

Multiparametric Magnetic Resonance Imaging (mpMRI): Prostate Imaging Guidance Document 1.5 Tesla

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Endorsed by:
Magnetic Resonance Advisory Group
(MRAG)

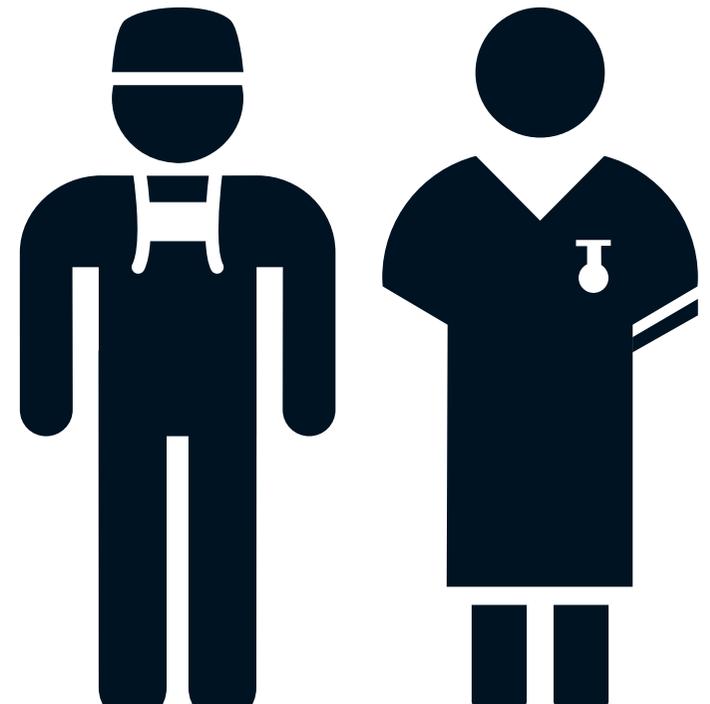


Introduction

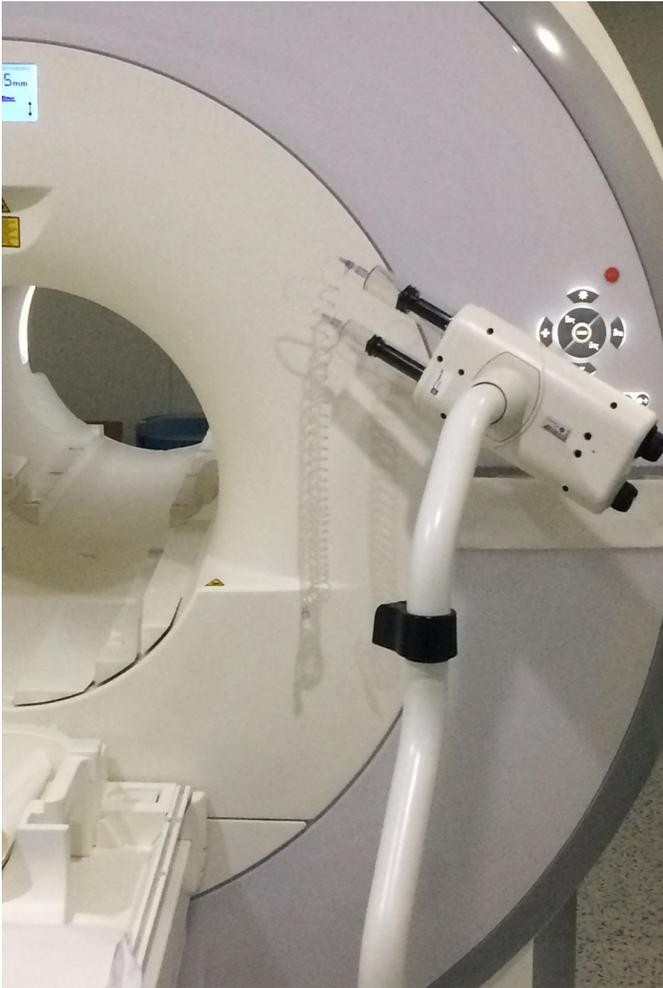
High-quality images are critical if mpMRI scans undertaken before a prostate cancer biopsy are to achieve the diagnostic accuracy made possible by the PROMIS trial. For men with suspected prostate cancer they are the means to more accurately detect clinically significant prostate cancer – a stage of disease, when missed, can be the difference between life and death. They can also enable some men to safely avoid an unnecessary immediate, often invasive biopsy. Prostate Cancer UK and the Society and College of Radiographers are pleased to have produced this imaging guidance document as an aide-mémoire for imaging departments to assist in developing a protocol for mpMRI prostate.

