


BMJ Open Study protocol for a single-centre non-inferior randomised controlled trial on a novel three-dimensional matrix positioning-based cognitive fusion-targeted biopsy and software-based fusion-targeted biopsy for the detection rate of clinically significant prostate cancer in men without a prior biopsy

Biming He , Rongbing Li, Dongyang Li, Liqun Huang, Xiaofei Wen, Guosheng Yang, Haifeng Wang

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BH and RL contributed equally.

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For numbered affiliations see end of article.

Correspondence to

Dr Haifeng Wang;
446720864@qq.com

ABSTRACT

Introduction The classical pathway for diagnosing prostate cancer is systematic 12-core biopsy under the guidance of transrectal ultrasound, which tends to underdiagnose the clinically significant tumour and overdiagnose the insignificant disease. Another pathway named targeted biopsy is using multiparametric MRI to localise the tumour precisely and then obtain the samples from the suspicious lesions. Targeted biopsy, which is mainly divided into cognitive fusion method and software-based fusion method, is getting prevalent for its good performance in detecting significant cancer. However, the preferred targeted biopsy technique in detecting clinically significant prostate cancer between cognitive fusion and software-based fusion is still beyond consensus.

Methods and analysis This trial is a prospective, single-centre, randomised controlled and non-inferiority study in which all men suspicious to have clinically significant prostate cancer are included. This study aims to determine whether a novel three-dimensional matrix positioning cognitive fusion-targeted biopsy is non-inferior to software-based fusion-targeted biopsy in the detection rate of clinically significant cancer in men without a prior biopsy. The main inclusion criteria are men with elevated serum prostate-specific antigen above 4–20 ng/mL or with an abnormal digital rectal examination and have never had a biopsy before. A sample size of 602 participants allowing for a 10% loss will be recruited. All patients will undergo a multiparametric MRI examination, and those who fail to be found with a suspicious lesion, with the anticipation of half of the total number, will be dropped. The remaining participants will be randomly allocated to cognitive fusion-targeted biopsy (n=137) and software-based fusion-targeted biopsy (n=137). The primary outcome is the detection rate of clinically significant prostate cancer for cognitive fusion-targeted biopsy and software-based

Strengths and limitations of this study

- This study is the first trial to compare a novel cognitive fusion-targeted biopsy, which is based on a three-dimensional matrix positioning method, with a software-based fusion-targeted biopsy.
- The study will determine the efficacy of the novel cognitive fusion-targeted biopsy in the diagnosis of prostate cancer.
- Rigorous randomised design and allocation concealment method will reduce bias, which enables the higher reliability of the results.
- This study takes place in one hospital, hence may make the finding less generalisable.
- The study is performed in the centre that developed the guiding method, which may overestimate its performance as compared with less experienced readers.

fusion-targeted biopsy in men without a prior biopsy. The clinically significant prostate cancer will be defined as the International Society of Urological Pathology grade group 2 or higher.

Ethics and dissemination Ethical approval was obtained from the ethics committee of Shanghai East Hospital, Tongji University School of Medicine, Shanghai, China. The results of the study will be disseminated and published in international peer-reviewed journals.

Trial registration number ClinicalTrials.gov Registry (NCT04271527).

INTRODUCTION

Prostate cancer (PCa) is the second most common cancer worldwide which leads the

five causes of death among men.¹ Men with an elevated serum prostate-specific antigen (PSA) level or an abnormal digital rectal examination (DRE) are usually considered at risk for PCa and typically have a prostate biopsy subsequently to get samples for pathological diagnosis. The common pathway is a systematic 12-core biopsy under the guidance of transrectal ultrasound (TRUS), an approach to randomly get the samples from the whole prostate gland; however, its blind attribution makes it tend to underdiagnose the clinically significant tumour and overdiagnose the clinically insignificant disease.^{2,3}

