 

# Imaging quality and prostate MR: it's time to improve

- Commentary -

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**Abstract**

The PI-RADS guidelines set out the minimal technical requirements for the acquisition of multiparametric magnetic resonance imaging (mpMRI) of the prostate. However, the rapid diffusion of this technique has inevitably led to variability in scan quality among centres across the UK and the world. Suboptimal image acquisition reduces the sensitivity and specificity of this technique for the detection of clinically significant prostate cancer and result in clinicians losing confidence in the technique.

Two expert panels (one from the UK and one from the ESUR/ESUI) have stressed the importance to establish quality criteria for the acquisition of mpMRI of the prostate. A first attempt to address this issue has been the publication of the Prostate Imaging Quality (PI-QUAL) score, which assesses the mpMRI quality against a set of objective criteria (PI-RADS version 2.1 guidelines) together with criteria obtained from the image.

PI-QUAL represents the first step towards the standardisation of a scoring system to assess the quality of prostate mpMRI prior to reporting and allows clinicians to have more confidence in using the scan to determine patient care. Further refinements after robust consensus among experts at an international level need to be agreed before its widespread adoption in the clinical setting.

## Introduction

There has been a steep increase in the use of multiparametric magnetic resonance imaging (mpMRI) of the prostate over the last decade and this has resulted in high variability of scan quality and reporting . [1]

High-quality MR images of the prostate are a key determinant in an MRI-led prostate cancer diagnostic pathway. MRI-derived targeted biopsies are used to detect clinically significant prostate cancer and a negative scan can be used to safely avoid unnecessary immediate biopsy. [2]

It is impossible to provide a tailored mpMRI prostate imaging protocol for every MR system due to the number of different vendors and the different ages of the scanners available. There will also be some variability due to patient factors such as movement and rectal gas.

For either detection or exclusion of prostate cancer, images with good spatial resolution and high signal-to-noise ratio for each sequence [T2-weighted imaging (T2-WI), diffusion-weighted imaging (DWI) and dynamic contrast enhanced (DCE) sequences] are needed.

The first attempt to overcome this issue was the publication of the Prostate Imaging Reporting and Data System (PI-RADS) guidelines version 1 in 2012, which outlined the minimum technical requirements and standards for prostate mpMRI reporting. [3]

Following the increasing body of evidence gained from their widespread application, the PI-RADS guidelines were subsequently refined in 2015 (v. 2.0) and in 2019 (v. 2.1). [4,5]

The most recent technical requirements for a good quality prostate mpMRI according to PI-RADS v. 2 guidelines are presented in Table 1.

**Where are we?**

There is growing evidence that a formal assessment of prostate MRI quality is needed and interesting results from different institutions across the world have been published. [6–10]

A UK consensus meeting has stressed the importance of ensuring high-quality MR acquisition and reporting, especially if prostate mpMRI is used as a means of avoiding biopsy. [11]

In addition to this, a recent statement from the European Society of Urogenital Radiology (ESUR) and the EAU Section of Urologic Imaging (ESUI) has shown that there is still huge variability in the conduct of prostate mpMRI and has also highlighted the need to define requirements for learning and accumulation of reporting experience for mpMRI. [12,13]

The ESUR/ESUI consensus paper includes a summary of the opinions of recognised experts in diagnostic prostate MRI following a Delphi consensus process on quality measures that are not adequately addressed by current literature, but a set of objective criteria for assessing image quality has not been provided. [12]

A first attempt to fill this gap is represented by the recent publication of a dedicated scoring system from the multicentre randomised PRECISION trial [2], called Prostate Imaging Quality (PI-QUAL). [14]

The PI-QUAL score is based on a 1-to-5 Likert scale derived by evaluating each mpMRI sequence (T2-WI, DWI and DCE) against a defined set of objective quality criteria in line with PI-RADS v.2 guidelines [4] and using a subjective assessment of the image (Table 2). A poor-quality scan should not be used for a diagnostic assessment of the prostate.

