Detecting prostate cancer with MRI — why and how

P. Puech*, A. Sufana lancu, B. Renard, A. Villers, L. Lemaitre

Nephro-urological radiology department, CHRU de Lille, 1, rue Michel-Polonovski, 59037 Lille cedex, France

Keywords
Prostate; Malignant tumour; Detection; Interpretation; Standardisation

Abstract
Multiparametric MRI of the prostate is an essential examination for the diagnosis, preoperative evaluation and planning of treatment for prostate cancer. This examination can accurately detect cancer foci in the gland so that the most appropriate management can be offered, reduce the risk of over-treatment and also ensure that certain aggressive lesions or unusual locations, which might affect the prognosis, are not ignored. We present here its main indications, focusing on the techniques for interpreting MRI, its performance and its limitations, as well as the recent European recommendations underlining the need for international harmonisation.

© 2012 Éditions françaises de radiologie. Published by Elsevier Masson SAS. All rights reserved.

Urologists are asking for prostate MRIs more and more frequently, a trend that has intensified recently since the urological community has taken up this examination again. We say 'again', because, having seen success in the 1990s, this examination fell into disuse due to discordant results for the only indication that had been agreed for it — prostate cancer staging. It had therefore failed to take a hold, and was never officially recommended [1]. Things changed between 2000 and 2010, when the notion of 'over-treatment' was taken into consideration: from the traditional dichotomy of curative versus palliative treatment of the 1990s emerged conservative surgical treatment, localised radiotherapy (brachytherapy), the idea of active surveillance and more recently, focused cancer treatment. Many alternatives to radically blind treatments have developed, all guided or validated by imaging. With younger and younger patients who are ever better informed, it has become difficult to justify non-conservative treatment simply based on biopsies and digital rectal examination. Pepped up with constant technical developments (surface coils, high fields, new sequences), MRI of the prostate has returned to the forefront at the request of urologists, with the new name of multiparametric MRI. It is now asserting itself as a highly effective

* Corresponding author.
E-mail address: puech@dicomworks.com (P. Puech).
examination for identifying cancer foci in the gland, differentiating the most aggressive from those which are not yet significant, guiding the diagnosis and treatment of the cancer [2–6]. It has thus become a leading theme in the management of prostate cancer.

Prostate MRI: what is its role in diagnosis?

The limitations of prostate biopsy

The gold standard for diagnosing prostate cancer is a prostate biopsy, performed under ultrasound guidance and providing histopathological evidence. This technique mainly samples the posterior part of the gland (the most posterior 18 mm), and is acknowledged to usually fail to include the entire anterior part, where a significant number of cancers develop (20%) [7]. Conversely, this technique often leads to the diagnosis of millimetre size cancer foci, called microfoci, which theoretically should not be treated radically by prostatectomy or radiotherapy because of the mediocre risk/benefit ratio. Moreover, biopsies can under-evaluate large cancers, simply because one of the biopsy cores grazes the posterior part of the cancer which then just seems to be a microfocus. In these cases, management of the patient may be unsuitable (active surveillance instituted, postope- nent decided of a new set of biopsies, treatment delayed, conservative surgery misjudged with the risk of margins remaining, poor treatment option, etc.) [8,9].

The advantages of multiparametric MRI

Lesions can be detected using multiparametric MRI of the prostate in areas poorly sampled by biopsies (parts of the base and the extreme apex, the anterior compartment, pre-urethral topography etc.) and the presence of a significant cancer can be eliminated due to the excellent specificity of the technique. It can effectively address the shortcomings of blind transrectal biopsies [10,11].

