RESEARCH LETTER

Multiparametric magnetic resonance imaging of the prostate at 1.5-Tesla without endorectal coil: Can it be used to detect clinically significant prostate cancer in men with medical devices that are contraindicated at 3-Tesla?

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Introduction

Multiparametric magnetic resonance imaging (mpMRI) is accurate for detection of clinically significant (International Society of Urogenital Pathology [ISUP] grade group ≥2) prostate cancer (CS-PCa).[1] Imaging quality is crucial for accurate mpMRI and should be compliant with Prostate Imaging and Data Reporting System (PI-RADS) specifications.[2,3] mpMRI can be performed without endorectal coil (ERC) at 3-Tesla (T),[4,5] which improves patient tolerance, ease of use, and imaging artifact.[5] A 1.5T mpMRI without ERC is more controversial. PI-RADS version 2 suggests imaging at 3T should be performed over 1.5T whenever possible and ERC may be indispensable at 1.5T;[2] however, it is acknowledged that credible results have been obtained at 1.5T without ERC.[6] There remains a subset of men in whom 3T imaging is contraindicated and where 1.5T imaging is required, namely those with uncleared (MRI-unsafe) medical devices for 3T. At institutions such as our own, that now perform mpMRI exclusively without ERC at 3T, accessibility and experience with ERC for 1.5T mpMRI is limited. This study evaluates the accuracy for detecting CS-PCa using 1.5T mpMRI without ERC in men with uncleared medical devices for 3T.

Methods

Through a quality-assurance waiver from the institutional review board, a search of our PACS identified 22 men with mpMRI at 1.5T performed from 2013–2018 due to uncleared medical devices for 3T; these include: coronary stents or metallic cardiac graft/marker (m=16); metallic foreign body (n=1); iliac stent (n=1); aortic valve replacement (n=2); and unknown endoscopy clip (n=1). For a control group, 79 men with 3T mpMRI performed during the same study period using a similar generation MRI system were identified. MRI were performed for active surveillance or previous negative biopsy in all men with no MRI performed for biopsy-naive patients. Fig. 1 depicts patient inclusion/exclusion criteria.

MRI technique

MRI examinations were performed using 3T TRIO-TIM or 1.5T Symphony-TIM scanners (Siemens Medical, Malvern, PA, U.S.) using external phased-array coils (four channels 3T, 12 channels 1.5T) and integrated spine-array coils (three channels 3T, six channels 1.5T) with the same operating software application (Siemens Syngo version MR B17, Malvern, PA, U.S.). ERC was not used. Table 1 shows mpMRI protocols used at 1.5T and 3T. As described previously, 1.5T mpMRI was matched, as closely as, possible to 3T.[7]