There can be significant variability in the acquisition of prostate mpMRI and often adherence to the PI-RADS guidelines does not necessarily lead to a diagnostic quality image. For example, although the apparent diffusion coefficient (ADC) values have been reported to correlate inversely with adverse histology in prostate cancer, there is still considerable overlap between benign prostatic hyperplasia, low-grade and high-grade tumours. Although the PI-RADS v. 2.1 guidelines suggest a threshold of 750-900 $\mu m^2$/sec to differentiate between benign and malignant prostate tissue, ADC calculations are influenced by the choice of *b*-values and cannot be standardised due to the inconsistency across vendors. It has been shown that the use of a ratio (ADC ratio) of prostate tumour ADC to normal tissue ADC or to the ADC of the urine in the bladder on a single scanner can provide a more robust means of assessing restricted diffusion in the prostate. [15–18] However, visual assessment is often used as the primary method to assess the quality of DWI.

Other factors related to the patient (e.g. patient motion, patient size, or the degree of rectal distension) or dependent on the expertise of the radiographer acquiring the MR study, could heavily impact on the quality of prostate mpMRI.

In addition to this, the scans from non-specialist centres usually show poorer imaging quality due to a lack of insight into the problem and lack of awareness of the quality achieved in high-volume, academic centres. Therefore, PI-QUAL represents the first effort to inform the radiological community of the importance of prostate MR quality and its widespread adoption could help to drive improvements when the imaging quality is inadequate.[19]

We also know that the negative predictive value of mpMRI is far higher than the positive predictive value (for example using a threshold of PI-RADS ≥3), which means that mpMRI is better as a 'rule-out' (i.e. biopsies can be avoided) rather than as a 'rule-in' (i.e. biopsy required to confirm cancer, as imaging alone insufficient) test. [20] Therefore, with a PI-QUAL score of 3 (i.e. the examination is of acceptable diagnostic quality) but high clinical suspicion (e.g. family history of prostate cancer or high PSA density), a systematic biopsy cannot be confidently avoided, as although the quality of the scan is acceptable, the negative predictive value may be compromised.[21] It should be also mentioned that a large conspicuous lesion may still be apparent on sub-optimal quality imaging (e.g. PI-QUAL 2) and could therefore still be called despite the poor image quality, but any small lesion will be inevitably missed at the same time.

**What's next?**

During the quality assurance work in PRECISION that led to the publication of PI-QUAL [14], the highest variability in quality of mpMRI sequences was for DCE sequences, followed by DWI and T2-WI. This may explain why some centres have been able to drop the DCE sequence with no effect on their ability to diagnose significant prostate cancer. It should be stressed that PI-QUAL has been conceived for mpMRI and assumes that all three sequences (T2-WI, DWI and DCE) have been acquired. Therefore, PI-QUAL cannot be applied on biparametric MRI and this will be definitely taken into account in PI-QUAL v. 2, especially since a recent study has shown that 44% of MRI studies in the UK are performed without contrast. [22]

Scanner age is also a significant factor that influences the quality of prostate mpMRI. This requires more investigation but from our preliminary work and our experience MR scanners over 10 years old are not able to produce diagnostic quality studies. In addition to this, Burn and colleagues have shown a significant difference in prostate MR quality at a 7 years cut-off for scanner age. [6]

Adherence to the minimum acceptable technical parameters of mpMRI as outlined in the PI-RADS v. 2.1 guidelines [5] is a good starting point to improve the quality of prostate MR, however this is just a guide and the quality can also be improved using newer fat saturation techniques, parallel imaging and motion reduction techniques. Often the sequences that are preloaded by the MR vendor are not of sufficient quality for prostate imaging and it is important to work with MR radiographers and physicists until a diagnostic set of sequences is obtained.

Therefore, it is important that the quality is high both at a 'centre level' (i.e. a centre should produce good quality prostate MRI with up-to-date MR scanners and dedicated radiologists/radiographers highly experienced in prostate MRI) and at a 'patient level' (i.e. patient-related artefacts such as rectal gas or movement should be minimised).