Thanks to the development of multiparametric MRI (mpMRI) in identifying PCa, another pathway named targeted biopsy is getting prevalent. It aims to first perform an mpMRI for localising the tumour precisely and then obtain the samples from the suspicious lesions, and is shown to be more purposeful and less random compared with the systematic biopsy. Several pieces of evidence have proven the superiority of targeted biopsy in detection rates of clinically significant PCa (csPCa) and avoidance of unnecessary biopsy.^{4,5}

Targeted biopsy can be subdivided into three different methods: in-bore MRI, cognitive fusion and software-based fusion. An in-bore MRI-targeted biopsy is described as to perform a targeted biopsy under real-time MRI guidance. Although this method is accurate in locating the targeted lesions, it is a failure to be widely used in clinical practice for its inconvenience and time-consuming use.⁶ Compared with in-bore MRI-targeted biopsy, another two methods are more acceptable. Cognitive fusion, a procedure of mental state that locates the target of suspicious lesions in the ultrasound image after a review of MRI, is cost-saving because it needs no extra equipment, aside from the essential requirement for a TRUS biopsy. Software-based fusion is an overlap of the real-time ultrasound image and the previous MRI images by software assistance. Although it is widely adopted by urologists or physicians, the barriers of being time-consuming, and having excessive price and training for the additional equipment cannot be omitted.⁷⁻⁹ There is always an interesting topic about whether the ability of cognitive fusion

with human brains can achieve the same result as a fusion with intricate fusion software.¹⁰ However, evidence from the comparative trials is little.^{9,11-13} To date, the preferred targeted biopsy technique in detecting csPCa between cognitive fusion and software-based fusion is still beyond consensus.

We have developed a method named three-dimensional matrix positioning to increase the accuracy of cognitive fusion for targeted biopsy detection of csPCa, which involves several fiducial axes derived from MRI localisation of the region of interest, then transposed onto the ultrasound image to help direct the biopsy needle into the right place.¹⁴ This method had shown a reasonable detection rate for csPCa in a pilot cohort. Hence, we conduct this single-centre randomised controlled trial (RCT) in order to confirm the finding further.

This trial aims to compare three-dimensional matrix positioning cognitive fusion-targeted biopsy and software-based fusion-targeted biopsy for the detection rate of csPCa for men without a prior biopsy for localised PCa. The primary objective is to assess whether the cognitive fusion-targeted biopsy is non-inferior to software-based fusion-targeted biopsy in the detection rate of clinically significant cancer.

TRIAL DESIGN

This prospective, single-centre, randomised controlled and non-inferiority study will take place at Shanghai East Hospital, Tongji University School of Medicine, Shanghai, China. The primary objective of this study is to identify whether the three-dimensional matrix positioning cognitive fusion-targeted biopsy is non-inferior to software-based fusion-targeted biopsy in the detection rate of clinically significant cancer in men without a prior biopsy.

The study flow chart is shown in figure 1. Patients will be initially screened and recruited by the urologists in outpatient. Those who meet the entry criteria and sign the consent form will go for mpMRI within 2 weeks, and only those whose MRI indicates at least one lesion with a