Subjective interpretation of studies using PI-RADS v2

A genitourinary radiologist with 14 years of experience in prostate MRI, the director of prostate imaging at our institution, evaluated each examination blinded to patient clinical parameters and histopathology for the presence of tumor using PI-RADS v2 guidelines and sector map.[2]
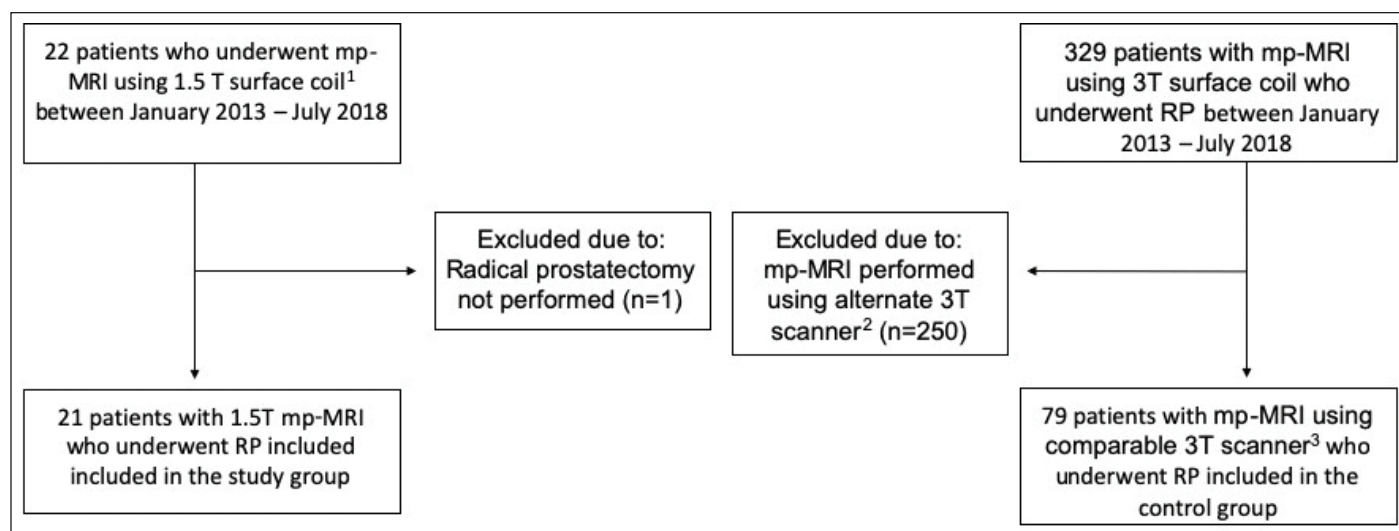
Fig. 1. Flow diagram shows patient selection used in this retrospective study. [1]Clinical 1.5T Tesla system: Symphony Tim (Siemens Syngo version MR B17, Malvern, PA, U.S.). [2]Discovery 750W (General Electric, Milwaukee, WI, U.S.). [3]Clinical 3 Tesla system: TRIO Tim (Siemens Syngo version MR B17, Malvern, PA, U.S.). mpMRI: multiparametric magnetic resonance imaging; RP: radical prostatectomy.

Reference standard

The reference standard was radical prostatectomy (RP). A genitourinary pathologist with 14 years of experience (blinded) reviewed the RP results. The dominant tumor foci within each RP (tumor foci measuring at least 0.5 mL in size) were identified and mapped to a prostate sector MRI-RP map (Fig. 2). For all patients, there was a single dominant tumor focus.

Statistical analysis

Patient age, prostate-specific antigen (PSA), and ISUP grade group were compared using independent t-tests and Chi-squared. Clinical indication, lesion size, and pathological stage were also compared using Wilcoxon sign-rank test and Student's t-test. Diagnostic accuracy of mpMRI for detection of CS-PCa was tabulated. McNemar test was used to compare the detection rate of CS-PCa at 1.5T and 3T.

Table 1. Sequence parameters for multiparametric MRI of the prostate protocol performed with pelvic surface coil[a] at 3 Tesla[b] and pelvic surface coil[c] at 1.5 Tesla[d]

	Imaging plane	Field of view (mm)	Matrix size	Slice thickness/ gap (mm)	TR/TE (ms)	Echo train length	Flip angle	Acceleration factor	Receiver bandwidth (Hz/Voxel)	Acquisition time (min)	Number of signals averaged
3 Tesla											
T2 TSE	Coronal Sagittal Axial	220x220	320x256	4.0/0 3.0/0 3.0/0	3890–5250/ 105–125	27-35	111	N/A	122	4 min 4 min 4 min	1–2
DWI[e]	Axial	280x280	128x80	5.0/1.0	4200/90	1	90	2	1950	5 min	8–10
T1 GRE[f] dynamic contrast	Axial	220x220	128x128	4.0/0	4.3/1.3	N/A	12	2	488	2 min	1
1.5 Tesla											
T2 TSE	Coronal Sagittal Axial	200x200	320x256	3.0/0 3.0/0	3890–5250/ 105–125	27-35	111	N/A	122	4 min 4 min 4 min	1–2
DWI[e]	Axial	300x300	128x128	3.0/0	4200/ 90	1	90	2	1950	5 min	8–10
T1 GRE[f] dynamic contrast	Axial	250x250	256x192	2.5/0	4.3/1.3	N/A	12	2	488	2 min	1

