MRI-targeted, transrectal ultrasound-guided prostate biopsy for suspected prostate malignancy: A pictorial review

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Learning objectives

With the current standardised non-targeted trans-rectal ultrasound (TRUS)-guided prostate biopsy, the localisation of prostate cancer can be challenging. We detail our experience with the use of multiparametric magnetic resonance imaging (mp-MRI) prior to TRUS-guided biopsy in a tertiary referral centre, including our technique and potential pitfalls that may lead to false positive and false negative results.
Background

Prostate carcinoma is the most frequently diagnosed cancer in males and the second leading cause of cancer-related death in men. The incidence of prostate carcinoma in Ireland is 50% higher than the European average at 149 per 100,000 men\(^1\). There are three well-established risk factors: increasing age, ethnicity and genetic predisposition. At present the core diagnostic tools include digital rectal examination (DRE), prostate-specific antigen (PSA), and non-targeted transrectal ultrasound (TRUS)-guided prostate biopsy obtaining 10-12 cores. The current standardised non-targeted transrectal approach to biopsy is poor at sampling the anterior, midline and apex of the prostate and so the localisation of prostate carcinoma can sometimes be challenging.

With more frequent use of PSA testing, there is an increasing cohort of patients with elevated PSA and negative TRUS-guided biopsy. The strategies for managing these patients include PSA monitoring, which can risk the progression of localised disease and repeat biopsy. Recently published guidelines by the European Society of Urogenital Radiology (ESUR) and National Institute for Health and Care Excellence (NICE) recommend the use of multiparametric MRI (mp-MRI) in patients with negative initial TRUS-guided biopsy to determine the need for repeat biopsy\(^2,3\).

A number of different approaches can be taken to repeat biopsy. Repeat non-targeted TRUS-guided biopsy will still miss clinically significant tumours. Saturation biopsy, which involves taking more than 20 cores, is associated with increased patient morbidity\(^4\). It also remains controversial whether taking more biopsy cores results in the detection of more clinically insignificant tumours\(^5\). Transperineal prostate biopsy has not been shown to be superior to TRUS-guided biopsy in the detection of prostate carcinoma in patients undergoing rebiopsy\(^6,7\). With these issues in mind, an image-guided approach to biopsy is needed to identify areas of greater likelihood of cancer for further assessment.

Using a multiparametric approach, combining anatomical and functional data, MRI can be useful in the detection and characterisation of prostate carcinoma. MRI has been shown to have a high degree of accuracy in the detection of clinically significant prostate cancer when compared with radical prostatectomy histology\(^8\). Systematic review has shown that MRI-derived prostate biopsies were associated with a detection rate of clinically significant prostate cancer of 42%\(^9\).

There are three major methods using MRI guidance in prostate biopsy. While direct MRI-guided biopsy allows accurate localisation of the lesion to be biopsied, it is time-
consuming and costly. MRI-targeted TRUS-guided prostate biopsy is a more favourable alternative and can be performed by either software coregistration or cognitive fusion. Software coregistration involves combining pre-biopsy MRI data with real-time ultrasound to target a lesion for TRUS-guided biopsy. Cognitive fusion involves identifying a target on MRI prior to biopsy and performing a TRUS-guided biopsy directly targeted to that area. Cognitive fusion is relatively quick and does not require additional training or equipment beyond conventional TRUS-biopsy training and equipment.
Findings and procedure details

In our institution, patients with raised PSA are referred to the Rapid Access Prostate Clinic before proceeding to standardised non-targeted TRUS-guided prostate biopsy if required. Each patient is then discussed at a urological multi-disciplinary meeting. If there is high clinical suspicion for prostate carcinoma in patients with negative TRUS-guided biopsies, either based on significantly elevated PSA or abnormal DRE, the patient proceeds to mp-MRI. Our standard protocol includes an axial T1 sequence, axial and coronal T2 sequences and diffusion weighted imaging with apparent diffusion coefficient (ADC) mapping in a 1.5 Tesla Siemens Avanto MRI scanner using a body coil. MRI images are reviewed and if a focal abnormality is identified the patient proceeds to targeted TRUS-guided biopsy, using the cognitive fusion technique, or transperineal biopsy as appropriate.