MRI performed after biopsies

When performed after prostate biopsies, MRI can:

- confirm that there is no suspect lesion in the area of a microfocus, which will reassure the patient and allow active surveillance or conservative treatment to be serenely envisaged;
- identify whether there is a significant lesion in the biopsied area that was falsely detected as a microfocus;
- evaluate the intraprostatic extension of the lesion in order to plan surgery better (to minimise the risk of margins, to propose preservation, etc.) or possibly to propose a focused treatment;
- identify other cancer foci in the gland which may alter the therapeutic approach;
- provide staging of the disease, admittedly not very sensitive but very specific, particularly for an extension to the seminal vesicles. Recent publications have confirmed its ability to improve the efficiency of nomograms to predict seminal vesicle [12] or extracapsular involvement [13] or even the insignificant character of a cancer [14].

MRI performed before biopsies

Better when performed before prostate biopsies [6,15,16], MRI can in this case also:

- diagnose lesions invisible with ultrasound, such as lesions of the anterior compartment (30% of cancers);
- improve targeting of guided biopsies for more precise assessment of the size and histological grade of the cancer (concept of upgrading or upsizeing), or for more precisely confirming a tumour recurrence after treatment;
- allow biopsy of specific sites (such as the seminal vesicles if there is doubt about extraprostatic involvement).

The MRI and biopsy combination

The ability to distinguish tumour foci in areas under-sampled by biopsies makes the MRI + systematic ultrasound-guided biopsy combination the most rational solution for diagnosing an occult cancer in patients whose PSA has continued to rise despite negative biopsies [17,18]. This indication is no longer controversial, since the alternatives (saturation biopsy, transperineal biopsy, alternative biopsy schemes, biopsies under MRI etc.) are invasive and/or costly, and/or confined to research [19,20]. In developing this approach, some urologists propose immediate MRI before the first series of biopsies, in order to obtain better quality MR images (without artefacts, to locate tumour foci more accurately) and improve the results of biopsies as well as patient comfort. This means that optimal stratification of patients can be envisaged and provides doctors with the best conditions for deciding on the patient’s future. The relative medical/economic benefits have yet to be evaluated.

Anticipating a little, some authors believe that, given its excellent negative predictive value, multiparametric MRI could soon be used before biopsy as a test to screen patients with almost no risk of having a significant lesion (and requiring only surveillance) from those with sufficient risk of a significant lesion such that it needs to be proved by prostate biopsy (guidance of which will be optimised by MRI) [16]. It could thus significantly reduce the number of unnecessary procedures.

What tools should be used to detect lesions?

Performing MRI

The examination can be performed on 1.5T or 3T systems, with or without an endorectal coil. These topics are under discussion, but recent consensus conferences now advise using a high resolution pelvic phased array coil (such as ‘Cardiac’ or ‘Torso’), reserving the endorectal coil for certain indications where pericapsular extension information is crucial.

Apart from the technical choice, the success of the examination also largely depends on the preparation and installation of the patient: to reduce rectal peristaltic movements which produce artefacts in long sequences (T2), an enema should be administered a few hours before the examination, preferably with the addition of an injection of a digestive antiperistaltic, such as glucagon, when the patient is installed. The quality of the examination also depends on
the presence or absence of artefacts associated with biopsies (producing artefacts not only in dynamic T1 sequences [21], but also in T2 diffusion sequences [22]). This is the reason many teams perform the examination just before biopsy [6,15,16], instead of waiting for a period of 6 weeks to allow haemorrhagic changes to disappear. Finally, an original paper has recently suggested not waiting for this time because of the low impact of the haemorrhagic changes; this does not reflect our experience [23]. When the patient is installed, his arms must not be in the field of view (but on the chest or raised) to avoid aliasing artefacts, and the coil must be centred on the prostate. A scout scan can be used to check this centring and, if necessary, to reposition the coil.

Sequences

Multiparametric MRI must include T2-weighted morphological sequences, a diffusion imaging sequence, and a dynamic contrast-enhanced T1-weighted sequence [6]. It may also include spectroscopy sequences (not covered in detail here).

