

ACR-SPR-SSR PRACTICE PARAMETER FOR THE PERFORMANCE AND INTERPRETATION OF MAGNETIC RESONANCE IMAGING (MRI) OF THE FINGERS AND TOES

Revised 2023 (Resolution 14)

The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

PREAMBLE

The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

I. INTRODUCTION

This practice parameter was developed and written collaboratively by the American College of Radiology (ACR), the Society of Pediatric Radiology (SPR), and the Society of Skeletal Radiology (SSR). It addresses magnetic resonance imaging (MRI) performed to evaluate musculoskeletal disorders and to investigate symptoms that are believed to originate in the musculoskeletal system. Practice parameters for wrist and ankle/hindfoot MRI are not discussed herein. See the [ACR-SABI-SPR-SSR Practice Parameter for the Performance of Magnetic Resonance Imaging \(MRI\) of the Wrist](#) and the [ACR-SPR-SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging \(MRI\) of the Ankle and Hindfoot](#) [1,2].

MRI is a proven, established imaging modality for the detection, evaluation, staging, and follow up of musculoskeletal conditions of the fingers and toes in adults and children. Properly performed and interpreted, MRI not only contributes to diagnosis but also serves as an important guide to treatment planning and prognostication [3-9]. However, MRI should be performed only for a valid medical reason and only after careful consideration of alternative imaging modalities. The strengths of MRI and other modalities should be weighed against their suitability in particular patients and in particular clinical conditions.

Radiographs should be the initial imaging study for suspected abnormalities of the fingers and toes, such as fractures, dislocations, and the presence of radio-opaque foreign bodies [10]. Sequential images are a key component in the postoperative evaluation of joint arthroplasty and other orthopedic procedures. Bone scintigraphy and PET/CT are used to screen the entire skeleton for conditions such as metastases and can detect

radiographically occult fractures and osteonecrosis, infection, and stress changes associated with tendon insertions [11-13]. Ultrasound can be used for detecting and evaluating tendon or ligament tears, tenosynovitis, inflammatory arthritis/erosions, soft-tissue foreign bodies, and soft-tissue masses or fluid collections [14-24]. Ultrasound can also be used to guide percutaneous procedures. Conventional arthrography usually performed in conjunction with MRI can be used to evaluate joint capsular abnormalities, such as ligament tears or volar/plantar plate tears, in select cases [25-27], but it has been largely replaced by MRI and ultrasound for this purpose.

Computed tomography (CT) is often preferred to MRI for detailed evaluation of bony alignment and cortical pathology. CT systems can employ software that increase the utility of CT for orthopedic purposes. The software includes multiplanar 2-D reformatting and 3-D volume rendering. Typical applications include evaluation of the joints after fracture dislocations [28], preoperative planning for osteotomies [29], and evaluation of bone or soft-tissue tumors [30,31]. CT can detect radiographically occult fractures and stress fractures of the hallux sesamoid bones [32]. CT can detect erosions in patients with arthritis, and dual-energy CT may be used in the diagnosis and management of gout [33,34].

Although MRI is often the most sensitive, noninvasive diagnostic test for detecting anatomic abnormalities of the fingers and toes, its findings may be misleading if not closely correlated with the clinical history, physical examination, physiologic tests, and other imaging studies. Adherence to the following parameters will enhance the probability of detecting such abnormalities.

