ACR–SABI–SPR–SSR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETIC RESONANCE IMAGING (MRI) OF THE WRIST

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PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

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

This practice parameter was revised and written collaboratively by the American College of Radiology (ACR), the Society of Advanced Body Imaging (SABI), the Society for Pediatric Radiology (SPR), and the Society of Skeletal Radiology (SSR).

Magnetic resonance imaging (MRI) is a proven, established imaging modality for the detection, evaluation, staging, and follow-up of disorders of the wrist. Properly performed and interpreted, MRI not only contributes to the diagnosis but also serves as an important guide to treatment planning and prognosis. Early use of wrist MRI for patients with suspected scaphoid fractures decreases the morbidity associated with such injuries. Other benefits include reduction in cost of treatment, time immobilized, and time away from work. However, wrist MRI should be performed only for a valid medical reason and after careful consideration of alternative imaging modalities. The strengths of MRI and other modalities should be weighed against their suitability in particular patients and specific clinical conditions. Wrist MR Arthrography can be used to detect intrinsic ligament tears, triangular fibrocartilage complex (TFCC) tears, intra-articular bodies, and articular cartilage lesions. MR Neurography with specialized 3-D and diffusion sequences may be used for evaluation of neuropathic conditions, such as nerve entrapment, injury, and neuritis. In experimental studies, quantitative MRI has been applied to carpal tunnel syndrome and may aid in diagnosis and staging.

A radiographic examination should be the first imaging test performed for suspected bone, joint, and soft tissue abnormalities in the wrist. It will often suffice for diagnosis or exclusion of an abnormality or will direct further imaging workup. Bone scintigraphy may be used to evaluate for radiographically occult scaphoid and other fractures but has lower specificity than MRI or computed tomography (CT). Fluoroscopic examination can be used for evaluating carpal instability, and wrist arthrography can be used for diagnosing and staging abnormalities of the triangular fibrocartilage complex (TFCC) and wrist ligaments. High-resolution sonography may be considered as an acceptable alternative to MRI for evaluation of suspected ganglion cysts, tendon pathology, peripheral nerve pathology, synovitis, bone erosion, fluid collection, and soft tissue foreign body. Sonography may also be considered in the evaluation of ligament injuries such as for evaluation of scapholunate ligament tears and carpal tunnel syndrome.

CT with multiplanar reformatted images as well as 3-D volume-rendered reconstructions play an important role in the characterization of fractures, alignment, tendon subluxation and entrapment at injury sites, and other osseous abnormalities. CT examination may also be used in post-treatment evaluation of fracture healing and hardware complications. Wrist CT arthrography with multiplanar reformatted images can show tears of the intrinsic ligaments, tears of the TFCC, intra-articular bodies, and articular cartilage defects. Last, diagnostic arthroscopy can provide a detailed examination of the intra-articular structures of the wrist but is more invasive and usually considered only after imaging.

Although MRI is often the most sensitive noninvasive diagnostic test for detecting anatomic abnormalities of the wrist, MRI findings may be misleading if not correlated with clinical history, physical examination, laboratory tests, physiologic tests such as nerve conduction analysis and electromyography, and/or other imaging studies. Adherence to the following practice parameters should enhance the probability of detecting and accurately diagnosing clinically important abnormalities.

II. INDICATIONS AND CONTRAINDICATIONS

A. Primary Indications

Primary indications for MRI of the wrist include, but are not limited to, diagnosis, exclusion, grading, and/or treatment planning of suspected:

1. Abnormalities of the TFCC: partial tears, complete tears, and degeneration of TFCC disc, ulnar collateral ligament injury, extensor carpi ulnaris tendon abnormality and subluxation[1]
2. Abnormalities of the scapholunate and lunotriquetral interosseous ligaments: sprains, partial tears, and complete tears[2]
3. Abnormalities of the dorsal and volar extrinsic wrist ligaments[2,][2]
4. Ulnocarpal impaction or abutment syndrome[2]

5. Fractures of the distal radius, scaphoid, and other carpal bones with normal or equivocal radiographs
6. Soft tissue abnormalities including injury, fluid collections, and masses such as ganglion cysts[3]
7. Complications of scaphoid fractures: displacement, nonunion, malunion, and osteonecrosis[3]
8. Osteonecrosis of the carpal bones[3]
9. Carpal tunnel syndrome: primary, secondary, and recurrent [1]
10. Abnormalities of peripheral nerves: neuropathy, injury, intrinsic or extrinsic compression, and tumors[3]
11. Flexor and extensor tendon disorders: partial and complete tears, tendon subluxation, tendinosis and tenosynovitis[3]
12. Osteochondral and articular cartilage lesions[2]
13. Vascular abnormalities: arterial aneurysms and pseudoaneurysms, varices, hemangiomas, and vascular malformations[3]
14. Congenital and developmental conditions: dysplasia and clarification of normal variants
15. Arthritis: degenerative, inflammatory, autoimmune, and septic