Disclaimer

Due to the broad range of MRI scanners, receive coil technologies, gradient slew rates, static field strengths and software platforms in common clinical practice; it would be futile to attempt to provide a bespoke mpMRI prostate imaging guidance document for every MR system in the UK. Therefore this imaging guidance is designed to provide MR radiographers with a platform on which to build a mpMRI prostate scan protocol tailored to their specific MR system. This guidance is based upon the recently published UK consensus document¹ (see reference list). The imaging guidance is devised for initial diagnosis of prostate cancer. Some imaging departments may add extra sequences to their mpMRI prostate protocol if they wish to acquire more information for staging of metastatic prostate cancer and with the subsequent increase in overall scan time. This imaging guidance, planned to diagnose initial prostate cancer is intended to take no more than 30 minutes of total scan time.

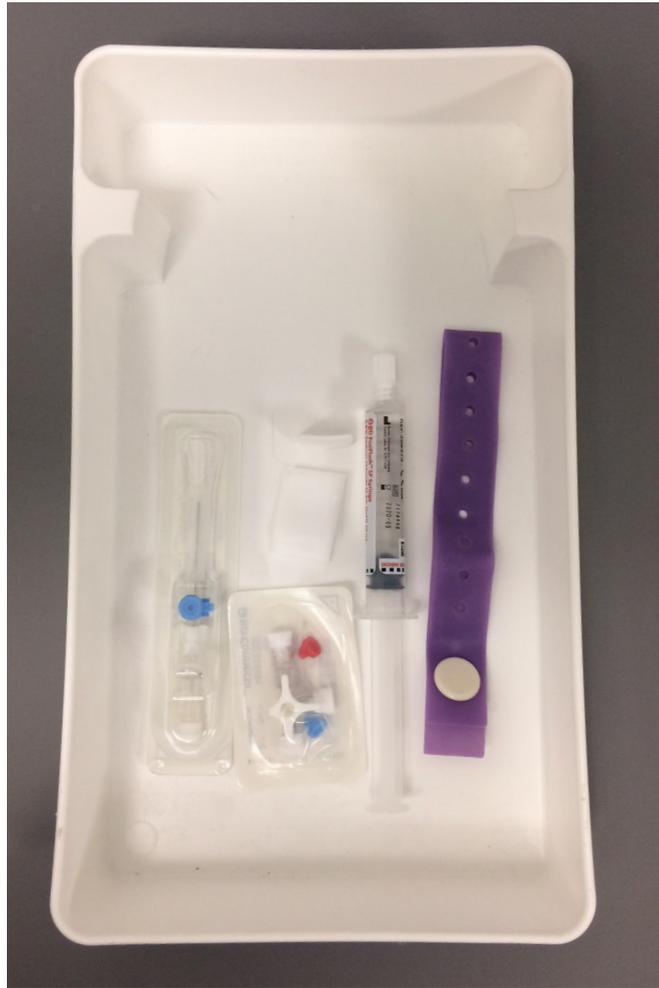


Patient preparation



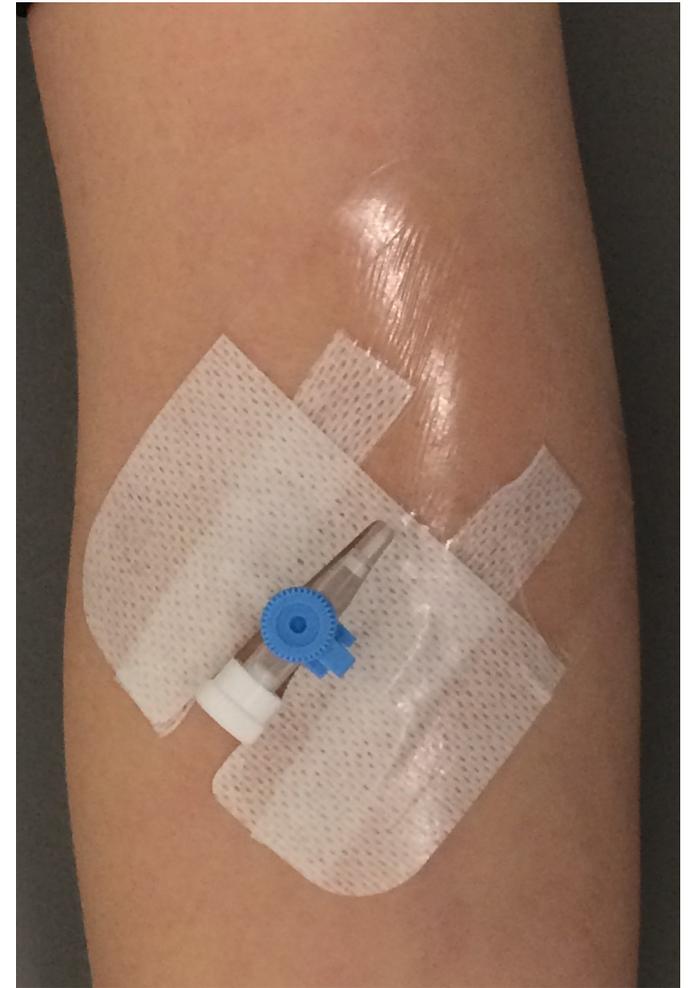
scanner image with injector pump

You will need to prepare an injector pump with gadolinium and 50mls of saline flush.



cannulation tray

Please choose a cannula that will allow an injection rate of 2-3mls per second.



patient's arm – cannula inserted

You are ready to position the patient.