[a]Integrated pelvic surface coils (4 channels) with activated spine coils (3 channels). [b]Clinical 3 Tesla system: TRIO Tim (Siemens Healthcare). [c]Integrated pelvic surface coils (12 channels) with activated spine coils (6 channels). [d]Clinical 1.5 Tesla system: Symphony Tim (Siemens Healthcare). [e]DWI: Diffusion weighted imaging performed with spectral fat suppression echo planar imaging with tridirectional motion probing gradients and B values of 0, 500, 1000 mm²/sec with automatic apparent diffusion coefficient map generation. [f]Dynamic fast spoiled 2D Gradient Recalled Echo performed with a temporal resolution of 10 seconds after injection of 0.1 mmol/kg of gadobutrol (Gadovist, Bayer Inc. Toronto, ON, Canada) at a rate of 3 mL/sec.
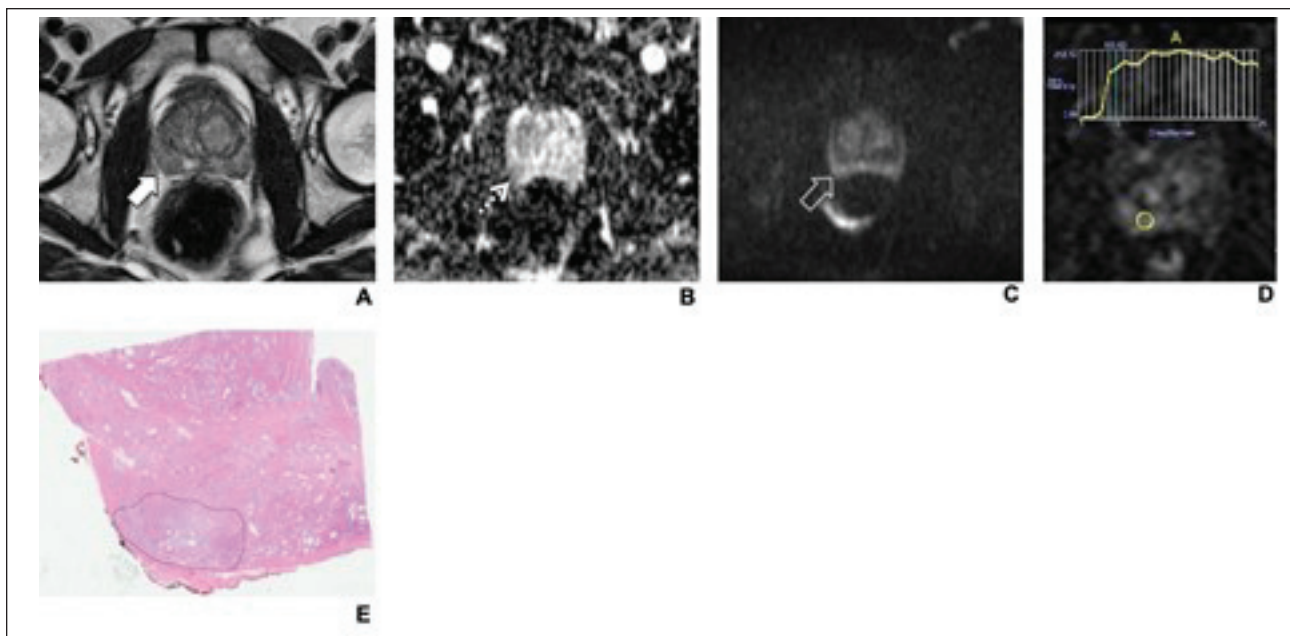
Fig. 2. 62-year-old male with Gleason 3+4=7 prostatic adenocarcinoma (PCa) in the right middle peripheral zone (PZ). Examination was obtained in a 1.5 T magnet. *(A)* Axial T2-weighted (T2W); *(B)* axial apparent diffusion coefficient (ADC) map; *(C)* echo-planar diffusion weighted image (DWI, b=1000 mm2/s); and *(D)* axial image from dynamic contrast enhanced (DCE) imaging with time-signal intensity (SI) curve show the tumor as a 11 mm hypointense focus (solid white arrow in *A*), which is mildly hypointense on ADC map (dotted arrow in *B*) and isointense to the adjacent parenchyma on high b value DWI (open white arrow in *C*). It was detectable as a focal enhancing nodule on DCE with a time-signal intensity (SI) curve within the tumor demonstrating type II kinetics. The tumor was considered PI-RADS v2 category 4 (DWI score 3 upgraded by DCE) observation. Corresponding low microscopic power (10x) hematoxylin and eosin (H&E) stained photomicrograph *(E)* shows the corresponding tumor outlined in black.

