patient	NR	NR	NR	NR	NR	94	28	38	91
[32] (2011) [a]	114	68/114 (60)	Biopsy	Region	217/252 (86)	64	153	3	32	95	84	68	98
[33] (2014)	150	92/150 (61)	Biopsy	Patient	49/150 (33)	49	49	2	50	96	50	50	96
[34] (2014)	125	45/125 (36)	Biopsy	Region	21/28 (75)	NR	NR	NR	NR	NR	NR	NR	NR
[35] (2014)	140	91/140 (65)	Biopsy	Region	67/140 (48)	NR	NR	NR	NR	NR	NR	NR	NR

RP = radical prostatectomy; TP = true positives; TN = true negatives; FN = false negatives; FP = false positives; Sens = sensitivity; Spec = specificity; PPV = positive predictive value; NPV = negative predictive value.

[a] Publications from the same centre.

[b] Prostate was divided in halves.

[c] University College London definition 2 used (Table 6).

Table 6 – Definition of clinically significant disease

Study (year)	Clinically significant disease
[25] (2014) [a]	UCL1 / UCL2 / Gleason 3 + 4 or higher / Gleason 4 + 3 or higher / CCL_{max} ≥6 mm / CCL_{max} ≥4 mm
[26] (2014)	Epstein criteria / Epstein criteria or ADC <850 $\mu m^2/s$
[27] (2013)	Epstein criteria / UCL1 / UCL2 / Gleason score ≥7 / Gleason score ≥8
[28] (2014) [a]	UCL2
[22] (2013) [a]	UCL1 / UCL2
[29] (2013) [a]	UCL2
[30] (2012)	PSA >10 ng/ml, PSA density >0.15, clinical stage ≥T2b, Gleason 4 or 5, total CCL ≥10 mm
[31] (2013)	Gleason ≥7 / Gleason ≥8
[32] (2011) [a]	CCLI ≥3 mm and/or Gleason ≥7 / CCLI ≥5 mm and/or Gleason ≥7
[33] (2014)*	Gleason 7 with >5% Gleason 4 + either ≥30% of cores positive or Or Gleason 6–7 with ≤5% Gleason 4 + either ≥30% of cores positive or CCL_{max} >8 mm
[34] (2014)	Gleason ≥7
[35] (2014)	Epstein criteria

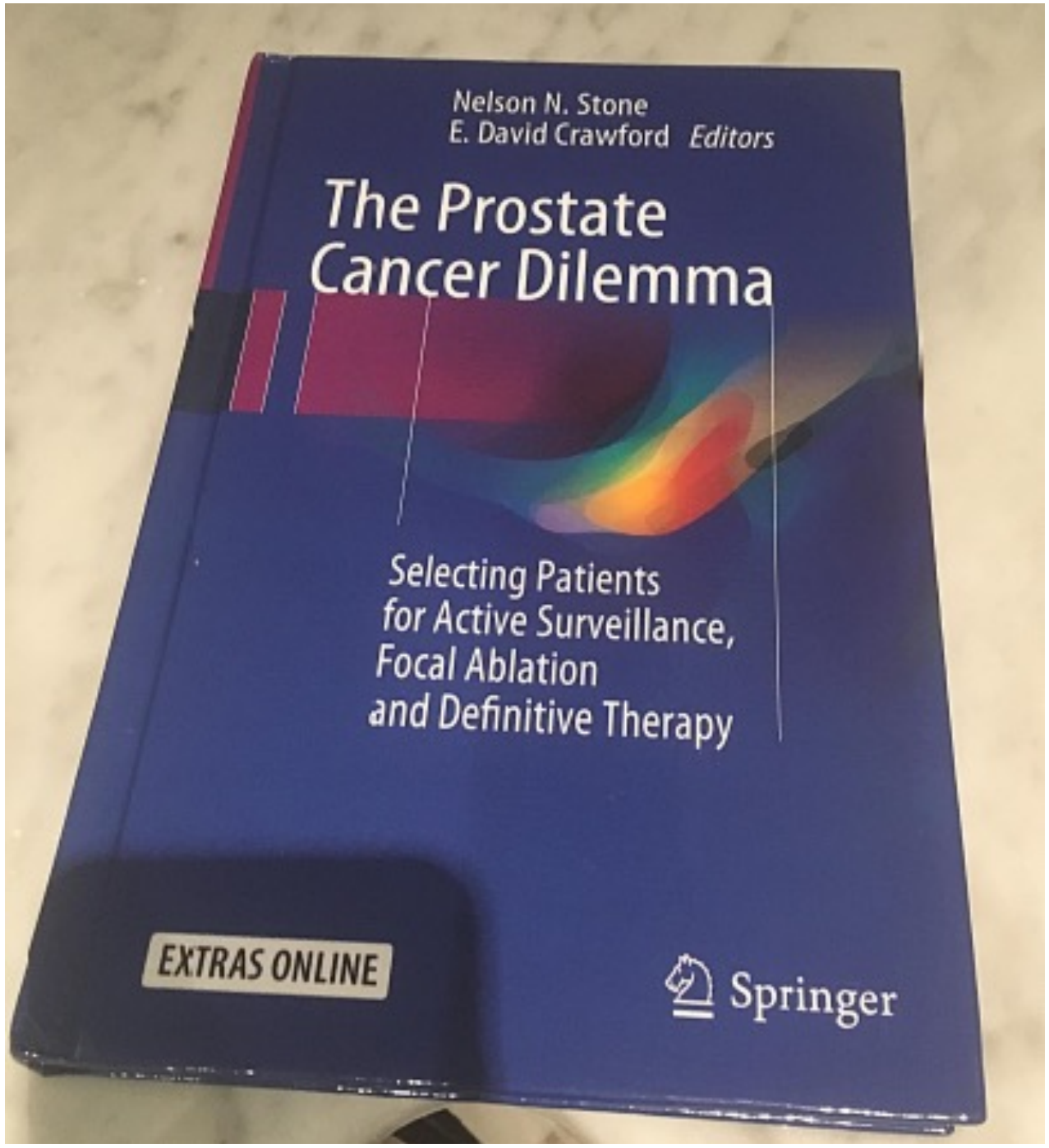
ADC = apparent diffusion coefficient; CCL = cancer core length; CCL_{max} = maximum CCL; Epstein criteria = Gleason score > 6, PSA >10 ng/ml, >3 biopsy cores positive, or at least one biopsy core with >50% involvement; UCL1 = University College London definition 1: Gleason ≥4 + 3 and/or CCL_{max} ≥6 mm and/or total CCL ≥6 mm; UCL2 = UCL definition 2: Gleason ≥3 + 4 and/or CCL_{max} ≥4 mm and/or total CCL ≥6 mm.

* Definition 4 was used.

[a] Publications from the same centre.

Conclusions

- mpMRI has high NPV
  - Limited to the definition of clinically significant disease
  - Finds high risk lesions in anterior of gland missed by routine TRUS biopsy
- Cost is an issue
  - Less expensive in Europe
  - Not covered by all plans
  - No current reimbursement for urologist
- Will a negative MRI mean no biopsy and change in follow-up????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