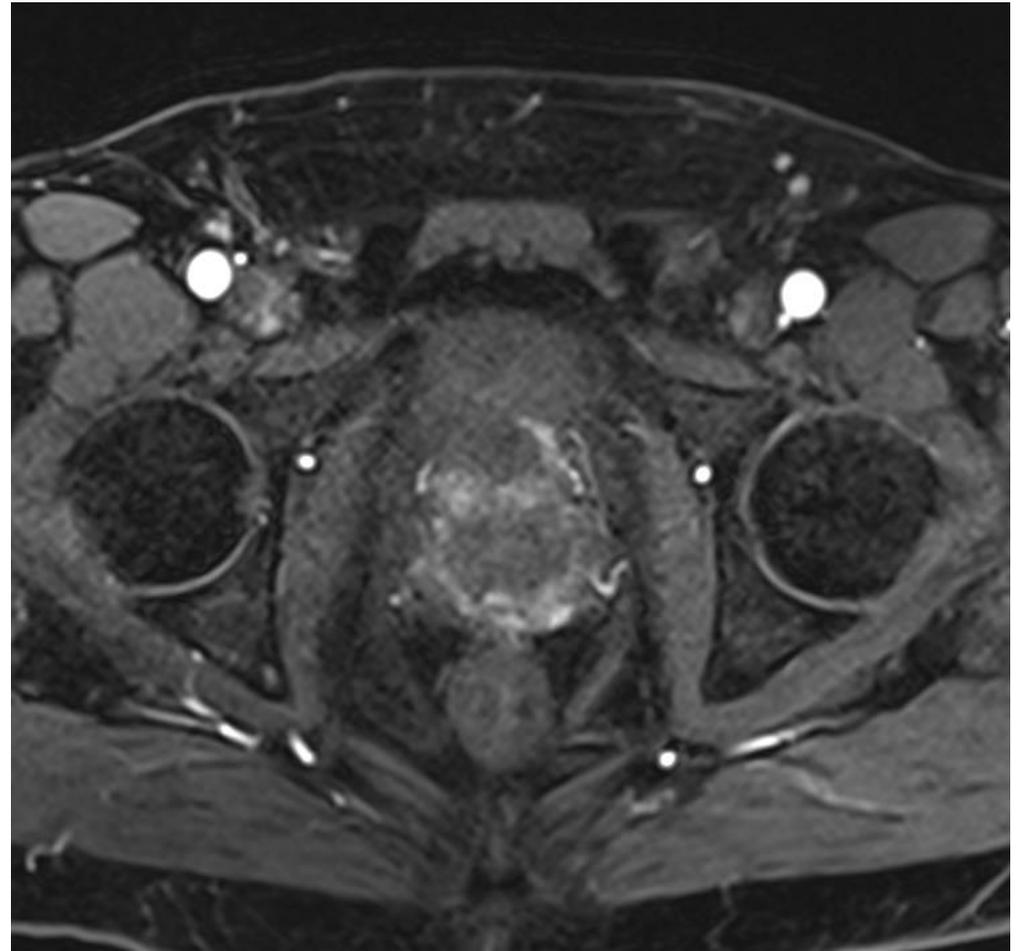
Patient preparation

- The patient should be consented and screened for MRI safety as per departmental local rules. The patient's weight in kilograms (kgs) (and for some MR systems the patient's height) should be recorded for Specific Absorption Rate (SAR) level and intravenous contrast administration purposes.
- The patient should be changed as per departmental local rules.
- Cannulation – a cannula should be positioned intravenously into the patient as per departmental local rules to achieve a flow rate of 2-3mls per second for contrast administration.
- A contrast media pump injector should be prepared. The dose of gadolinium recommended is 0.1-0.2mls/kg of body mass depending on your departmental choice of gadolinium product. To note the consensus document¹ does not advocate or advise on a specific gadolinium product that should be used for mpMRI prostate examinations.
- 20mls of saline should be prepared to flush the bolus of contrast media around the body.
- Adherence to departmental local rules regarding pre checking of a patient's renal function prior to gadolinium administration is necessary.
- Prior to entering the scan room all patients should be asked to use the toilet to empty their rectum of stool and bowel gas when possible.
- Patients should be consented and screened to assess their suitability to administer intravenously/intramuscularly an anti-peristaltic drug to reduce bowel motion.¹ Unless contraindicated, this drug can be administered prior to the patient being positioned in the isocentre of the MR scanner.
- A phased array body coil should be correctly positioned over the patient's pelvis. There is no guidance on the minimum or maximum number of coil elements/channels for the phased array coil; however a larger number of coil elements will provide higher Signal to Noise Ratio (SNR) which can be used to reduce overall scan time and/ or improve image resolution. Note: An endorectal coil is not recommended for routine clinical use.¹ Noise reduction ear plugs/ear defenders should be provided as well as a call buzzer for the patient.
- The patient should be positioned supine on the scan table. If after the first localizer view the rectum is still filled with air, then consideration to scan the patient prone to decompress the rectum is advised.²

Image acquisition



An example of a small field of view coronal T2 weighted Turbo Spin Echo (TSE) image.



An example of a axial 3D T1 weighted, fat suppressed post gadolinium dynamic contrast enhanced image.