Clinical cases:

Case 1:

A 62 year-old male presented with PSA 30 µg/l. Repeated TRUS-guided biopsies demonstrated prostatic intraepithelial neoplasia (PIN) and squamous metaplasia. The patient proceeded to MRI which demonstrated diffusion restricted lesions at the right base and left base (Figure 1). Targeted TRUS-guided biopsies were performed of both lesions. Histology confirmed Gleason 7 adenocarcinoma at the right base.
**Fig. 1:** Axial T2 (a) and axial ADC map (b) of the prostate demonstrating T2 signal abnormality with correlating diffusion restriction in the right and left base.

*References:* Cork University Hospital - Cork/IE

**Case 2:**

A 59 year-old male presented with PSA 11 µg/l. Repeated TRUS-guided biopsies demonstrated multifocal high grade PIN. The patient proceeded to MRI which demonstrated a diffusion restricted lesion in the left anterior midzone (Figure 2). Targeted TRUS-guided biopsy was performed and histology confirmed Gleason 8 adenocarcinoma.
Fig. 2: Axial T2 (a) and axial ADC map (b) of the prostate demonstrating T2 signal abnormality with correlating diffusion restriction in the left anterior midzone.

References: Cork University Hospital - Cork/IE

Case 3:

A 61 year-old male presented with PSA 30 µg/l. Repeated TRUS-guided biopsy demonstrated high grade PIN. The patient proceeded to MRI which demonstrated a diffusion restricted lesion in the left mid peripheral zone (Figure 3). Targeted TRUS-guided biopsy was performed (Figure 4) and histology confirmed Gleason 7 adenocarcinoma.
Fig. 3: Axial T2 (a) and axial ADC map (b) of the prostate demonstrating a T2 signal abnormality with correlating diffusion restriction in the left mid peripheral zone.

References: Cork University Hospital - Cork/IE
Case 4:

A 69 year-old male presented with PSA 13 µg/l. Repeated TRUS-guided biopsies demonstrated Gleason 6 adenocarcinoma. The patient proceeded to MRI which demonstrated diffusion restricted lesions at the right base and right mid gland anteriorly (Figure 5). Targeted TRUS-guided biopsies were performed of each lesion (Figure 6). Histology confirmed Gleason 7 adenocarcinoma.

Fig. 4: Transrectal ultrasound of prostate demonstrating a hypoechoic lesion in the left mid peripheral zone corresponding to MRI findings.

References: Cork University Hospital - Cork/IE
**Fig. 5:** Axial T2 (a) and axial ADC map (b) of the prostate demonstrating T2 signal abnormality with correlating diffusion restriction in the right mid gland anteriorly.

**References:** Cork University Hospital - Cork/IE
Fig. 6: Transrectal ultrasound of prostate demonstrating a hypoechoic lesion in the right mid gland anteriorly corresponding to MRI findings.

References: Cork University Hospital - Cork/IE

Case 5:

A 60 year-old male presents with PSA 36 µg/l. TRUS-guided biopsy demonstrated Gleason 6 adenocarcinoma in the left mid gland. The patient proceeded to MRI which demonstrated a diffusion restricted lesion in the left mid transition zone (Figure 7). Targeted TRUS-guided biopsy was performed and histology confirmed Gleason 7 adenocarcinoma in the transition zone in the left mid and apex of the gland.
Fig. 7: Axial T2 (a) and axial ADC map (b) of the prostate demonstrating T2 signal abnormality with correlating diffusion restriction in the left mid transition zone.

References: Cork University Hospital - Cork/IE

Case 6:

A 59 year-old male presents with PSA 34µg/l. TRUS-guided biopsy demonstrated high grade PIN. Subsequent MRI demonstrated two diffusion restricted lesions in the left mid central and right mid peripheral zones (Figure 8). Subsequent targeted TRUS-guided biopsy demonstrated Gleason 7 adenocarcinoma.
Fig. 8: Axial T2 (a) and axial ADC map (b) of the prostate demonstrating T2 signal abnormality in the left mid central and right mid peripheral zones with corresponding restricted diffusion.

References: Cork University Hospital - Cork/IE
Conclusion

MRI-targeted TRUS-guided prostate biopsies are a valuable advancement in the diagnosis of prostate cancer. We have demonstrated that using the cognitive fusion technique outlined above can give a measurable benefit to patients. When employed as part of an evidence-based, multi-disciplinary management framework, this technique can result in earlier diagnosis of clinically significant prostate cancer. This can subsequently lead to earlier treatment decisions and reducing the need for repeated non-targeted biopsies.
Personal information

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