T2-weighted sequences

T2-weighted sequences provide so-called 'anatomical' images of the prostate, in thin slices. It is useful to obtain these in at least two planes (axial and coronal), with axial slices perpendicular to the posterior surface of the gland, and coronal slices strictly perpendicular to this plane and therefore in the axis of the seminal vesicles. A third sagittal plane is recommended, to provide a better view of the cranio-caudal extent of the lesions and the apex of the gland. Since these sequences are long (4 min each), it can be helpful to make use of the latest technology to speed up the examination, particularly 3T. With this, it is possible to carry out a spin echo sequence with classic high axial resolution (0.3 × 0.3 × 3.5 mm) with the addition of a single 3D millimetric sequence (1 × 1 × 1 mm), admittedly with lower contrast resolution, but higher spatial resolution, allowing more detailed, multiplanar, oblique exploration and better analysis of the lesions identified on the other sequences. These sequences may be blurred (patient or digestive movement etc.); if this is the case, there should be no hesitation in repeating them, possibly using an accelerated variant of the T2 sequence (reduction in the matrix, number of excitations etc.).

Diffusion sequences

Diffusion sequences use the same axial plane, and, to be interpreted correctly, need an apparent diffusion coefficient (ADC) map. To obtain this, two series of diffusion images must be produced, the first always with a b0 gradient, and the second usually with a diffusion gradient between b600 and b1000, optimal quality varying depending on the protocol and the machine [24]. Some authors have recently reported the potential usefulness of diffusion imaging (without an ADC map) with high gradients (b2000) to distinguish tumour lesions better [25–27]. On the most recent or 3T machines, this question no longer arises because it is possible (and desirable) to perform more than two diffusion sequences (e.g. b0, b100, b500, b1000, b2000) in a single series, in order to calculate a more accurate ADC.

Perfusion sequences

Perfusion sequences, acquired with T1-weighting every 10 to 15 s, detect the most vascularised areas of the prostate, including tumour foci. They are acquired in fast echo gradient, in 2D, or more often in 3D, in a plane identical to that of the T2 and diffusion sequences, to facilitate reading the series synchronously. Note that in looking for recurrences after prostatectomy, acquisition in a sagittal plane may be more effective than in an axial plane, because the anatomical landmarks will have changed, and contrast enhancement is often linear in front of the urethra at the apex. Contrast enhancement can be analysed visually, looking for the series showing the arrival of the contrast agent (early contrast enhancement). Specialised workstations or software help go further, by visualising the signal intensity/time curve in a region of interest, and extracting simple semi-quantitative parameters from it — the rate of enhancement (wash-in), rate of contrast wash-out, time to peak, brevity of the enhancement etc. Other software programs provide more advanced, so-called quantitative analysis, which, after conversion of signal intensity into concentration of contrast agent, can estimate tissue permeability at each point of the image and produce parametric maps (Ktrans, Ve etc.).

Is 3T essential?

The vast majority of examinations today are done on 1.5T machines, but 3T machines, which appeared in routine use over a year ago, are beginning to replace them. In general, multiparametric examination of the prostate at 3T is better than at 1.5T, because of a better signal/noise ratio, allowing images to be obtained more rapidly and in more detail in T2 (3D sequences, very high resolution etc.), excellent contrast, faster, less noisy sequences, multiple b values in diffusion sequences, improved temporal resolution of dynamic sequences and less noisy spectroscopy, finally possible externally. Unfortunately this is marred by very high sensitivity to artefacts (gaseous, metallic, aliasing) that very often interfere with the result of the examination. A non-negligible increase in contraindications to the examination must also be taken into account (mainly prostheses and implants untested at 3T).

What is the additional value of functional imaging sequences?