Small Field of View (FOV) T2 TSE (2D)

Plane of acquisition	FOV (mm)	FOV phase (RFOV) (%)	TR (msec)*	TE (msec)*	ETL/turbo factor	Slice thickness (mm)	Slice gap	No. of slices**	Acquisition matrices (frequency x phase)*	In plane resolution (frequency x phase) (mm)	Over sampling/foldover suppression	Foldover direction	NSA/NEX (approx)	Parallel imaging (approx. factor)	Approx scan time (mins)
Sagittal	240	100	4000	120	22	3.0	10%	35	600 x 342	0.40 x 0.70	Yes	F/H	2	1.5/2	4 - 5
Axial	200	100	3800	120	20	3.0	10%	30	500 x 285	0.40 x 0.70	Yes	R/L	3	1.5/2	4 - 5
Coronal	200	100	3800	128	20	3.0	10%	30	500 x 285	0.40 x 0.70	Yes	R/L	3	1.5/2	4 - 5

*TR/TE and acquisition matrices are approximations and can alter slightly depending on scanner type and the number of slices required to cover the relevant anatomy.

** Number of slices can depend on size of prostate gland.

- In plane resolution should ideally be $\leq 0.7\text{mm}$.¹ The American College of Radiology advise 0.4mm (frequency) x 0.7mm (phase).² In plane resolution is calculated using – field of view in (mm)/matrix size.
- You may consider commencing with the sagittal T2 TSE sequence to assist with planning the axial and coronal sequences.
- Should be acquired using the femoral heads as a bony landmark to achieve true orthogonal axial and coronal images of the prostate (rather than along the prostate gland base to apex axes).¹
- It is preferable to acquire three separate T2 TSE sequences rather than one 3D acquisition.¹
- Anatomic coverage for all three planes; superiorly the bladder neck, all of the seminal vesicles through the prostate gland to inferiorly the prostate apex. Laterally the medial aspects of the femoral heads and posteriorly the anterior rectum and all of the seminal vesicles. Anteriorly the symphysis pubis should be included.

Diffusion Weighted Imaging (DWI) – Echo Planar Imaging (EPI) with spectral fat suppression

Plane of acquisition	FOV (mm)	FOV phase (RFOV) (%)	TR*	TE*	Slice thickness (mm)	Slice gap (mm)	No. of slices	Acquisition matrices (frequency x phase)*	In plane resolution (mm)	Over sampling / foldover suppression	Foldover direction	NSA/NEX	Parallel imaging (approx. factor)	b-values (s/mm ²)	Other
Axial	250	100	2195	73	4	1	15	152 x 132	1.64 x 1.89	Yes	A/P	Incremental increase in NEX for increasing b-values if available	2	0,50, 400, 800, 1400	EPI single shot. Use 'Halfscan'

*TR/TE and acquisition matrices are approximations and can alter slightly depending on scanner type and the number of slices required to cover the relevant anatomy.