B. MRI of the wrist may be indicated to further clarify, stage, and follow up conditions diagnosed clinically and/or suggested by other imaging modalities, including, but not limited to:
1. Neoplasms of bone, joint, tendon sheath, or soft tissue.[3] See also the ACR–SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging (MRI) of Bone and Soft Tissue Tumors [2]
2. Infections of bone, joint, or soft tissue.[3] See also the ACR–SPR–SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging (MRI) of Bone, Joint, and Soft Tissue Infections in the Extremities [3]
3. Rheumatoid arthritis, juvenile idiopathic arthritis, psoriatic arthritis, gout, and related diseases[3]

C. MRI of the wrist may be useful to evaluate specific clinical problems, including, but not limited to:
1. Acute and chronic wrist instability[2]
2. Dorsal or ulnar-sided wrist pain[2]
3. Wrist symptoms in adolescent gymnasts and other athletes [4]
4. Unexplained chronic wrist pain recalcitrant to conservative measures[2]
5. Acute wrist trauma
6. Wrist malalignments[2]
7. Limited or painful range of motion[2]
8. Unexplained wrist swelling, mass, or atrophy[3]
9. Planning for diagnostic or therapeutic arthroscopy[2]
10. Recurrent, residual, or new symptoms following wrist surgery[2,3]

D. Contraindications and Safety
See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [5], the ACR Manual on Contrast Media [6], and the ACR Guidance Document on MR Safe Practices [7].
Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis.

[1] Conditions in which intra-articular contrast (performed by direct intra-articular injection or indirect joint opacification following IV administration) may be useful

[2] Conditions in which intravenous (IV) contrast may be useful

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [5].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for MRI of the wrist should provide sufficient information to demonstrate the

medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). 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's scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

The supervising physician must have adequate understanding of the indications, risks, and benefits of the imaging examination, as well as alternative imaging procedures. The physician must be familiar with potential hazards and adverse events 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 wrist MRI interpretation must have a clear understanding and knowledge of the anatomy and pathophysiology relevant to the region of interest.

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, ideally at least annually.

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 prior to the examination to exclude those 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 [8]).

Pediatric patients or patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Use of sedation in pediatric patients can be minimized by employing Administration of moderate sedation or occasionally general anesthesia may be needed to achieve a successful examination, particularly in young children. If moderate sedation is necessary, refer to the ACR-SIR Practice Parameter for Minimal and/or Moderate Sedation/Analgesia [10].

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.

C. Examination Technique

High-resolution wrist MRI is typically performed using high field strength (=1.0 T) systems. 3T scanner is preferred when evaluating intra-articular pathologies which require high signal-to-noise ratio (SNR) and high spatial resolution [11]. However, certain indications (eg occult fractures, carpal bone osteonecrosis, osteomyelitis or diffuse synovitis) that rely on contrast resolution rather than high spatial resolution for their evaluation may be accomplished at a lower field of strength (0.1 to 0.9 T). In such situations, the reduced SNR inherent at lower field strength may necessitate modifications in the imaging parameters. For example, increasing the number of signals averaged improves SNR at the expense of longer imaging times and risk of patient motion. Alternatively, an increase in voxel size (by a combination of larger field of view (FOV), thicker slices, and/or decreased matrix) will increase SNR, but at the expense of spatial resolution. Overall, a balance of superior spatial resolution, high SNR, and high contrast resolution is important to

optimize wrist MRI examination for the evaluation of bone and soft tissue injuries.

Suppressing the signal from fat may enhance the diagnostic yield of some pulse sequence. Fat suppression may be performed using spectrally selective radiofrequency (RF) pulses, a phase-dependent method (eg, the Dixon technique), or a short-tau inversion recovery (STIR) sequences. Fat suppression techniques that rely on the difference between fat and water precessional frequencies (chemical shift) may be unreliable at low field strengths, and substituting STIR or T2-weighted Dixon water may be necessary.