Dynamic perfusion imaging

Dynamic perfusion imaging obtained in T1-weighted gradient echo is no longer a novelty. It is practised in most centres, because it improves the sensitivity of T2-weighted morphological imaging by about 10%, without loss of specificity [28]. Its notable contribution is in detecting anterior lesions, of the anterior fibromuscular stroma (AFMS) and the apex, which are difficult areas to explore in T2-weighting (normal heterogeneity of the signal). Analysis of these regions in diffusion imaging can be compromised, especially when the lesion is peripheral, and when its hyposignal merges with that of the surrounding fat (suppression of the fat signal on diffusion sequences) (Fig. 1). The injection of contrast agent also improves extracapsular staging [29].
Detecting prostate cancer with MRI — why and how

Figure 1. Sixty-nine-year-old man with PSA raised to 7.34 ng/ml. Digital rectal examination was normal. MRI, performed before a first series of biopsies, showed, in its contrast-enhanced dynamic sequence (d) a significant lesion of the left base (white arrow), whereas this was not detectable in T2 (a), due to considerable changes in signal at the base, nor on the diffusion sequence (c), because of its topography (the lesion was surrounded by periprostatic fat over more than half its surface). The diagnosis was confirmed by MRI-guided biopsy. Prostatectomy confirmed an adenocarcinoma with a Gleason score $3 + 4 = 7$ with focal extracapsular extension; pT3aN0R0; PSA was not measurable at 1 year. This example illustrates the complementarity of functional sequences (diffusion and perfusion), with, in this case, the essential character of dynamic imaging for the diagnosis.

and is essential for evaluating extension to the seminal vesicles (contrast uptake by the vesicles is almost specific for invasion). Finally, perfusion imaging is the only useful method for detecting recurrence after radiotherapy or focused treatment (e.g. high intensity focused ultrasound [HIFU]), and is very successful in these indications, when T2 and diffusion imaging cannot be interpreted.

Diffusion imaging

Diffusion imaging reflects the ability of water molecules to move freely in their environment. Various publications have shown that diffusion imaging indirectly shows cellularity [30–32] and correlates with the Gleason score [30,33]. Interestingly, all studies to date have shown the benefits of adding diffusion imaging to T2-weighted morphological imaging to improve detection of tumour lesions. The combination with perfusion imaging has also been evaluated, and appears to be significantly better than just T2 and diffusion combined, or just T2 and perfusion [4]. The additional value compared with a protocol including T2 and spectroscopy has also been demonstrated [34,35]. In practice, based on our experience and the literature, the gain in accuracy in determining the pathological character or otherwise of a prostate area can be estimated to be about 10% for lesions > 0.5 cm$^3$, but this figure remains to be verified [4].

Can we do without perfusion imaging?

The contribution of diffusion imaging to imaging the prostate has been such that some authors have logically suggested no longer performing perfusion series, which have the disadvantage of the extra cost of the contrast agent and the potential noxious effects of the injection in the long term. Our experience, like the literature [4], has shown that in some cases, the cancer is only detectable on perfusion sequences, because neither the T2 nor the diffusion sequences are explicit, and that in other cases, the opposite is true, perfusion imaging failing to show a cancer when it is clearly visible on the diffusion sequence. We therefore think that perfusion and diffusion sequences are complementary at the present time and one cannot replace the other.
How is the aggressiveness of a lesion assessed?

The aggressiveness of a lesion is principally defined by its Gleason score. In this regard, various studies have shown inverse correlation of this score with the value of the ADC [30,33], with the ratio of (choline + creatine)/citrate spectroscopy peaks [36], with the degree of enhancement (wash-in) in perfusion imaging, and even with T2-weighted signal intensity [30,37].

In practice, it has been found that a low ADC is a good marker of Gleason grade 4 and hence of a score greater than 6. In certain cases, a distinction can thus be made between high risk and low risk lesions [38].

The denser the lesion, the greater the contrast it will have, whatever the sequence. The ability of MRI must not be over-estimated and it should be kept in mind that in some cases, tumour trabeculae that are visible histologically insinuate themselves into a considerable volume of normal tissue, but are not detectable by imaging which lacks the resolution of a microscope.