- In plane resolution should ideally be $\leq 2.0\text{mm}$.¹ This is calculated using – field of view in (mm)/matrix size.
- The minimum high b-value at 1.5T should be 1400s/mm^2 .¹
- ADC map to be calculated.
- Fat suppression is important to reduce phase shift. Checking of shim volumes to optimise fat suppression is advised.
- Anatomic coverage; at least include all of the prostate gland and if possible provide the same coverage as the T2 TSE sequences.
- Should be acquired using the femoral heads as a bony landmark to achieve true orthogonal axial images to the prostate (rather than along the prostate gland base to apex axes).¹
- Free breathing sequence.
- Total scan time approximately six minutes.
- If a patient is known to have a single or bilateral hip prosthesis, then consideration of alternative EPI sequences e.g. Siemens Multishot EPI Resolve or GE EPI Focus is advised. Otherwise omitting the DWI sequence should be performed in consultation with the reporting radiologist.
- To optimise the DWI sequence, parallel imaging to reduce inter-echo spacing is advised.

Diffusion Weighted Imaging (DWI) single high b-value

A separate single high b-value may be acquired with the consequence of an increased overall scan time. The minimum high b-value at 1.5T should be 1400s/mm^2 .¹ If adequate SNR permits (which will depend on scanner type and field strength) then the upper range could be around 2000s/mm^2 .² To note the higher the b-value the less the SNR.²

3D T1 W GRE fat saturated sequence – THRIVE (Philips), VIBE (Siemens), LAVA XV (GE), TIGRE (Hitachi) Dynamic Contrast Enhanced (DCE) MRI

Plane of acquisition	FOV (mm)	TR (msec)*	TE (msec)*	Voxel size F/H (slice thickness) (mm)	Overcontiguous /overlapping slices	Approx. number of slices**	Acquisition matrices (frequency x phase)*	In plane resolution (mm ²)	Approx. flip angle (°)	Foldover direction	NSA/NEX	Parallel imaging (approx. factor)	TFE Factor	Dynamic/ phase scan time (temporal resolution)	No. of dynamics/ phases
Axial 3D	200	5.6	2.7	1.5	Yes	55	125 x 111	1.6 x 1.8	≥35	A/P	1	2	40	≤15 secs per dynamic	≤15***

*TR/TE and acquisition matrices are approximations and may alter slightly depending on scanner type and the number of slices required to cover the relevant anatomy.

** Number of slices will depend on size of the prostate gland, seminal vesicles.

*** The total scan time should be ≥2minutes. This will allow for variations in patient cardiac outputs.

- Should be acquired using the femoral heads as a bony landmark to achieve true orthogonal axial images to the prostate (rather than along the prostate gland base to apex axes).¹
- Free breathing sequence.
- No need for bolus tracking.
- It is preferable to achieve isotropic voxels in 3D imaging, however it is appreciated that this can be technically challenging to achieve.
- Increasing the flip angle will increase the T1 weighting of the sequence but may also increase scan time due to increases in the TR.
- The dynamic sequence should be set up to acquire first one dynamic scan without gadolinium. Then contrast can be administered and the remaining dynamic sequence acquisitions commenced at the same time.
- Injection rate for gadolinium contrast – 2/3mls per second (mls/sec). Dose 0.1/ 0.2mls per/kg of body mass (depending on choice of gadolinium product, please see patient preparation for further details).
- 20mls of saline injected at 2/3mls/sec to flush contrast bolus.
- Anatomic coverage – as per T2 TSE sequences.
- As it is not necessary to quantitatively calculate pharmacokinetic modelling from the DCE-MRI, temporal resolution can be up to 15 seconds per dynamic to achieve higher spatial resolution.¹
- If a patient is known to have a single or bilateral hip prosthesis, then image quality may be reduced on the DCE-MRI sequence. Alternatively you may consider using a dynamic DIXON sequence to improve fat saturation for the DCE-MRI.
- Fat suppression is important to optimise contrast to noise ratio. Checking of shim volumes to optimise fat suppression is advised.

References

1. Brizmohun Appayya et al (2018). National implementation of multiparametric MRI for prostate cancer detection – recommendations from a UK consensus meeting. British Journal of Urology International (BJUI). [electronic publication] doi:10.1111/bju.14361
2. American College of Radiology (ACR) (2015). Prostate Imaging – Reporting and Data System (PI-RADS) Version 2. www.acr.org/-/media/ACR/Files/RADS/Pi-RADS/PIRADS-V2.pdf (last accessed: 5 June 2018).



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