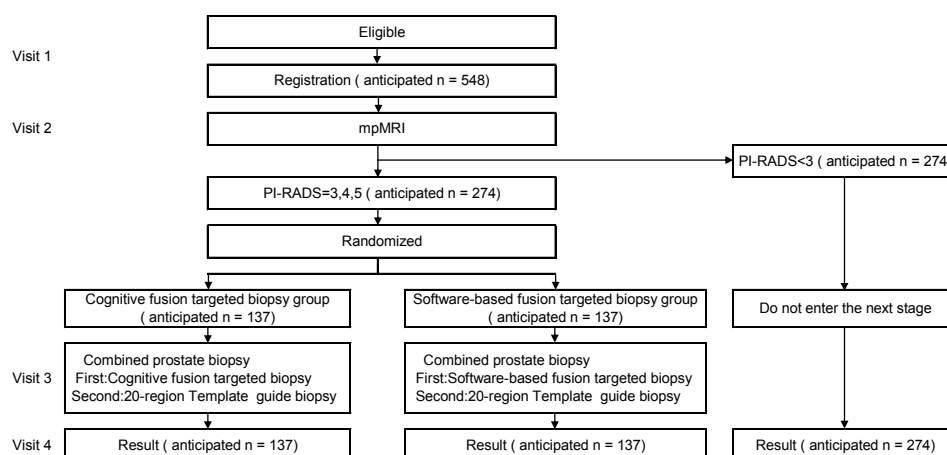


Figure 1 Trial flow chart. mpMRI, multiparametric MRI; PI-RADS, Prostate Imaging-Reporting and Data System.

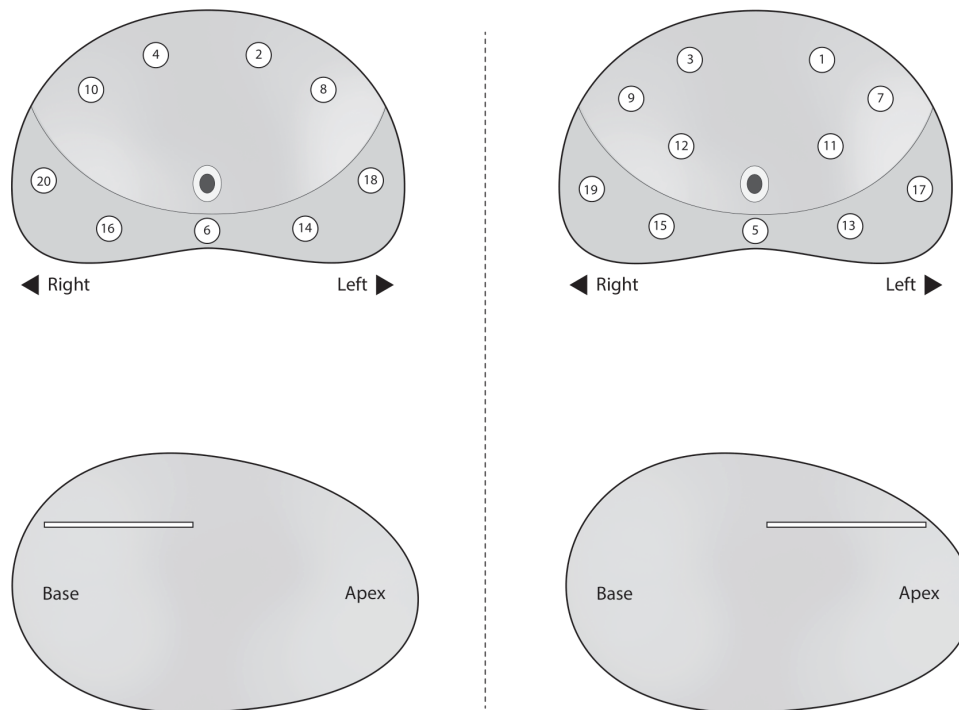


Figure 2 Twenty-region template-guided prostate biopsy.

Prostate Imaging-Reporting and Data System (PI-RADS) V.2.1 ≥ 3 will proceed to the randomisation. With allocation, men will be assigned to cognitive fusion-targeted biopsy using the three-dimensional matrix positioning method or to software-based fusion-targeted biopsy using the MIM symphony software in a 1:1 ratio while others will drop out of the trial. Men in both arms will be hospitalised 1 hour before the prostate biopsy. The biopsy procedure, which usually lasts for less than 30 min, will be performed under a local anaesthetic block in an operation room. In addition to different targeted biopsy methods, a 20-region template-guided prostate biopsy (figure 2) will be performed after the targeted biopsy in each man, which can be a reference to the different targeted techniques. The samples from the biopsy will be sent to the pathological department for assessment after the procedure. All participants will be discharged the following day after the biopsy. The pathological assessment will be reported within 2 weeks of post-biopsy. The details and timeframe of the trial are shown in table 1.

