ACR–SABI–SAR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETIC RESONANCE IMAGING (MRI) OF THE PROSTATE

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The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

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[1] *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

I. INTRODUCTION

Magnetic resonance imaging (MRI) is a proven and useful tool for the evaluation, assessment of severity, and follow-up of diseases of the prostate. It should be performed only for valid medical reasons.

MRI of the prostate is the imaging modality of choice for many clinical scenarios . This technique has superior soft-tissue contrast and has the advantage of providing multiplanar and 3-D depiction of anatomy and pathology. Additional benefits include an absence of ionizing radiation and exposure to iodinated contrast material. Careful attention to patient comfort before beginning the MR examination will result in improved diagnostic quality.

Prostate MRI has emerged as an important tool for managing men with elevated prostate-specific antigen (PSA), men with abnormal digital rectal examination, and those suspected of harboring or diagnosed with prostate cancer. There is strong evidence demonstrated by prospective randomized clinical trials that men undergoing prostate MRI before biopsy (biopsy naïve) and after negative systematic transrectal ultrasound (TRUS) biopsy benefit from improved detection of clinically significant prostate cancer while avoiding overdiagnosis of indolent cancer [1-4]. An important role of prostate MRI is the integration into the biopsy pathway with TRUS imaging (MR-TRUS fusion) allowing targeted tissue sampling with the goal of detecting high-grade lesions otherwise missed or undersampled; more than 20% of all prostate cancers are localized in the anterior gland, which is not routinely biopsied with TRUS [5]. The Prostate Imaging Reporting and Data System (PI-RADS) Steering Committee outlined the clinical utility of the multiparametric MRI (mpMRI) of the prostate and MRI-directed biopsy pathway highlighting the diagnostic benefits of incorporating MRI into the workup and risk stratification of biopsy-naïve men and men with a prior negative biopsy with persistent clinical suspicion for prostate cancer [6]. mpMRI also plays a role in the initial staging of intermediate-risk and high-risk prostate cancer by detecting extraprostatic extension, seminal vesicle invasion, and lymph node involvement. It has high prognostic accuracy in predicting organ-confined versus non–organ confined disease, when compared with clinically available nomograms (cancer risk calculators) that use the clinical features of prostate cancer (Gleason score, serum PSA, and clinical stage) such as Partin Tables [7]. mpMRI is also used for surgical planning for nerve-sparing radical prostatectomy [8] and establishing the location and local extent of the tumor in patients being considered for radiation therapy [9]. The National Comprehensive Cancer Network guidelines now incorporate mpMRI for the early detection of prostate cancer in men with indications for biopsy, confirmation of candidacy for active surveillance and monitoring, and evaluation of regional recurrence [10].

An additional role of MRI evaluation in men involves the assessment of causes of infertility, such as obstructive abnormalities of the ductal system for sperm transport to include prostate, seminal vesicles, vas deferens, and ejaculatory ducts (ie, prostatic utricle, Mullerian duct cyst, ejaculatory duct cyst, seminal vesicle cyst, aberrations of vas deferens) [11]. In the benign prostatic hyperplasia (BPH), MRI has a role for guiding interventions aimed at the reduction of periurethral prostatic tissue, monitoring outcomes, and in the evaluation of postprocedural complications [12, 13].

II. INDICATIONS AND CONTRAINDICATIONS

Indications for MRI of the prostate include, but are not limited to, the following:

1. Detection and staging of malignancies of the prostate to guide management
2. Assessment of known malignancy of the prostate in men on active surveillance
3. Assessment for recurrence of tumors of the prostate following treatment (surgical resection, radiation, or focal therapy)
4. Evaluation of the prostate and seminal vesicles for benign indications (BPH, infertility, hematospermia)

Contraindications for MRI include the implanted devices, clips, and other medical hardware that do not meet safety parameters as outlined in the ACR Guidance Document on MR Safe Practices.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [15].

Personnel Qualifications

More information about the optional ACR prostate cancer MRI center designation program can be found at this reference [16].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for MRI of the prostate should provide sufficient information to demonstrate the medical necessity of the examination and allow for the proper performance and interpretation of the examination.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). The provision of additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements; adopted 2006, 2016 (Res. 12-b).