A local receiver coil or transmit receive coil is essential to maximize the SNR. Many choices are available for wrist MRI. Curved or flat surface coils can be used alone or paired in a Helmholtz configuration. "Microscopy" surface coils ?5 cm in diameter can provide exquisitely detailed images of individual structures like the TFCC but have a limited FOV that does not allow imaging of the entire wrist and, thus, are not universally available or used. Whole-volume (those designed to completely surround a limb), transmit-receive, and receive-only coils for wrist imaging have been designed in saddle, birdcage, solenoid, quadrature, phased-array and other flexible configurations. Larger coils such as those used for extremity (knee) imaging will typically produce lower SNR but may be useful when a larger aperture is required. Examples include imaging both wrists simultaneously in a patient with rheumatoid arthritis or suspected distal radioulnar joint (DRUJ) subluxation or examining a fractured wrist in a splint or cast. When using a larger coil for unilateral wrist MRI, a small extremity setting should be selected if it is available.

The choice of MRI unit and coils often dictates positioning of the patient and extremity. For whole body units, most whole-volume coils (those designed to surround a limb) can be placed next to the patient, who is in supine position with the affected arm at the side. Although this position is comfortable, the magnetic field homogeneity at the periphery of the magnet is less than at the center and may result in lower SNR or difficulty achieving homogeneous, chemically selective fat saturation. Patients can be rolled partly onto their sides to place the wrist more centrally. To achieve improved homogeneity of fat suppression, the patient can be placed prone or semiprone with the affected wrist placed overhead in the isocenter of the magnet (so-called superman position). Although some claustrophobic patients may be more relaxed lying face down, other patients may not tolerate the overhead position as it may produce upper extremity discomfort. Placing a soft pad under the chest similar to breast coil positioning may help achieve superman positioning without added discomfort. One must also be aware that magic angle artifacts will occur if the wrist is angled significantly in the magnet. When evaluating for radioulnar instability, it may be appropriate to image the patient with the wrist in full supination and then in full pronation in the axial plane with or without neutral position MRI. Imaging with the wrist in ulnar and/or radial deviation may be beneficial for evaluating intrinsic ligaments. Kinematic MRI can be performed with fast gradient echo or steady-state imaging sequences for evaluation of dynamic or predynamic instability, but it is not routinely used [12,13].

Wrist MRI typically includes images acquired in 3 orthogonal planes with positioning of coronal plane along the line joining the radial and ulnar styloid processes. The coronal plane depicts the wrist ligaments, TFCC, bones, and the radiocarpal, intercarpal, and carpometacarpal joints. Transverse images are used to evaluate the carpal tunnel and Guyon's canal, the flexor and extensor tendons and tendon sheaths, the intrinsic wrist ligaments, the neurovascular structures, the distal radioulnar joint, and suspected masses. Sagittal images contribute to the assessment of masses, including ganglia; the tendons; the TFCC; and the articulations and alignment of the bones. Fracture assessment often requires evaluation of the sagittal and coronal images together. 3-D fast spin echo sequences now available on many platforms can be acquired as a single volume and used to generate thin-section intermediate or long echo time (TE) images in multiple planes with isotropic voxels to supplement or replace separate acquisitions in individual planes. 3-D sequences with MR arthrography have also been reported to better demonstrate ligament and TFCC injuries than the standard 2-D MRI.

A FOV of 10 to 12 cm is typically preferred for assessment of intra-articular derangements, although larger FOVs may be appropriate for indications such as fractures, and smaller FOVs may be required when imaging pediatric patients. Using a rectangular FOV can save imaging time without sacrificing in-plane resolution. For 2-D pulse sequences, slice thickness should be 3 mm or less to minimize partial-volume effect for

evaluating intraarticular pathology. Thicker slices may be appropriate for other indications. The interslice gap should be as small as possible to decrease signal loss due to interslice cross-talk but should not impair complete visualization of the intra-articular structures.

The imaging matrix should balance intravoxel SNR with desired in-plane spatial resolution and reduction of truncation artifacts but should be at least 192 steps in the phase direction and 256 steps in the frequency direction for 2-D imaging (in-plane resolution less than 0.6mm is preferred) [14-18]. In certain situations, it may be appropriate to use a reduced imaging matrix such as 256 × 160 to improve temporal resolution and reduce motion artifacts, such as for multiphase, IV contrast-enhanced imaging or for kinematic imaging of joint motion. Use of higher imaging matrices increases spatial resolution at the expense of imaging time or lower SNR. High resolution 3-D fast (turbo) spin-echo (FSE) or gradient echo (GRE) sequence with sub–1 mm voxel size can be beneficial by reducing partial volume averaging and allowing for multiplanar reconstructions in arbitrary planes. Specialized 3-D sequences such as reversed imaging in free precession (PSIF) or dual echo in steady state (DESS) with or without diffusion imaging can be beneficial for peripheral nerve assessment and included as a part of MR Neurography protocols. Quantitative 3-D sequences can also provide additional information for evaluating degenerative, posttraumatic, and inflammatory processes [19,20].