Results

Mean patient age and PSA were 69.2±7.6 years and 8.5±6.5 ng/mL at 1.5T, respectively, and 63.4±5.2 years and 8.4± 5.2ng/mL at 3T, respectively. Patients imaged at 1.5T were older (p<0.001), with no difference in PSA (p=0.913). No difference in tumor size or clinical indication between groups was found (p>0.05). The 3T group had higher rates of pT3 disease; however, only the former was significant (Table 2).

Distribution of PCa by ISUP grade group and PI-RADSv2 scores by field strength are summarized in Table 2. There was no difference in grade groups (p=0.922). At 1.5T, 85.7% (18/21) of tumors were localized to the peripheral zone (PZ) and 14.3% (3/21) the transition zone (TZ) at RP, compared to 89.9% (71/79) PZ and 10.1% (8/79) TZ at 3T (p=0.588). At 1.5T, the dominant tumor was accurately detected in 90.5% (19/21) compared to 93.7% (74/79) at 3T, (p=0.76). Diagnostic accuracy at 1.5T and 3T are summarized in Table 2.

Discussion

This study evaluated the accuracy of 1.5T mpMRI performed without ERC for detection of CS-PCa in men with uncleared medical devices for imaging at 3T. Using similar generation 1.5T and 3T scanners from the same vendor with the same operating system, we demonstrated comparable accuracy at 1.5T and 3T. Our results support the growing body of evidence suggesting that mpMRI at 1.5T for PCa detection may be an acceptable alternative to imaging at 3T for patients with implanted devices uncleared for 3T and, if more broadly applied, to patients who do not have reasonable access to 3T systems.[7]

Ullrich et al6 demonstrated similar PI-RADS scores in patients imaged at 1.5T and 3T scanners. Similarly, Bratan et al[8] and Thompson et al[9] showed that MRI field strength and coil configuration had little influence on tumor detection rate. Moreover, a meta-analysis showed that ERC yielded no additional benefit for PCa detection accuracy or image quality at 1.5T and 3T.[10]

Our study is limited by sample size, which can be expected given the single-center, retrospective nature of our analysis. A proportion of the uncleared medical devices in our study group could now be considered relative rather than absolute contraindications for imaging at 3T. For example, many institutions (including at present, our own) no longer consider manufacturer recommendations for field strength when imaging coronary stents.

Conclusions

Our study demonstrates comparable accuracy of mpMRI for detecting CS-PCa at both 1.5T and 3T without ERC and

Table 2. Distribution of prostate cancer by ISUP grade group and PI-RADS v2 scores by field strength. Diagnostic accuracy for clinically significant prostate cancer, lesion size, MRI indication, presence of EPE and SVI on both magnets is also shown

	1.5 T Magnet	3 T Magnet	p
ISUP grade group			0.922
1	0% (0/21)	2.5% (2/79)a	
2	47.6% (10/21)	38% (30/79)	
3	28.6% (6/21)	32.9% (26/79)	
4	9.5 (2/21)	8.9% (7/79)	
5	14.3 (3/21)	17.7% (14/79)	
PI-RADS v2 score			
3	4.7% (1/21)	11.4% (9/79)	
4	42.9% (9/21)	31.6% (25/79)	
5	52.4% (11/21)	57% (45/79)	
Diagnostic accuracy			
Sensitivity (CI)	0.92 (0.79–0.98)	0.93 (0.87–0.97)	
Specificity (CI)	0.98 (0.95–0.99)	0.98 (0.98–0.99)	
EPE presence	36.4% (8/22)	67.1% (53/79)	0.011
SVI presence	9.1% (2/22)	20.3% (16/79)	0.262
Size on MRI (mm)	20±10	20±11	0.890
MRI Indication	Active surveillance Previous negative biopsy	Active surveillance Previous negative biopsy	

aIn this study, these 2 patients were counted as negative for clinically significant prostate cancer which was defined as ISUP ≥2. CI: confidence interval; EPE: extraprostatic extension; ISUP: International Society of Urogenital Pathology; MRI: magnetic resonance imaging; SVI: seminal vesicle invasion.

that non-ERC 1.5T mpMRI could be acceptable in men who cannot undergo 3T MRI due to an uncleared medical device and, if more broadly applied, to those men who do not have access to 3T.

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