The supervising physician should have adequate understanding of the indications, risks, and benefits of the examination, as well as alternative imaging procedures. The physician must be familiar with potential hazards associated with MRI including potential adverse reactions to contrast media. The physician should be familiar with relevant ancillary studies that the patient may have undergone. The physician performing MRI interpretation must have a clear understanding and knowledge of the anatomy and pathophysiology relevant to the MRI examination.

The supervising physician must also understand the pulse sequences to be used and their effect on the appearance of the images, including the potential generation of image artifacts. Standard imaging protocols may be established and varied on a case-by-case basis when necessary. These protocols should be reviewed and updated periodically.

IV. SPECIFICATIONS OF THE EXAMINATION

A. Patient Selection

The physician responsible for the examination should supervise patient selection and preparation and be available in person or by phone for consultation. Patients must be screened and interviewed before the examination to exclude individuals who may be at risk by exposure to the MR environment.

Certain indications require administration of intravenous (IV) contrast media. IV contrast enhancement should be performed using appropriate injection protocols and in accordance with the institution's policy on IV contrast utilization (See the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media [17]).

Patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Administration of moderate sedation may be needed to achieve a successful examination. If conscious sedation is necessary, refer to the ACR–SIR Practice Parameter for Sedation/Analgesia [18].

IV. SPECIFICATIONS OF THE EXAMINATION

B. Facility Requirements

Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

The multiparametric MRI (mp-MRI) combines diffusion-weighted imaging (DWI) and dynamic contrast-enhanced (DCE) imaging which complement the conventional anatomic T2-weighted (T2-W) imaging. Advances in hardware and software have allowed mpMRI to become an effective tool for detecting prostate cancer [19].

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

1. Hardware

a. Field Strength

Improvements in performance at both 1.5T and 3.0T scanning systems allow both to achieve consistent high-quality images; thus, prostate MRI should be performed on a 1.5T or 3.0T system. A 3.0T system offers higher signal-to-noise ratio (SNR), which results in higher spatial and temporal resolution, and also decreased image acquisition time [20]. The disadvantages of a 3.0T system include increased artifacts from adjacent structures such as bowel gas or hip prostheses, especially on DWI [21]. Subjective image quality has been shown to be better on 3.0T scanners. However, with appropriate coil and pulse sequence choice, studies have demonstrated no significant diagnostic differences between 3.0T and 1.5T scanners [22-24]. "Open" or "stand up" MRIs, which employ a lower magnetic field, usually 0.3T or 0.6T, are not recommended due to their low SNR. Although there is ongoing research for the use of low-field MR scanning systems of less than 0.1T and high-field MRI, including those at 7T, currently these are not routinely recommended because efficacy and consistency have not been adequately assessed [25].

In patients with unilateral or bilateral hip prostheses, consideration may be given to scan patients with 1.5T instead of 3.0T to decrease susceptibility artifact; however, it has been shown in a multicenter study that diagnostic evaluation is not significantly different [26]. Instead, adjusting the scanning protocol to include more robust artifact reduction sequences should be employed, such as T2-W imaging acquired with radial filling of k-space (PROPELLER or BLADE) or reduced field of view (FOV) DWI [27, 28]. Other metal artifact reduction techniques such as SEMAC and MAVRIC increase receiver bandwidth, echo train length, and matrix and decrease slice thickness [29]

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

1. Hardware

b. Coil Set Up

The choice of coil setup is also integral to producing quality images. The two types of coils that may be used include an external body phased array coil placed over the pelvis or an endorectal coil. For patients scanned on 1.5T, an endorectal coil may be needed to improve SNR and spatial resolution. Comparisons between the use of endorectal coil on a 1.5T and an external phased array coil on a 3.0T MRI did not reveal significant differences [23, 24]. However, the application of both the external phased array coil and endorectal coil on a 3.0T MRI is more controversial and may offer slightly increased diagnostic performance, especially on DWI [30-33]. Although it may improve image quality slightly, endorectal coil placement requires skilled personnel and may be uncomfortable for patients, which may deter patients from undergoing prostate MRI [34]. In addition, the endorectal coil may distort the prostate and, at times, cause artifacts along the posterior prostate. A newly developed rigid phased array endorectal coil, meant to be used with an external phased array coil, is smaller in diameter in contrast to the traditional inflatable endorectal coil and has been shown to have improved SNR. However, lesion detection has not significantly improved, and surveyed patients reported increased discomfort [35]. Decision on coil setup should ultimately be made to produce the best and most consistent imaging possible while maintaining patient comfort and efficient workflow.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