Finally, the aggressiveness of a lesion is not limited to its histology. Other prognostic factors must be taken into account such as the volume of the lesion, its topography and extraprostatic extension. MRI can improve estimation of the volume of a lesion. Some teams have studied and demonstrated a positive correlation between the volume observed by MRI and the volume of prostatectomy specimens [39–42]. The description of a lesion at the apex or base of the prostate will, for example, have a significant impact on the decision concerning the surgical approach, the resection technique and the preservation or not of neurovascular bundles. Some teams have shown that the opinion of the trained radiologist, ranging from 1 (preservation is certainly possible) to 5 (preservation is dangerous), could change the urologist’s attitude in almost 40% of cases [43]. It is also important to detect and describe an AFMS lesion because this topography requires special dissection to avoid leaving a largely positive margin [41].

How in practice do you distinguish, locate and describe suspect foci?

Interpretation technique

Prostate MRI is nowadays multiparametric. This means that for a single slice level, three to five images must be interpreted simultaneously. This is not a simple task, and requires a certain organisation for reading images, including having software capable of displaying all the series in a synchronised manner, and displaying a pointer on all the series in real time to quickly analyse the signs of a suspect area. It should indeed also be noted that some software programs work in full 3D, which simplifies synchronising the slices and facilitates reading in the three spatial planes.

When analysing the prostate, we recommend following a systematic reading pattern, independently reviewing the three main compartments of the prostate: the peripheral zone (PZ), the transitional zone (TZ) and the AFMS. There is a significant difference in the signs seen in each zone.

Figure 2. Prostate partitioning scheme recommended by the PREDICT consensus conference (London, 2010) [44].

Separate analysis speeds up reading and allows systematic interpretation.

Location of lesions and standardised scoring

When MRI is performed before biopsy, the aim in interpreting the images is to determine whether the gland has significantly suspect lesions from which samples could be obtained by guided biopsy. Each abnormality is located in a zone (using a standardised scheme of 27 zones, as recommended in a recent consensus conference [44]) (Fig. 2), and evaluated according to a standardised score the scale for which may vary between centres, but which must be unique within each centre. At present, we use a Likert scale between 1 and 5 to characterise abnormalities (1: not suspect; 2 hardly suspect; 3 ambiguous; 4 suspect; 5 highly suspect). This avoids using 0 (because MRI cannot provide certainty of the benign nature) and leaves a place for doubt with a score of 3. Some teams and the future recommendations of the European Society of Urogenital Radiology (ESUR) suggest sub-scores for each sequence, summarised in a final score between 1 and 5, which could in the future result in a standardised score, as has happened for the breast (Bi-RADS).

Signs

The peripheral zone

In the PZ, we mainly look for concordance of morphological criteria (T2 hyposignal, homogeneous signal area, nodular shape or an area with convex edges, posterolateral location) with functional criteria (early intense enhancement, significant ADC restriction compared with adjacent tissue). When these criteria are concordant, the probability of cancer is high, and we can use a score of 4, suspect, or 5, highly suspect. When one of the sequences does not agree with the others, it is wise to use the term ‘ambiguous’.
The transition zone
In the transition zone, it is difficult to recognise the signs, as an adenoma is often multinodular, with early enhancement, and highly cellular, reducing the ADC. We must therefore look for asymmetrical, poorly circumscribed nodular lesions, usually located in the anterior half, with signs in diffusion and perfusion (ADC restriction and uptake of contrast agent) that concur. When this is not the case or where there are factors favouring the benign nature of an anterior nodule (small hypersignals in the nodule; a halo appearance), interpretation must be restrained and the lesion classified as ambiguous (3/5) or hardly suspect (2/5).