We chose the randomised trial instead of a paired cohort to reduce bias. Because if two biopsies are performed on the same participant, the progress of one may lead to the bleeding and deformation of the prostate, which will affect the progress of the other.

OUTCOMES

The primary outcome is the detection rate of csPCa for cognitive fusion-targeted biopsy and software-based fusion-targeted biopsy in men without a prior biopsy. The csPCa will be defined as International Society of

Table 1 Participant timeline in the study

	Contact with patient			
	Visit 1	Visit 2	Visit 3	Visit 4
	0	0~2 weeks	2~4 weeks	5~6 weeks
Consent	X			
Screening	X			
Baseline characteristic	X			
PSA	X			
MRI		X		
Randomisation		X		
Prostate biopsy			X	
Cognitive fusion-targeted biopsy+20-region template-guided biopsy (cognitive fusion arm)			X	
Software fusion-targeted biopsy+20-region template-guided biopsy (software fusion arm)			X	
Pathological assessment				X
Withdrawal	Complete as required at any time following registration			
SAE	Complete as required at any time following registration			

PSA, prostate-specific antigen; SAE, serious adverse event.

Box 1 Patients' inclusion and exclusion criteria

Inclusion criteria

- ▶ Age over 18 years old.
- ▶ Prostate-specific antigen increase to 4–20 ng/mL and/or abnormal digital rectal examination.
- ▶ Without previous prostate biopsy.
- ▶ Fully understand the clinical trial protocol and sign the informed consent.

Exclusion criteria

- ▶ Previous history of prostate biopsy.
- ▶ Evidence of acute or chronic prostatitis.
- ▶ Contraindications to prostate biopsy (eg, fever, evidence of urinary tract infection).
- ▶ Contraindications to MRI (eg, metal implant, contrast agent allergy).
- ▶ The investigator judges that patients are not suitable for this clinical trial.
- ▶ Any other conditions that make the investigator judge that participants are not suitable for this trial.

Urological Pathology (ISUP) grade group 2 or higher, according to the 2014 ISUP classification.¹⁵

The main secondary outcomes are as follows:

- ▶ The detection rate of any PCa for cognitive fusion-targeted biopsy and software-based fusion-targeted biopsy.
- ▶ The detection rate of csPCa for each targeted technique combined with a template-guided biopsy.
- ▶ The detection rate of any PCa for each targeted method combined with a template-guided biopsy.
- ▶ The comparison of the results between the two urologists, including the detection rate of csPCa and any PCa in the targeted biopsy, template biopsy and combined biopsy.
- ▶ The influence of prostate volume on the difference between the two fusion-targeted biopsies.

METHODS AND ANALYSIS

Patient population

Patients with suspicious PCa and had no previous biopsy will be considered eligible for registration in this trial if they can meet all inclusion criteria and had no any exclusion criteria. The main criteria include men with elevated serum PSA above 4–20 ng/mL or with an abnormal DRE and have never had a biopsy before. The details of inclusion and exclusion criteria are shown in [box 1](#). All eligible patients will be informed in detail, and only those who sign the consent form can participate in the trial. Men who are ineligible or do not want to participate in the study will be returned to the regular clinical pathway.

Multiparametric MRI

All participants who sign the informed consent will subsequently undergo a 3.0-Tesla mpMRI (Magnetom Skyra, Siemens Medical Solutions, Erlangen, Germany) with an 18-channel phased-array coil. The sequences of examination mainly included T2-weighted imaging (T2WI), diffusion-weighted imaging (acquired b-values 0, 400,

1000 and 2000 s/mm)² and dynamic contrast-enhanced imaging (with the setting of temporal resolution less than 7 s and 5 min acquisition). Images will be evaluated and scored by one of two expert radiologists (20 and 10 years of experience in prostate MRI) according to PI-RADS V.2.1 criteria.¹⁶ The probability of cancer will be assessed by the score from 1 to 5 (1: highly unlikely to be clinically significant cancer, 2: unlikely to be clinically significant cancer, 3: equivocal to be clinically significant cancer, 4: likely to be clinically significant cancer, 5: highly likely to be clinically significant cancer). The MRI report will only be marked as 'not abnormal' or 'less than 3' when scoring 1 or 2, while a specific score will be recorded at a score 3, 4 or 5.