2. Software

a. Post Processing of Dynamic Contrast Enhanced Imaging

Evaluation of DCE imaging is most commonly qualitative. There has been extensive investigation of enhancement kinetics of prostate cancer in comparison with benign prostate tissue, especially in describing the types of kinetic curves and evaluating quantitative coefficients. The outcomes of the studies have been varied. Most show some positive correlation of rapid early enhancement curve with washout (type 3 curve) with higher-grade prostate cancer, Grade Group (GG) 2 (Gleason score 3 + 4 = 7) or greater compared with GG 1 (Gleason score 3 + 3 = 6) or benign tissue, but do not show added value to DWI [36-39]. Quantitative postprocessing requires additional software, which may not be accessible to all and also requires time to perform. Although there may be added confidence in risk stratifying prostate lesions when using the DCE processing software, the cost and time required may not justify it in a higher volume workflow [40].

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

2. Software

b. Software Support for Interpretation

There are many new software platforms available that offer features that may assist readers in the interpretation process. Many offer automated or semiautomated segmentation of the prostate gland. This is helpful in determining clinical metrics such as PSA density, which has been correlated with grade of prostate cancer [41]. Many tools also have features which help with workflow, organization, and presentation of results in a pictorial manner for easier understanding to patient and clinicians. There are also FDA computer-aided detection algorithms available that assist in identifying and grading lesions. Although this supplemental software may assist with the interpretation of prostate MRI, they are not required and should be validated with data from the radiologists' own institution before clinical use.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

2. Software

c. Novel Image Acceleration Techniques

Both T2-W imaging and DWI require long acquisition times. Novel imaging techniques have decreased scan times, most using deep learning in combination with other MR accelerating techniques such as parallel imaging, compressed sensing, and simultaneous multislice imaging [42]. These techniques have been shown to have equal or improved image quality compared withtraditional T2-W imaging and DWI, which may be due to decreased motion artifact from reduced scan time [43-46]. Validation of these techniques should be performed and compared with traditional scanning techniques at the radiologists' own institution before clinical use.

IV. SPECIFICATIONS OF THE EXAMINATION

C. Technical Advances

2. Software

d. Examination Technique

1. General considerations

The mpMRI is established in prostate cancer detection, localization, staging, characterization, risk stratification,

and post-treatment evaluation [47]. MpMRI refers to the use of T2-W imaging in combination with functional imaging techniques: DWI and DCE imaging [47, 48]. Use of MR spectroscopic imaging (MRSI) has not been widely incorporated in clinical practice to date. Prostate MRI as a primary screening tool has not been well studied, and mpMRI is typically used as a secondary screening test in a PSA prescreened population [49].

Biparametric MRI (bpMRI) of the prostate, in general, focuses on the combination of high-quality small FOV T2-W imaging and DWI, the same as that of mpMRI, but omits all of the contrast-related imaging for considerations of cost, time, and patient experience. The use of bpMRI is being heavily investigated as a prebiopsy triage method to reduce the number of unnecessary biopsies and overdetection of insignificant prostate cancers. It has been recognized that bpMRI should be introduced based on well-defined patients' clinical eligibility with close monitoring of image quality and a mechanism for recalling patients for suboptimal examinations [50, 51]. The technique of bpMRI has not been established. Although there are meta-analyses showing noninferiority of bpMRI to mpMRI, investigations on this technique have been conducted at large, experienced centers with high volumes and extensive experience interpreting mpMRI. There is currently a lack of prospective multicenter data to make evidence-based recommendations for the use of bpMRI [51]. At this time, bpMRI should only be performed at centers where they have documented noninferiority with this technique based on local data.