The anterior fibromuscular stroma
The main objective is to determine whether the AFMS is normal or not. In our experience, normal AFMS is in deep T2-weighted hyposignal, with a very low ADC and it is not enhanced. If there is a not very marked T2-weighted hyposignal, almost identical to that of an adenoma nodule, or contrast uptake, even if slight, it is reasonable to suspect an AFMS lesion and to propose a guided biopsy.

The extension of each suspect image must be evaluated, also using a standardised scale and explicitly describing in the report the signs leading to the score. The same is needed for any signs of aggressiveness or to highlight the particular topography or unusual relationships of a lesion (urethra, prostate apex, seminal vesicles etc.).

Standardisation of results
Doctors requesting an MRI for the assessment of cancer want to have reliable, objective and reproducible results. At the initiative of British urologists, the first consensus conference attended by European radiologists, urologists, oncologists and radiotherapists was held in London in 2010. It aimed to highlight points of consensus on prostate imaging and, as a consequence, those areas in which it was possible to propose a standardised approach at a European level. Its conclusions were published recently [44]. It was quickly followed by the formation of an ESUR working group, whose conclusions will be published shortly and will be the basis of recommendations.

Location of lesions
The use of a common reference system for the location of lesions was identified as an essential item for standardising, as this information is shared by all those involved in the management of the cancer — radiologists, urologists, histopathologists, radiotherapists, oncologists — who all need to speak the same language. Our team put forward a scheme dividing the gland into 27 zones, each labelled by four characters: the first, a ‘z’ identifying it as a prostate zone (easily identified in a report), followed by two figures indicating each of the 12 biopsy zones already described as 01 to 06 on the right and 07 to 12 on the left (01: base of right median lobe; 02: base of right lateral lobe; 03: middle of right median lobe; 04: middle of right lateral lobe; 05: apex of right median lobe; 06: apex of right lateral lobe; 07: base of left median lobe; 08: base of left lateral lobe; 09: middle of left median lobe; 10: middle of left lateral lobe; 11: apex of left median lobe; 12: apex of left lateral lobe), then a letter ‘p’ if it is a posterior zone or an ‘a’ if it is an anterior zone (Fig. 3). To this list of 24 zones, three special zones have been added corresponding to the AFMS in the median part of the gland, from bottom to top, respectively, z13a, z14a and z15a. Example: z04a indicates the right anterolateral strip while z15a indicates the apical AFMS. Unlike division into 8 or 16 zones frequently used in studies, this division into 27 zones allows accurate individualisation of all the zones where a cancer can be found in the gland, including those that require guided biopsy or special attention at the time of treatment such as the AFMS (10% of anterior lesions; z13a, z14a and z15a), or the anterolateral horns of the PZ (z02a, z04a, z06a, z08a, z10a and z12a). The choice to include the few most posterior millimetres of the transition zone in the posterior and median zones (z01p, z03p, z05p, z07p, and z09p z11p) was suggested by the urologists, preferring ‘practical’ zoning modelled on biopsies rather than ‘theoretical’ zoning modelled on the zonal anatomy that would have required conversion to make it correspond with biopsy results.

Scoring: determining the probability of an image corresponding to cancer or normal tissue
When MRI is used to detect tumours, the radiologist is not expected to know whether there is cancer or not, or if it does exist, its location. He must decide on the level of suspicion of each suspect image, and, where appropriate, of each prostate zone. Beyond the typical signs (nodule in T2-weighted hyposignal with enhancement after injection, and with diffusion restriction), the description of a lesion leaves a considerable subjective part to the interpretation and experience of the reader.

To mitigate this effect and make interpretation more reproducible and accessible to non-specialist radiologists, efforts have been made to analyse the signs for distinguishing prejudicial from reassuring features in each type of multiparametric MRI sequence, and to propose a theoretically more reproducible score. This task is not easy, because the choice of sequences (need spectroscopy be included?), the weighting of each one, like the importance of each individual sign, has not been studied. As the consensus meeting showed [44], several teams are already using a subjective scale with four or five levels to describe each MRI anomaly in summary form (1: certainly not cancer; 2: probably not cancer; 3: ambiguous; 4: probably a tumour; 5: certainly a tumour) [11,15,42,45–47]. At present, there is no standard similar to the standard in breast imaging (BI-RADS), but this could soon change: the ESUR is currently working on it (Fig. 4).