II. INDICATIONS

- A. Primary indications for MRI of the fingers or toes include, but are not limited to, screening, diagnosis, exclusion, grading, and/or prognostication of suspected:
1. Tendon tears, including flexor/extensor tendons and adductor/abductor tendons of the thumb and great toe [24,35-42]
 2. Plantar plate injuries of the toes [43-47]
 3. Ligament tears, traumatic and/or degenerative, including gamekeeper's thumb [5,6,26], Stener lesion of the thumb [78-82]
 4. Annular pulley injuries of the fingers [48-54][1].
 5. Sagittal band and extensor hood injuries of the fingers [55,56].
 6. Subungual tumors, including glomus tumors [15,57-64]²
 7. Congenital anomalies [65,66]
 8. Osteomyelitis, septic arthritis, and soft-tissue infection [67-75]
- B. MRI of the fingers or toes may be indicated to further clarify and stage conditions diagnosed clinically and/or suggested by other imaging modalities, including, but not limited to:
- Inflammatory arthritis, tenosynovitis, or enthesitis, including rheumatoid arthritis, juvenile idiopathic arthritis, seronegative arthritis, and connective tissue disease [16,18,76-89]
1. Radiographically occult traumatic or stress/insufficiency fractures [32,35,87,90-97]
 2. Morton's neuroma [19,95,98-103]²
 3. Primary and secondary bone and soft-tissue tumors [7,15,20,104-108]² (See also the [ACR-SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging \(MRI\) of Bone and Soft Tissue Tumors](#) [109])
 4. Joint dislocations [110,111]
- C. MRI of the fingers or toes may be useful to evaluate specific clinical scenarios, including, but not limited to:
1. Prolonged, refractory, or unexplained pain or disability [112]
 2. Overuse syndromes [113]
 3. Sesamoiditis [32,95,96,114-119]
 4. Freiberg infraction [92,120]
 5. Bone and/or joint deformity with or without suspected soft-tissue abnormalities, acquired or congenital [65,121-125]
 6. Trigger finger [126,127]

7. Preoperative planning [112,128]
 8. Surveillance after surgery or postoperative complications [129-132]²
 9. Neuropathy [133,134]
 10. Nonneoplastic reactive/proliferative disorders, such as bizarre parosteal osteochondromatous proliferation (Nora lesion) and intravascular papillary endothelial hyperplasia [135]
 11. Disorders of unclear etiology such as microgeodic disease [136]
-

[1]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 \(MRI\)](#) [137].

IV. SAFETY GUIDELINES

See the [ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging \(MRI\)](#), the [ACR Manual on Contrast Media](#), and the [ACR Guidance Document on MR Safe Practices](#) [137-139].

Peer-reviewed literature pertaining to MR safety should be reviewed on a regular basis [140].

V. SPECIFICATIONS OF THE EXAMINATION

The supervising physician must 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 written or electronic request for MRI of the fingers or toes for musculoskeletal disorders 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 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.

V. 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](#) [141]).

Young patients or 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 moderate sedation is necessary, refer to the [ACR–SIR Practice Parameter for Minimal and/or Moderate Sedation/Analgesia](#) [142].

V. 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.

V. SPECIFICATIONS OF THE EXAMINATION

C. Examination Technique

Diagnostic-quality finger and toe MRI can be performed with low-, medium-, or high-field systems of either closed bore or open design. High-field magnets (1.5T and higher) have higher signal-to-noise ratios (SNRs) than lower-field systems, providing greater flexibility to obtain high-resolution images in a reasonable amount of time [40,143,144]. Specifically, 3T MRI systems offer higher SNRs and may offer improvements in assessment of joint erosions and small structures, such as joint cartilage, ligaments, and finger pulleys [42,51,79].

Unlike larger anatomic parts elsewhere in the body, high-resolution imaging of the small structures in the fingers and toes almost always requires the use of a local coil [6]. The coil should be as small as possible to provide a field of view (FOV) adequate to cover the area of interest. Multichannel coils can provide higher SNR. Coils with cylindrical housing into which the finger or toe can be placed, such as those designed for wrist or extremity imaging, are widely available and can provide extended FOV if necessary, such as for imaging the proximal extent of tendons, staging of tumors that may extend into the hand/wrist, or arthritis screening of the entire hand/wrist. Larger patients may require a knee/extremity coil as opposed to a wrist coil for adequate anatomic coverage of the toes. Specially designed small receiver coils can provide higher SNR with higher spatial resolution than larger coils but are not as widely available commercially [144,149].