Randomisation

Only participants with a PI-RADS score 3, 4 or 5 will be allocated 1:1 to cognitive fusion-targeted biopsy group or software-based fusion-targeted biopsy group by using block randomisation. The random sequence will be generated by PROC PLAN statement of SAS v9.4 program which will be kept by one research nurse and blinded to other researchers. A random number will be revealed only when one participant is being randomised.

Interventions

Biopsy

All biopsies in both arms will be performed via the perineum by two urologists (HW with an experience of more than 10 years and BH with an experience of more than 5 years) with an UltraView 800 ultrasound device (BK Ultrasound, USA) and a bi-planar TRUS probe (8848, BK Ultrasound) under a local anaesthetic block. Before performing the biopsy, one urologist will read the report and the image of MRI to identify the location of target lesions, while another one will be blinded to the MRI result.

Cognitive fusion-targeted biopsy arm

Each participant in this arm will undergo a cognitive fusion-targeted biopsy first. A novel three-dimensional matrix positioning-based cognitive fusion-targeted biopsy will be performed under the guidance of a bi-plane TRUS probe after reviewing the mpMRI finding. Three cores of biopsy will be taken for each suspicious lesion which is showed in mpMRI with PI-RADS score of 3–5. The details of the cognitive fusion-targeted biopsy were described in our previous research.¹⁴ After the targeted biopsy, a 20-region template-guided biopsy will be subsequently performed by another urologist who will be blinded to the MRI results.¹⁷ The urologist who performs the targeted biopsy will be determined by a random number generated by PROC PLAN statement of SAS program.

Software-based fusion-targeted biopsy arm

The software-based fusion-targeted biopsy will be performed with the MIM symphony software by taking two-dimensional mpMRI images to create a three-dimensional map then be fused with the ultrasound

images. Each suspicious area with a PI-RADS score equal to or more than 3 will be performed a three-core biopsy by one urologist, which will be followed with a 20-region template-guided biopsy by another. Also, whoever performs the targeted biopsy will be randomised.

Histology

A pathology group, which is blinded to all clinical data including the technique of biopsy, will evaluate the samples. The pathological finding will be reported within 2 weeks post-biopsy. Clinically significant cancer is defined as the ISUP grade group 2 or higher.

Statistical analysis

Continuous variables will be reported by using means with SDs or median with IQR, while categorical variables will be shown by using frequencies with proportions.

The primary analysis in this trial will follow the intention-to-treat principle, including all patients who have undergone randomisation. The primary outcome is the detection rate of csPCa for cognitive fusion-targeted biopsy and software-based fusion-targeted biopsy. The absolute difference between these two arms will be calculated with a 95% CI by estimating with a generalised linear model. The cognitive fusion-targeted biopsy will be described as non-inferior if the lower bound of the 95% CI of the difference in the clinically significant cancer detection rate of the cognitive fusion-targeted biopsy arm compared with the software-based fusion-targeted biopsy arm (cognitive fusion arm minus software-based arm) is higher than -10%.

The second outcomes will be analysed with 95% CI and Pearson χ^2 test. All reported p values were two sided in this trial.

Sample size

A retrospective data review for cognitive fusion-targeted biopsy performed at our institution during 2017 showed a clinically significant cancer detection rate of 52.8%,¹⁸ while a literature from Germany revealed a clinically significant cancer detection rate of 45%¹⁹ for software-based fusion-targeted biopsy. The patients with PI-RADS score ≥ 3 account for 60.6% in all patients who had undergone an mpMRI examination at our institution.