2. Patient Preparation

There are no widely agreed on consensus recommendations for patient preparation (ref PI-RADS v2.1, which states, "At present, there is no consensus concerning all patient preparation issues.") [52]. Multiple techniques have been employed and studied, singularly and in combinations.

The presence of stool and gas within the rectum can lead to significant artifacts, and gas-mitigation techniques are recommended. The patient should evacuate the rectum, if possible, immediately before the MRI examination. Dietary modifications, enema administration, and narrow caliber rectal tube insertion have been reported to reduce rectal gas and improve examination quality and should be considered, although there is not currently consensus on the optimal gas reduction technique [53-56].

Antispasmodic agents such as glucagon can be considered to reduce motion from bowel peristalsis, although they may not always be necessary and must be balanced against the cost and risk of adverse drug reactions [56].

All of the patient preparation techniques involve some degree of additional cost, time, and/or impact on patient experience with the examination, as well as some small risk such as with administration of an antiperistaltic drug. A radiologist needs to weigh the potential benefits of various preparatory methods and their impact on the image quality, patients' experience, and practice.

Recent biopsy may lead to hemorrhage and inflammation, which can adversely affect cancer staging, and an interval of 6 weeks or more should be considered when performing MRI for staging after biopsy. Detection of clinically significant cancer at a site of postbiopsy hemorrhage without a corresponding abnormality on mpMRI is low, and a study showed that the presence of extensive hemorrhage and short delay after biopsy did not negatively impact accuracy for tumor detection using mpMRI [57]. When the primary purpose of the examination is to detect and characterize clinically significant cancer after a negative TRUS-guided biopsy, a delay in mpMRI may not be necessary [58]. Conversely, postbiopsy hemorrhage may adversely affect image interpretation for staging in some instances, and an interval between biopsy and MRI should be considered if delay is feasible for patient management, while recognizing the reality that the increased time interval between the biopsy and definitive therapy may negatively affect patients' outcomes [59, 60].

When evaluating the seminal vesicles or related indications (eg, infertility, hematospermia), it is recommended that patients avoid ejaculation for 3 days before the examination to improve seminal vesicle distention. However, for prostate cancer evaluation, this has not been demonstrated to improve assessment.

Imaging should be performed at either 1.5T or 3.0T following the technical parameters outlined in the PI-RADS 2.1 recommendations with the goal of achieving high spatial and temporal resolution and optimal SNR [69].

The PI-RADS recommendations on voxel size and slice thickness should be used whenever possible, acknowledging that in some situations, larger voxel sizes may be needed to optimize SNR. Suggested sequences (regardless of coil) include the following:

i. Small FOV high-resolution T2-W fast spin echo (FSE) of the prostate in the axial and at least 1 additional orthogonal plane
ii. Small FOV DWI, with ADC map derived from at least 2 b-values. It is recommended to use 1 low b-value set at 0–100 s/mm^2 (preferably 50-100 s/mm) and one intermediate b-value set at 800–1.000 s/mm^2. High b-value (=1400 s/mm^2) DWI is also required and can be generated from a separate acquisition or calculated high b-value extrapolated from low and intermediate b-values.
iii. Precontrast fat-suppressed 3-D T1-W gradient echo and DCE T1-W imaging with high temporal resolution (<15 seconds).
iv. Optional larger FOV imaging of the pelvis for locoregional staging that may include T1-W, T2-W, and DWI sequences.

High spatial resolution T2-W FSE imaging is used for the detection, localization, and staging of prostate cancer and should be obtained in the axial plane and at least 1 additional orthogonal plane. The axial T2-W imaging should cover the prostate gland and seminal vesicles, and orientation should be either straight axial to the patient or in an oblique axial plane matching the long axis of the prostate. The same orientation should be used for DWI and DCE-MRI. Phase-encoding direction should be right-to-left or left-to-right to minimize motion and pulsation artifacts overlapping the prostate gland. Recommended slice thickness is =3 mm and no gap. Three-dimensional T2-W acquisition with a slice thickness <1.5 mm may be used as an adjunct to orthogonal T2-W FSE sequences, although soft-tissue contrast is not identical [70].