In a recent study, we showed that when this type of score was considered positive, between 3 and 5, compared with the results of prostatectomy, it could produce acceptable diagnostic precision, with sensitivity, specificity, and an area under the curve (AUC) of 86%, 94% and 0.874 respectively, for lesions larger than 0.5 cm³ [11].

Performance and limitations

The performance of multiparametric MRI

Performance analysis of prostate MRI is not easy because it requires histopathological comparison either with a prostatectomy specimen or with the result of prostate biopsies. In the first case, there is major bias due to the fact that patients with negative biopsies will not be operated on, and that in many studies in the literature, readers already know of the ‘operated’ status of the patient at the time of interpretation (including in some studies said to be prospective). In addition, these series usually concern a small number of cases, because the detailed analysis of prostatectomies is a long process. In the second case, it would simply not be possible to evaluate the (not biopsied) anterior compartment of the gland even if guided biopsies are performed, because determination of an AUC in theory requires evaluation of false negatives. Finally, another important bias in the performance studies concerns lesion size, which can obviously alter interpretation, but is rarely mentioned [11].

The results in the literature must therefore be analysed with considerable caution, and preference given to ‘relative’ analyses [4] over those presenting the raw performance of a technique.

One of the simplest indicators for analysing performance of a test and comparing it with another is its AUC calculated by the ROC curve technique. This implies that a positive or negative (cancer or no cancer) test response is available for an area where the gold standard is known, and that the proportion of cases (true positive, false positive, true negative, false negative) is homogeneous. Under these conditions,
Figure 4. How to evaluate a prostate lesion with a score of 1 to 5. (a) Nodular lesion of the transition zone, non-suspect (1/5) despite its hypervascularisation, because of a halo around the nodule in T2, and the absence of signal drop on the apparent diffusion coefficient (ADC) map. Negative biopsies. (b) Suspect lesion (4/5) in the left transition zone, due to its anterior position, its homogeneous and asymmetric character relative to the rest of the adenoma in T2, its hypervascularity and despite its slight diffusion restriction. If diffusion had been concordant, it would have been logical to propose a score of 5/5. Cancer confirmed by prostatectomy. (c) Ambiguous lesion (3/5) of the left peripheral zone, despite its being isolated in the peripheral zone making it like the lesion visible in (d). In fact, the T2 hyposignal is not very marked and not nodular; there is slight diffusion restriction and little contrast enhancement compared with the rest of the parenchyma. These points are discordant. Finally, the T2 and perfusion sequences are 'hardly suspect', which does not lead to a decision and causes it to be classed as 'ambiguous'. Prostatectomy confirmed the benign nature of this image. (d) Highly suspect lesion in the left peripheral zone (5/5) because of its being isolated in a normal peripheral zone, its nodular form, and its deep, homogeneous T2 hyposignal. Considerable nodular diffusion restriction and contrast enhancement. All these features are consistent and lead to a score of 5/5 instead of 4/5. Lesion confirmed by prostatectomy.

Comparison of techniques is possible, and the greater the AUC (tending towards an ideal of 1), the better the precision of the technique studied. Conversely, the smaller the AUC (tending towards 0.5), the less it is distinguished from mere chance.

Various studies concur in showing that the AUC of the T2-weighted analysis alone was close to 0.7, that by adding diffusion imaging 0.75 (0.66 to 0.79) was obtained and when perfusion imaging was added (i.e., multiparametric MRI) the value obtained was between 0.85 and 0.87 [4,11,48–50], i.e. precision of 87%. Finally, the negative predictive value of MRI is an interesting parameter because it can be directly evaluated by biopsy. It is this parameter that will make it possible to state that a prostate contains no significant lesions. In a recent study on 93 patients with a series of negative biopsies, it was shown that the negative predictive value of T2-weighted MRI alone was 79.5% against 93.3% for perfusion imaging alone and 100% when the two techniques were associated [10]. Spectroscopy combined with T2 had similar results in the same context [51].