For the non-inferiority hypothesis, using a 10% non-inferiority margin, using 80% power and 5% one-sided α , assuming a detection rate of clinically significant cancer for cognitive fusion-targeted biopsy of 50% and a detection rate for software-based fusion-targeted biopsy of 45%, using allocation ratio of 1:1, 137 men per arm will be required. Assuming that 50% has at least one suspicious lesion on mpMRI, 548 men are needed. Account for 10% withdraw/loss, a total of 602 participants are required for inclusion.

Harms and adverse events

A research nurse will record all harms or adverse events relevant or not relevant to the procedure of biopsy. Adverse events will be assessed by Common Terminology

Criteria for Adverse Events. The serious adverse events that include (1) death; (2) life-threatening; (3) hospitalisation and (4) disability or permanent damage will be recorded immediately and then sent to the ethics committee and the monitoring board within 24 hours. All harms and adverse events will be recorded from the registration to 1 week after the biopsy.

Data collection

The data will be collected from the patient/relative of a patient at registration, and the medical record on 2 weeks and 6 weeks. The demographic information (age, height, weight, body mass index), PSA and family history will be recorded on registration, as well as the DRE will be performed. On 2 weeks after the registration, an MRI result will be recorded, including a PI-RADS score, prostate volume and suspicious lesion volume. Both prostate volume and suspicious lesion volume will be measured by mpMRI on the T2WI sequence. The data of pathological assessment will be recorded on 6 weeks (2 weeks post-biopsy) including an overall Gleason score and a separate Gleason score for each biopsy core. Besides, the length and per cent of tumour in each biopsy core will also be reported.

Monitoring

A team of independent clinical research associates (CRAs) with all more than 5 years of experience is responsible for being familiar with the trial protocol and monitoring all researchers and all participants involved in the whole processes of this trial. The CRA's role is to (1) monitor the trial plan, the record forms and the case report form before the start of the trial; (2) monitor participants' informed consent and enrolment rates; (3) monitor the compliance of participants and investigators with the protocol, and monitor data quality and authenticity.

ETHICS AND DISSEMINATION

Ethical approval was obtained from the ethics committee of Shanghai East Hospital. The results of this study will be disseminated for international peer-reviewed journals and disseminated for presentation at international or national academic conference.

TRIAL STATUS

This RCT was first registered online at ClinicalTrials.gov on 13 February 2020. The study is expected to start on 1 September 2020. Recruitment is anticipated to continue until 1 September 2021 with 6-week follow-up to be completed in November 2021.

PATIENT AND PUBLIC INVOLVEMENT

This trial protocol was written without patient or public involvement. The participants were not involved in the contribution of the design, recruitment or conduction of the study. Each participant will be informed of the latest

results at follow-up and receive a summary of the main finding at the end of the trial.

Author affiliations

Department of Urology, Shanghai East Hospital, Tongji University School of Medicine, Shanghai, China

Contributors BH, RL and HW—conceptualisation. BH, RL, DL, LH and HW—data curation. BH, RL, DL and LH—formal analysis. BH, RL, DL, LH and HW—investigation. XW and GY—supervision. BH and HW—original draft. RL, XW and GY—review and editing.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not required.