DWI improves the diagnostic performance for cancer detection when combined with T2-W images and provides information about tumor aggressiveness [71-75]. DWI should be acquired in the axial plane with slice thickness of 4 mm, no gap, and with motion-probing gradients applied in 3 orthogonal planes. Diffusion kurtosis effect occurs at b-values of 1,000 s/mm^2; therefore, ADC maps should be calculated with b values that are =1,000 s/mm^2 [76]. Although the optimal b-values have not been determined for calculation of the ADC map, it is agreed that at least two b-values are required and should include low (0-100 s/mm^2 and preferably 50-100 s/mm^2) and intermediate (800-1,000 s/mm^2) b-values [52]. High b-values between 1,400 and 2,000 s/mm^2 have added value for tumor localization, although field strength and coil selection, technical parameters—including SNR—and analysis of trace DWI will impact the utility of these higher b-values [74, 77-85]. A high b-value DWI (=1,400 s/mm^2) should be acquired separately or calculated from the low and intermediate b-value images [52]. Axial slice thickness should be =4 mm with no gap, and the location should ideally match the axial T2-W and DCE-MRI images without sacrificing SNR.

The added value of DCE-MRI over the combination of T2-W and DWI is not certain and may be secondary, with only modest improvement in tumor detection, localization, and local staging. DCE-MRI specificity is lower for transition zone tumors and is also degraded in the setting of prostatitis and postbiopsy hemorrhage [47, 86, 87]. Serial imaging of the gland should be performed before and following IV gadolinium administration (injection rate 2-4 mL/s), and a rapid T1-W 3-D gradient-echo sequence [47, 86] with a temporal resolution of <15 seconds/phase. Determination of pharmacokinetic features beyond the visual inspection of early enhancement requires a much higher temporal resolution and continued imaging for 2–5 minutes. Unenhanced T1-W images from this sequence can be used to detect postbiopsy hemorrhage. Axial slice thickness should be =3 mm, with no gap, and the location should match axial T2-W and DWI images. Images can be evaluated qualitatively, semiquantitatively, or quantitatively.

American College of Radiology Imaging Network (ACRIN) multicenter trial showed no incremental benefit of MRSI in detection of cancer over 1.5T endorectal T2-W imaging

Finally, optional T1-W imaging, T2-W imaging, and DWI of the pelvis with a pelvic phased array coil can be performed to assess for common manifestations of locoregional metastatic disease (nodal or osseous metastasis). Their inclusion might be tailored to a patient's risk.

3. Active Surveillance

MRI of the prostate is now routinely performed for men with low-risk, low-volume prostate cancer who are enrolled in active surveillance. It is an important tool in the initial evaluation for lesion detection and sampling using MR-guided biopsy. Prostate MRI is performed at the time of enrollment, when clinical and pathological results are discordant, and when aggressive cancer is suspected, or PSA increases with negative systematic biopsies. The high negative predictive value of mpMRI is particularly important in this population [10]. The utility of mpMRI and MR-guided biopsy for monitoring these patients and for detecting the onset of aggressive disease is being actively investigated. The mpMRI imaging protocol for patients on active surveillance follows the same technical parameters as those used for diagnosis and staging of prostate cancer.

4. Local Recurrence After Therapy

MRI can accurately detect local recurrence after prostatectomy as well as nonsurgical treatments such as the various forms of ablative therapies, radiotherapy, and androgen deprivation therapy [93-95]. DCE-MRI is the most accurate sequence in detecting recurrence after either radical prostatectomy or radiation therapy [100]. DWI has been shown to be sensitive for the detection of local recurrence in patients following external radiation therapy and adds a small incremental improvement when added to DCE-MRI, but the benefit of DWI is less consistent and more limited following interstitial brachytherapy or prostatectomy given the susceptibility artifacts from seeds and surgical clips, respectively [96-98].

