Prostate MR Imaging for Post-Treatment Evaluation and Recurrence

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KEYWORDS

• Prostate cancer • Recurrence • mpMRI • Radical prostatectomy • Radiation therapy
• Focal therapy

KEY POINTS

- Multiparametric MR imaging (mpMRI) can help in evaluation of post-treatment changes after diagnosis and treatment of prostate cancer as well as for diagnosis of locally recurrent disease.
- After radical prostatectomy, radiation therapy, or focal therapy, there are certain expected changes in the remaining tissue.
- Many of the mpMRI patterns of recurrent disease are similar to those of primary prostate cancer. In diagnosis of recurrence, however, normal post-treatment changes and possible inflammation must remain considerations in the interpretation of imaging findings.

INTRODUCTION

Prostate cancer (PCa) is the most common solid organ malignancy and second most common cause of cancer-related deaths among men in the United States. Last year, approximately 190,000 men were newly diagnosed with PCa and 26,000 men died of this disease.[1] Increasingly, timely diagnosis of high-grade disease is achieved with use of prostate multiparametric MR imaging (mpMRI), giving patients with localized disease (stages I–III) early options for definitive treatment. Treatment commonly includes radical prostatectomy (RP) or radiation therapy (RT), which can include external-beam RT (EBRT) or brachytherapy. Generally, RP is preferred for younger men with localized tumors and RT is preferred for elder patients or patients who are not ideal surgery candidates.[2] More recently, patients with a certain pattern of disease visualized on mpMRI may also be offered prostate-sparing focal therapy treatment options that utilize laser technology, microwave ablation, cryotherapy, or high-intensity focused ultrasound (HIFU).[3,4] Unfortunately, despite advances in diagnosis and management of PCa, the disease recurs after definitive treatment in up to 40% of patients.[5] Therefore, detection and treatment of recurrent disease has become a relevant focus across multiple disciplines. From an imaging perspective, prostate mpMRI not only can provide insight into primary PCa but also can achieve good anatomic spatial resolution and provide functional data for visualization of recurrent disease.[6]

After treatment, patients are followed closely for biochemical recurrence (BCR), defined based on serum prostate-specific antigen (PSA) criteria specific for each treatment option.[7–9] PSA nadir achieved after each treatment option differs, because in RT and in focal therapy, PSA-producing prostate parenchyma is not completely eradicated.[9] After RP, PSA nadir of undetectable

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levels is expected, whereas after RT or focal therapy, a PSA nadir greater than zero is achieved within weeks or months after completion of therapy. Accordingly, in RP patients, recurrence is suspected with an increase in PSA above the threshold greater than or equal to 0.2 ng/mL with a second confirmatory level, whereas in RT patients, an increase in PSA 2.0 ng/mL above the established post-treatment nadir is suspicious.[10] PSA patterns are monitored after focal therapy as well, although consensus about kinetics and a threshold value is still being investigated.[9] In patients who receive definitive therapy, BCR indicates locally recurrent disease in up to two-thirds of patients, and this must be extensively evaluated for appropriate subsequent management.[11–13] Distinction of PSA-producing benign etiologies from local recurrence and distant metastasis is vital. Prostate mpMRI can greatly assist this by aiding visualization of local structures post-treatment, with some considerations.[14–16] This is clinically important because localized recurrence that can be visualized on mpMRI can be offered local salvage treatment, which is drastically different from systemic options offered to patients with distant metastatic disease.

Evaluation and imaging of recurrent disease with mpMRI require certain considerations based on treatment received. Prostate mpMRI's strength lies in combining anatomic data (T1-weighted [T1W] and T2-weighted [T2W] MR imaging) with functional data (diffusion-weighted imaging [DWI] and dynamic contrast-enhanced imaging [DCE]) to provide maximum information about the location and character of possible disease. Established guidelines for characterizing and reporting suspicious areas on prostate mpMRI, such as Prostate Imaging—Reporting and Data System, Version 2, are designed only for characterization of primary cancer.[17] Although baseline pulse sequences (**Box 1**) used are the same for post-treatment evaluation, treatment greatly changes anatomy visualized, can change signal intensity on certain sequences, and can introduce artifact that compromises sequence utility. For example, after RP, a drastically different anatomy is visualized on imaging and image artifact may be introduced with use of surgical clips during the procedure. In contrast, after RT, although the general anatomic structures remain the same, the prostate shrinks greatly in size and has different signal pattern on T2W imaging. The purpose of this article is to discuss general guidelines for identifying normal post-treatment changes and possible recurrence on mpMRI as well as pitfalls of mpMRI interpretation after the various treatments for PCa.

Box 1
Pulse sequences used for post-treatment evaluation with multiparametric MR imaging

mpMRI protocol in recurrent PCa work-up

Triplane T2W MR imaging

Diffusion-weighted MR imaging

- ADC map
- High *b*-value DW MR imaging (>1400) (acquired or calculated)

DCE MR imaging

Pelvic T1W MR imaging

MULTIPARAMETRIC MR IMAGING AFTER RADICAL PROSTATECTOMY

RP is a common active treatment chosen for PCa patients with localized disease, with approximately 40% of patients undergoing definitive therapy choosing this option.[18] RP includes total removal of the prostate and seminal vesicles, along with pelvic lymph node dissection to varying extents for evaluation of local metastasis.[19] Subsequent pathology analysis evaluates surgical margins and lymph nodes for staging. Risk for future BCR is a consideration at this point, because certain characteristics of the original PCa can increase risk of recurrence, such as seminal vesical invasion, positive surgical margins, extraprostatic extension, perineural invasion, lymphovascular invasion, and increased tumor volume.[18] After successful surgery, PSA should drop to undetectable levels within 2 weeks to 3 weeks and patients should be followed with serial serum PSA measurements for early detection of possible BCR. According to the American Urological Association guidelines, BCR after RP is defined as a serum PSA measurement greater than or equal to 0.2 ng/mL, followed by a second confirmatory serum PSA measurement of greater than or equal to 0.2 ng/mL.[7] Post-RP, approximately 35% of patients experience BCR within 10 years, and there are certain parameters that make this recurrence more likely to be found as localized disease.[20–24] These include PSA increase more than 3 years post-RP, PSA doubling time greater than 11 months, original Gleason score less than or equal to 7, and stage less than or equal to pT3a-pT3a pN0, pTx with negative surgical margins. In contrast, systemic disease can be predicted if PSA increases in less than 1 year post-RP, PSA doubling time is in 4 months to 6 months, original

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