A wide variety of pulse sequences—conventional spin-echo, FSE, STIR, Dixon, and gradient-recalled echo—are available for wrist MRI. The repetition time (TR), echo time (TE), and flip angle chosen will depend on the field strength of the magnet and the desired relative contrast weighting. The choice of sequences may be optimized to address specific clinical questions and may vary according to local preferences. T1-weighted imaging is useful for evaluation of bone and bone marrow abnormalities such as fractures, avascular necrosis, osteomyelitis, and marrow-replacing lesions, whereas fluid-sensitive imaging is useful for evaluation of soft tissue pathology such as ligament, tendon, and nerve abnormalities. For most indications, the preferred protocol should include at least 1 coronal non-fat-saturated T1-weighted sequence, 1 coronal fluid sensitive fat-saturated sequence, 1 axial fluid sensitive fat-saturated sequence, and 1 sagittal sequence. Alternatively, a T2-weighted Dixon sequence can also be used to obtain in-phase, out-of-phase, water-suppressed, and fat-suppressed images in a single acquisition, yielding fluid-sensitive images as well as providing marrow-specific information.

For nonarthrographic studies, fluid-sensitive (T2-weighted, T2*-weighted [gradient echo], fat-suppressed intermediate-weighted [long-TR, TE 30-60 ms], Dixon, or STIR) or proton density-weighted (long-TR, short-TE) sequences are used for evaluating the wrist ligaments, TFCC, and articular cartilage. Evaluation of joint effusions, synovitis, tenosynovitis, ganglion cysts, and tendons also relies on fluid-sensitive sequences. Fat-suppressed T2-weighted, T2-weighted Dixon water, or STIR images are most sensitive for detecting bone marrow edema and edema-like changes, although T1-weighted images are important for characterizing marrow lesions such as osteomyelitis or tumors. With gradient-recalled echo-based pulse sequences, lower flip angles and higher TEs will generate T2*-weighted images, and larger flip angles and RF spoiling make the images relatively more T1-weighted. Fat-suppressed 3-D spoiled gradient-recalled echo imaging and Dixon technique [21] have been shown to be useful for the evaluation of any growth disturbance or associated abnormality that may follow physeal injury. T1-weighted images, especially using fat suppression, following IV gadolinium-based contrast administration are useful for characterizing synovial processes, infection, and vascularity of tumors and other lesions.

Gadolinium-enhanced MR arthrography may improve diagnostic performance for TFCC, ligament, and articular cartilage abnormalities in the wrist. A dilute contrast mixture can be injected directly into the radiocarpal joint (direct MR arthrography). Alternatively, the radiocarpal, midcarpal, and distal radioulnar joints can all be enhanced directly by 3-compartment injection. If direct MR arthrography is unavailable, joint enhancement can be accomplished indirectly by IV contrast injection followed by a short delay or wrist exercise (indirect MR arthrography). Spin-echo or gradient-recalled echo T1-weighted images with fat suppression are used for MR arthrography. At least 1 fluid sensitive sequence and 1 T1-weighted sequence without fat suppression, preferably in the coronal plane, are still necessary when performing MR arthrography to detect abnormalities that do not communicate with the joint, and for characterizing bone

marrow and soft-tissue lesions. Direct MR arthrography with contrast injection of the radiocarpal joint is an invasive procedure and should be performed after consideration of anticipated benefits and risks. 3T nonarthrographic imaging is increasingly being used in lieu of MR arthrography, with relatively high accuracy comparable to arthrography for evaluation of intra-articular pathology [22]. The addition of traction techniques to wrist MR arthrography has been reported to enhance the detection of ligament, TFCC, and cartilage injuries, but these techniques are not routinely used in most practices.