Some of the current technical standards set out in PI-RADS v. 2.1 guidelines [5] could warrant reconsideration. For example, PI-RADS v. 2.1 technical recommendations mainly focus on spatial and temporal resolution but there is no mention of contrast resolution and other scan parameters. This should be addressed in the future, especially since the widespread adoption of mpMRI as a first-line investigation in patients with suspected prostate cancer.

Further research on what is most important in these technical guidelines and perhaps the formation of a sequence bank for sharing best practice to improve mpMRI quality along with the use of automated methods (including those based on deep learning) is advocated. [19]

In conclusion, the first version of PI-QUAL (v. 1) represents the start of identifying a framework for the assessment of prostate MR quality. It will give clinicians confidence to act on the scan findings and help to reduce scan variability. It is the basis for future works and will require further refinement and prospective validation.

**Table 1** – Minimal technical requirements for multiparametric prostate MRI according to the PI-RADS v. 2.1 guidelines

**Table 2:** Assessment of the diagnostic quality of multiparametric MRI scans using the PI-QUAL score.

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Table 1

**Table 1** – Minimal technical requirements for multiparametric prostate MRI according to the PI-RADS v. 2.1 guidelines

| | **T2-weighted imaging (T2-WI)** | **Diffusion - weighted imaging (DWI)** | **Dynamic contrast enhanced (DCE)** |
|---|---|---|---|
| **Imaging planes** | Same used for DWI and DCE | Same used for T2-WI and DCE | Same used for T2-WI and DWI |
| **Slice thickness** | 3mm, no gap | ≤ 4mm, no gap | 3mm, no gap |
| **Field of view** | 12-20 cm * | 16-22 cm | 12-20 cm * |
| **In-plane dimension** | ≤ 0.7mm (phase) x ≤ 0.4mm (frequency) | ≤ 2.5mm (phase and frequency) | ≤ 2 mm (phase and frequency) |
| **Specific recommendations** | | | |
| **T2-WI acquisition** | Axial plane: either straight axial to the patient or in an oblique axial plane matching the long axis of the prostate | - | - |
| | At least one additional orthogonal plane (sagittal and/or coronal) | - | - |
| | 3D axial as an adjunct to 2D acquisitions | - | - |
| **Low *b* value** | - | 0 (preferably 50) -100 sec/mm$^2$ | - |
| **Intermediate *b* value** | - | 800-1000 sec/mm$^2$ | - |
| **High *b* value** | - | - Dedicated (≥ 1,400 sec/mm$^2$)<br>- Synthesised (from other *b*-values) | - |
| **Temporal resolution** | - | - | ≤ 15sec |
| **Total observation rate** | - | - | > 2min |
| **Dose of GBCA** | - | - | 0.1mmol/kg |
| **Injection rate** | - | - | 2-3cc/sec |
| **Fat suppression/subtraction** | - | - | Recommended |

* to encompass the entire prostate gland and seminal vesicles)

Legend – T2-WI: T2-weighted imaging; DWI: diffusion-weighted imaging; DCE: dynamic contrast enhanced; GBCA: Gadolinium-based contrast agent

Table 2

**Table 2:** Assessment of the diagnostic quality of multiparametric MRI scans using the PI-QUAL score.

| PI-QUAL score | Criteria | Clinical Implications |
|---|---|---|
| **1** | All mpMRI sequences are below the minimum standard for diagnostic quality | It is NOT possible to rule in all significant lesions * |
| **2** | Only one mpMRI sequence is of acceptable diagnostic quality | It is NOT possible to rule out all significant lesions * |
| **3** | At least two mpMRI sequences taken together are of diagnostic quality | It is possible to rule in all significant lesions<br>It is NOT possible to rule out all significant lesions |
| **4** | Two or more mpMRI sequences are independently of diagnostic quality | It is possible to rule in all significant lesions |
| **5** | All mpMRI sequences are of optimal diagnostic quality | It is possible to rule out all significant lesions |

* Therefore reports should not include PI-RADS or Likert scores.

Legend: PI-QUAL: Prostate Imaging QUALity; mpMRI: multiparametric magnetic resonance imaging; PI-RADS: Prostate Imaging Reporting and Data System

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