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ORCID iD

Biming He <http://orcid.org/0000-0001-8400-7290>

REFERENCES

- Bray F, Ferlay J, Soerjomataram I, *et al*. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin* 2018;68:394–424.
- Caverly TJ, Hayward RA, Reamer E, *et al*. Presentation of benefits and harms in US cancer screening and prevention guidelines: systematic review. *J Natl Cancer Inst* 2016;108:djv436.
- Abraham NE, Mendhiratta N, Taneja SS. Patterns of repeat prostate biopsy in contemporary clinical practice. *J Urol* 2015;193:1178–84.
- Ahmed HU, El-Shater Bosaily A, Brown LC, *et al*. Diagnostic accuracy of multi-parametric MRI and TRUS biopsy in prostate cancer (PROMIS): a paired validating confirmatory study. *Lancet* 2017;389:815.
- Kasivisvanathan V, Rannikko AS, Borghi M, *et al*. MRI-targeted or standard biopsy for prostate-cancer diagnosis. *N Engl J Med* 2018;378:1767–77.
- Tyson MD, Arora SS, Scarpato KR, *et al*. Magnetic resonance-ultrasound fusion prostate biopsy in the diagnosis of prostate cancer. *Urol Oncol* 2016;34:326.
- Siddiqui MM, Rais-Bahrami S, Turkbey B, *et al*. Comparison of MR/ultrasound fusion-guided biopsy with ultrasound-guided biopsy for the diagnosis of prostate cancer. *JAMA* 2015;313:390.
- Sonn GA, Natarajan S, Margolis DJA, *et al*. Targeted biopsy in the detection of prostate cancer using an office based magnetic resonance ultrasound fusion device. *J Urol* 2013;189:86.
- Puech P, Rouvière O, Renard-Penna R, *et al*. Prostate cancer diagnosis: multiparametric MR-targeted biopsy with cognitive and transrectal US-MR fusion guidance versus systematic biopsy—prospective multicenter study. *Radiology* 2013;268:461–9.
- Marra G, Ploussard G, Futterer J, *et al*. Controversies in Mr targeted biopsy: alone or combined, cognitive versus software-based fusion, transrectal versus transperineal approach? *World J Urol* 2019;37:277.
- Wegelin O, Exterkate L, van der Leest M, *et al*. The future trial: a multicenter randomised controlled trial on target biopsy techniques based on magnetic resonance imaging in the diagnosis of prostate cancer in patients with prior negative biopsies. *Eur Urol* 2019;75:582–90.
- Wysock JS, Rosenkrantz AB, Huang WC, *et al*. A prospective, blinded comparison of magnetic resonance (Mr) imaging-ultrasound fusion and visual estimation in the performance of MR-targeted prostate biopsy: the PROFUS trial. *Eur Urol* 2014;66:343.
- Kaufmann S, Russo GI, Bamberg F, *et al*. Prostate cancer detection in patients with prior negative biopsy undergoing cognitive-, robotic- or in-bore MRI target biopsy. *World J Urol* 2018;36:761–8.
- Wang H-F, Chen R, He B-M, *et al*. Initial experience with a novel method for cognitive transperineal magnetic resonance imaging-targeted prostate biopsy. *Asian J Androl* 2020;22:432–6.
- Epstein JI, Egevad L, Amin MB, *et al*. The 2014 International Society of urological pathology (ISUP) consensus conference on Gleason grading of prostatic carcinoma: definition of grading patterns and proposal for a new grading system. *Am J Surg Pathol* 2016;40:244–52.
- Turkbey B, Rosenkrantz AB, Haider MA, *et al*. Prostate imaging reporting and data system version 2.1: 2019 update of prostate imaging reporting and data system version 2. *Eur Urol* 2019;76:340.
- He B-M, Chen R, Shi Z-K. Trans-perineal template-guided mapping biopsy vs. freehand trans-perineal biopsy in Chinese patients with PSA. *Front Oncol* 2019;9:758.
- He B-M, Shi Z-K, Li H-S, *et al*. A novel prediction tool based on multiparametric magnetic resonance imaging to determine the biopsy strategy for clinically significant prostate cancer in patients with PSA levels less than 50 ng/ml. *Ann Surg Oncol* 2020;27:1284.
- Hofbauer SL, Maxeiner A, Kittner B, *et al*. Validation of prostate imaging reporting and data system version 2 for the detection of prostate cancer. *J Urol* 2018;200:767.