The limitations of MRI

As for its performance, the limitations of MRI need to be known in order to maintain a balance between sensitivity and specificity, and to achieve optimal interpretation. It must be remembered that in the PZ, hyposignals may indicate inflammation, even if their appearance is perfectly nodular (cases of granulomatous prostatitis). They may also correspond to supporting tissue (strips perpendicular to the prostate capsule) or to a remnant of the central zone appearing as a T2 hyposignal on either side of the ejaculatory ducts at the base of the prostate. Haemorrhagic changes or scarring also appear as T2 hyposignals. In the transition zone, myomatous nodules have an identical appearance to the appearance of tumour foci — a deep T2
hyposignal, restricted diffusion and intense early contrast enhancement [42].

In all these cases, the unusual topography of the lesions, their asymmetry, collating the signs in all the sequences, and the experience of the reader will produce optimal, but never perfect, classification.

The most characteristic limitation of the examination has always been its inability to distinguish or correctly delineate low-density cancers, infiltrating healthy prostate tissue by fine trabeculae that cannot be distinguished from the healthy tissue whatever technique is used.

Conclusion

Multiparametric MRI of the prostate has become an essential examination for accurate assessment of the disease and choice of appropriate management. It can be performed on a 1.5 Tesla machine, with a pelvic coil, and should include at least a combination of T2-weighted anatomical, diffusion and perfusion sequences. Interpretation of the examination should be methodical for optimal performance, with precision of about 85% and a negative predictive value greater than 90%. The use of diagnostic aids could, in the future, make it a little easier to use for non-specialised radiologists. Standardised transmission of results to others involved is essential and is supported by recent European recommendations.

**TAKE-HOME MESSAGES**

- Multiparametric MRI is an accessible examination which is easy to perform in high resolution with a pelvic coil.
- This examination should include morphological, diffusion and perfusion sequences.
- Its negative predictive value for a significant cancer (> 0.5 cm³) is excellent, lending weight to urologists who wish to opt for active surveillance of microfoci.
- Its use allows guided biopsies of lesions that traditional methods could not sample or underestimate.
- It is recommended that lesions should be described in a standardised manner (localisation in 27 zones; Likert-like score from 1 to 5).

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


template-guided mapping biopsy in detecting prostate cancer in the initial and repeat biopsy setting. Prostate Cancer Prostati


[23] Park KK, Lee SH, Lim BJ, Kim JH, Chung BH. The effects of the period between biopsy and diffusion-weighted magnetic reso-


[26] Kim CK, Park BK, Kim B. High-b-value diffusion-weighted imag-
ing at 3 T to detect prostate cancer: comparisons between b values of 1,000 and 2,000s/mm². AJR Am J Roentgenol 2010;194(1):W33–7.


[44] Dickinson L, Ahmed HU, Allen C, Barentsz JO, Carey B, Fut-
terer JJ, et al. Magnetic resonance imaging for the detection, localization, and characterisation of prostate cancer: recommenda-

[45] Weinreb JC, Blume JD, Coakley FV, Wheeler TM, Cor-


[47] Kim CK, Park BK, Lee HM. Prediction of locally recur-

[48] Delongchamps NB, Rouanne M, Flam T, Beuvon F, Libera-

[49] Delongchamps NB, Beuvon F, Eiss D, Flam T, Muradyan N, Zer-
bib M, et al. Multiparametric MRI is helpful to predict tumor focality, stage, and size in patients diagnosed with unilateral low-risk prostate cancer. Prostate Cancer Prostati