Larger FOV imaging of the pelvis (T1-W imaging pre- and postcontrast, T2-W imaging, and DWI) with a pelvic phased array coil can also be performed to assess for common manifestations of locoregional metastatic disease (nodal or osseous metastasis). However, accuracy for nodal metastatic disease is limited given the morphologic limitations of MRI for lymph node assessment, which is less sensitive and specific than Prostate-Specific Membrane Antigen PET-CT [101].

5. Ablative Therapy for Prostate Cancer

Ablative therapy techniques include cryotherapy, high-intensity modulated focused or directional ultrasound, laser ablation therapy, radiofrequency ablation, irreversible electroporation, steam ablation and photodynamic therapy. Imaging criteria for focal therapy differ from imaging criteria for whole-gland treatment because the objective of imaging is accurate localization and contouring of the index lesions [102]. Although research evidence for MRI in focal therapy is limited, high-quality mpMRI is critical to achieve the objectives for focal therapy and monitoring after therapy.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [103].

Reporting Requirements

Reporting should follow the ACR Practice Parameter for Communication of Diagnostic Findings. Additionally, facilities should use the PI-RADS final assessment categories and terminology for reporting and tracking outcomes, except in patients with prostate cancer treated with radical prostatectomy, radiation therapy, whole gland tissue ablation therapy, or systemic therapy (such as androgen deprivation therapy and chemotherapy). The use of Prostate Imaging Recurrence Reporting has been suggested in this setting. The use of structured report with description of lesion location according to PI-RADS sector map or other well-defined location schema and key images with annotations is encouraged to facilitate communication with referring physicians and patients and in the auditing process.

Biopsy Planning

Imaging centers should have the capability to perform or prepare images for MRI-targeted biopsies. These include

any type of biopsy that uses the MR information to guide the procedure, such as "in-bore" MRI-targeted biopsy and cognitive or software-assisted MRI/US fusion biopsy. If the center is unable to perform MRI-targeted biopsy, it should have a referral arrangement with a cooperating radiology department or urology practice that provides this service.

Monitoring of Interpreting Physician Performance

Follow-up of biopsy results is encouraged and is a requirement of the ACR prostate cancer MRI center designation. Optimally, each facility establishes and maintains a medical outcome audit program to follow up on positive assessments and to correlate pathology results with the interpreting physician's findings. This serves as a continuous quality improvement tool and facilitates identifying cases in which the biopsy may have missed the target. If the facility does not perform MRI-guided intervention, it should be able to have access to correlative pathology results from the facility with which it has a referral arrangement. Monitoring should evaluate the accuracy of interpretation as well as the appropriateness of indications for the examinations. Summary statistics and comparisons generated for each physician and for each facility should optimally be reviewed at least annually by the lead interpreting physician.

VI. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR-AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance Imaging (MRI) Equipment [104].

The MRI equipment specifications and performance must meet all state and federal requirements. The requirements include, but are not limited to, specifications of maximum static magnetic strength, maximum rate of change of the magnetic field strength (dB/dt), maximum radiofrequency power deposition (specific absorption rate), and maximum acoustic noise levels.

Specific policies and procedures related to MRI safety should be in place with documentation that is updated annually and compiled under the supervision and direction of the supervising MRI physician. Guidelines should be provided that deal with potential hazards associated with MRI examination of the patient as well as to others in the immediate area [105-112]. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination [105, 109].

VII. SAFETY GUIDELINES

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [15], the ACR Manual on MR Safety [14], and the ACR Manual on Contrast Media [113].

Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis [105, 106].

Adherence to ACR's MR safe practices is recommended. A careful history of implant and medical device placement should be taken before scanning with attention to their MR safe status. For patients with orthopedic implants such as total hip arthroplasty, scanning protocol changes may be adjusted as mentioned in the "Field Strength" section to minimize artifact on imaging. For patients who have MR conditional devices which require scanning on 1.5T system, endorectal coil may be used if available to increase SNR and spatial resolution as described in the "Coil Set Up" section. Otherwise, using an external phased array coil should produce adequate imaging quality [114].

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading Position Statement on Quality Control & Improvement, Safety, Infection Control, and Patient Education on the ACR website

(https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

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