For imaging of the fingers, the patient can be positioned supine or decubitus with the hand at the side of the patient. This is generally more comfortable for the patient than prone or semiprone positioning because it does not require shoulder abduction [6,150]. If coil design permits, the hand can also be placed overhead with the patient semiprone so that the fingers can be centered in the bore of the MRI unit to reduce field heterogeneity, which can be problematic with the hand at the periphery of the bore of the MRI unit. For certain clinical indications, such as inflammatory arthritis, simultaneous imaging of both hands in the "prayer position" can decrease examination time and facilitate assessment of disease symmetry [151,152]. Comfortable positioning and padding/splint immobilization of the fingers can minimize involuntary motion [6,150]. Fingers should generally be extended and aligned with the long axis of the fingers parallel to the main magnetic field of the MRI unit to minimize magic angle artifact. When imaging of an annular pulley injury, the finger of interest can be imaged at 35–40 degrees of flexion to depict bowstringing of the tendon as a secondary sign of pulley injury [48,153]. If the thumb is to be imaged along with the rest of the fingers, the thumb should be placed in adduction to prevent magic angle artifacts in the thumb tendons. If the thumb is of primary clinical interest, the hand should be positioned so that the thumb is aligned parallel to the main magnetic field in a slightly abducted position, which may necessitate slight wrist extension and placement of a towel roll or foam pad in the palm of the hand.

For imaging of the toes, coil choices will dictate patient positioning. A "chimney"-type extremity coil designed for imaging of the foot with the ankle in neutral position will require supine patient positioning. Other extremity coils and wrist coils may require ankle plantar flexion, which may be better maintained by prone patient positioning. This position may also reduce involuntary toe movement because it allows for better immobilization of the foot and may improve visualization of Morton neuromas [102]. Small surface coils may be used with the patient in either prone or supine position depending on patient comfort or the ability to effectively reduce patient motion. The toes should ideally be aligned parallel or perpendicular to the main magnetic field to minimize magic angle artifact. Saline bags or a silicone device [154] over the distal tips of the extremities can help reduce regional magnetic field inhomogeneity, allowing more uniform fat suppression [154].

Primary imaging planes for imaging of the fingers and toes depend on which structures are of clinical concern. The imaging planes for axial, coronal, and sagittal acquisitions need to be prescribed with respect to the fingers or toes rather than the hand or foot, respectively. If the thumb is of primary interest, it is important to describe the imaging planes along the planes of the thumb and not the fingers [42,155]. The collateral ligaments of the joints are best imaged along their course with axial or coronal images [156], whereas the course of the flexor and extensor tendons is best seen with sagittal images. The dorsal and volar/plantar joint capsule plates are also best seen with sagittal images [6,42,45]. The phalangeal physes and anomalous longitudinal epiphyseal brackets are best depicted on coronal images [65]. Joint alignment should be assessed on both sagittal and coronal images if a deformity is of clinical concern. The digital neurovascular bundles are best seen discretely on axial (short axis) images, as are the finger pulleys, the intersesamoidal ligaments, and intermetatarsal bursae. Axial images are used to evaluate rotational deformities, such as those secondary to fractures [29]. Oblique images aligned orthogonal to the phalanges may be helpful to view the various phalanges if there are deformities that prevent straightening of the digit during imaging [157]. Regardless of the anatomy of clinical interest, at least two orthogonal imaging planes should be used, one of which is axial. Many, if not most, cases will require a third orthogonal imaging plane.

As in all imaging procedures, the FOV should be tailored to the size of the patient and the structures being examined, with special care to minimize FOV in order to maximize spatial resolution. Typically, this should be 6-12 cm. Use of rectangular FOV for transverse and sagittal images will reduce scan time without sacrificing FOV by reducing the number of phase-encoding steps [158]. A larger FOV may be required if the source of pain originates from several different anatomic structures or abnormalities that extend proximally into the hand or foot. Examples of clinical scenarios that may require a larger FOV include tendon tears of indeterminate anatomic level, infection or tumors extending proximally, and inflammatory arthritis evaluation. Low-field MRI units may require a larger FOV to maintain adequate SNR at the expense of spatial resolution [159].

Slice thickness should be minimized as well to achieve small voxel volume and high spatial resolution, keeping SNR acceptably high. High-resolution imaging requires slice thickness of no more than 2 to 3 mm for sagittal and coronal images and 3 to 4 mm for transverse images. A 512×512 imaging matrix should be used as the SNR permits. High SNR systems such as 3T MRI units and specially designed local receiver coils may allow higher imaging resolutions, such as up to a $1,024 \times 1,024$ matrix. Increased imaging matrix size will generally increase scan time, which can lead to patient discomfort and involuntary motion. Parallel imaging, which is available on many MRI systems, allows faster image acquisition without a loss in image quality at the expense of occasional image reconstruction artifacts [160]. Parallel imaging can also mitigate undesired energy deposition on higher field MRI systems like 3T scanners [161]. An interslice gap can increase coverage and decrease signal loss due to crosstalk [162] but should be no more than 33% of the slice width and should not impair visualization of the intra-articular structures. Many modern MRI scanners exhibit minimal crosstalk, and a slice gap is not necessary in these cases.