IV gadolinium chelate contrast-enhanced MRI (CE-MRI) with T1-weighted pulse sequences can be used for specific conditions of the wrist, in addition to indirect MR arthrography and contrast-enhanced MR angiography. CE-MRI has a role for tumor characterization, and MR angiography has a role for evaluating vascular anomalies (see the ACR-SPR–SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging (MRI) of Bone and Soft Tissue Tumors [2]). CE-MRI has been shown to be effective in assessing the viability of scaphoid fragments in nonunion with time-resolved postcontrast images obtained to assess arterial enhancement and standard delayed enhancement [23-32]. CE-MRI can help differentiate rheumatoid from psoriatic arthritis [33-36] using compartment and pattern analysis of synovitis and may predict progression of unclassified arthritis to rheumatoid arthritis [37]. CE-MRI has been used as a surrogate marker for synovitis in rheumatoid arthritis, providing a more accurate assessment of disease activity than noncontrast-enhanced MRI [38-41] as well as a marker for treatment monitoring [42-45]. CE-MRI adds sensitivity for detecting tenosynovitis in inflammatory arthritis patients, which can be an early marker of disease [46,47]. Differentiation of a ganglion cyst from synovitis is aided by CE-MRI [48].

Various techniques can minimize artifacts that reduce image quality. Magic angle artifacts can be avoided by aligning collagen-containing structures, such as tendons with the main magnetic field, as opposed to alignment in oblique plane to the main magnetic field. These artifacts are reduced above 55-degree angulation to the main magnetic field and on higher TE sequences. Aliasing is reduced or eliminated by reorienting the extremity or phase-encoding direction or by the use of phase oversampling and reducing the echo spacing. Gentle immobilization combined with patient comfort measures best controls involuntary motion. Presaturation pulses or gradient moment nulling will reduce ghosting artifacts from flowing blood and other periodic motion. Radial k-space sampling is another imaging strategy to reduce motion and pulsation artifacts. Motion artifacts can also be reduced by using faster image methods, such as parallel imaging, that reduce overall scan time per imaging sequence. Although parallel imaging does result in a decrease of SNR, this can be overcome by limiting the acceleration factors and through the use of high-field MRI (3T). Newer parallel imaging acceleration techniques such as grouped k-space sampling with offsets applied to phase encoding gradients [49,50], as well as compressed sensing and machine-learning acceleration techniques, can allow for greater acceleration factors without reducing SNR [51-53] and are available clinically for specific applications, such as 2-D and 3-D FSE sequences and metal hardware imaging [54].

Ferromagnetic materials such as orthopedic hardware cause susceptibility artifacts. Strategies to decrease metal artifacts include avoiding gradient-recalled echo sequences, reducing voxel size, increasing bandwidth during slice selection or readout, reducing echo spacing, aligning the frequency encoding gradient along the metal length, and employing view angle tilting (VAT) [55]. Advanced metal artifact reducing techniques such as slice encoding metal artifact correction (SEMAC) and multi-acquisition variable-resonance image combination (MAVRIC) can significantly further reduce metal artifact by reducing both in-plane and through-plane distortion but at the cost of SNR and longer acquisition times [55]. Longer scan times can be mitigated by the use of acceleration techniques such as compressed sensing, parallel imaging, and partial Fourier transformation. As susceptibility artifacts tend to be greater on a high field strength magnet, patients with known metal implants should be scheduled on a lower field strength (1.5T or lower) scanner when possible [56]. STIR sequences are the preferred method of fat saturation around metal, and spectral fat saturation methods should be avoided. Although less robust than STIR sequences, Dixon techniques can also be used for fat-suppression around metal especially in the setting of postcontrast T1-weighted imaging [57]. Subtraction of nonfat suppressed precontrast and postcontrast images can also be helpful to highlight enhancement when fat suppression techniques are likely to fail, such as in patients with metallic hardware [58].

It is the responsibility of the supervising physician to determine whether additional pulse sequences and imaging techniques confer added benefit for the diagnosis and management of the patient. Examinations that use techniques not approved for marketing by the Food and Drug Administration, such as direct MR arthrography with the intra- articular injection of gadolinium chelates (off-label use), can be considered when they are deemed medically appropriate to improve patient care.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [59].

At a minimum, the report should address the condition of the major wrist ligaments, TFCC, tendons, and bones. In selected cases, a description of findings in the bone marrow, synovium, joints, articular cartilage, retinacula, intrinsic muscles, carpal tunnel, Guyon's canal, neurovascular structures, and subcutaneous tissue would be appropriate. The report should use standard anatomic nomenclature, precise terms, and anatomic localization for describing identified abnormalities whenever possible.

VI. EQUIPMENT SPECIFICATIONS

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 RF power deposition (specific absorption rate), and maximum acoustic noise levels.

Equipment monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance Imaging (MRI) Equipment [60].

VII. RADIATION SAFETY IN IMAGING

Specific policies and procedures related to MRI safety should be in place along 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 the MRI examination of the patient as well as to others in the immediate area. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination.

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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