A wide variety of pulse sequences is available to image the fingers and toes [42,163]. The choice of sequences, like other aspects of the imaging protocol, can be tailored to optimize the examination to answer specific clinical questions and may vary because of local preferences. Short repetition time/echo time (TR/TE) (T1-weighted) images are typically obtained using conventional spin-echo (SE) or fast (turbo) spin-echo (FSE) sequences. Long TR/long TE (T2-weighted), long TR/intermediate TE (intermediate-weighted), and short-tau inversion recovery (STIR) images are frequently obtained using FSE techniques for more rapid image acquisition than with SE techniques. Gradient-recalled sequences tend to produce larger artifacts and may result in lower soft-tissue

contrast [164,165] but may be advantageous at lower field strengths [159] and for selected applications such as demonstration of hemosiderin in tumors [107] or evaluation of articular or unossified cartilage [149]. Gradient-echo and modified FSE sequences can also be acquired as a 3-D volume, which can produce images of high SNR and spatial resolution that may provide better assessment of joint cartilage and allow oblique image reformations as well [149,164]. Three-dimensional imaging is also used for MR angiography [166].

An imaging protocol will be composed of one or more pulse sequence types. For each sequence, the exact TR, TE, inversion time (TI), and flip angle chosen will depend on the field strength of the magnet and the desired image contrast weighting. A typical minimal MRI examination of the fingers and toes might consist of coronal or sagittal SE or FSE T1-weighted and fat-suppressed FSE T2- or intermediate-weighted or STIR images, and transverse T1-weighted and T2- or intermediate-weighted sequences [42,163]. The T1-weighted images optimally show anatomic details such as fracture lines and marrow signal abnormalities suggestive of marrow replacement, such as osteomyelitis or neoplasm, whereas T2-weighted, fat-suppressed intermediate-weighted, or STIR images demonstrate fluid collections and edema within the soft tissue and bone marrow; the combination is an effective screen for a variety of pathologies. T1-weighted sequences also have a role in characterizing various stages of hemorrhage [167] and for showing enhancement when IV gadolinium-based contrast agents are used [168]. T1-weighted images with fat suppression—either 2-D spin-echo or FSE [52] or 3-D spoiled gradient-echo [169]—are also used when MR arthrography or MR angiography is performed with a gadolinium-based contrast agent. At least one T2-weighted or proton-density weighted sequence with fat saturation should also be performed with MR arthrograms to show abnormalities that do not communicate with the injected joint. Additionally, at least T1-weighted sequence without fat suppression is useful for evaluating bone marrow and characterizing soft-tissue lesions. Suppressing the signal from fat may enhance the diagnostic yield of some pulse sequences at the expense of some loss of SNR. Fat suppression can use spectral suppression of water protons, water excitation, a phase-dependent method such as the Dixon technique, or an STIR sequence [170-172]. The latter two methods may be necessary on low-field systems [173]. Fat suppression increases the conspicuity of marrow abnormalities and soft-tissue edema on fluid-sensitive sequences [174], and it is useful with a T1-weighted sequence when using gadolinium-based contrast agents [99]. Water excitation is an alternative to fat suppression and has been investigated for evaluating articular cartilage [175].

For specific finger and toe disorders, IV contrast may be useful. Contrast enhancement may increase the conspicuity of soft-tissue injuries such as pulley tears [52] or plantar plate tears [46]. IV contrast can also aid in the evaluation of disease activity in inflammatory arthritis and tenosynovitis [76,82]. IV contrast may be useful for characterizing tumors [7,15,105,107].

MR arthrography with injection of dilute gadolinium contrast into the joint (direct arthrography) may improve accuracy in the detection of thumb ulnar collateral ligament tears [26] and improve visualization of great toe structures [27].

Various techniques are used to reduce artifacts that can reduce imaging quality. When the FOV excludes parts of the hand or foot that are within the sensitivity range of the coil, aliasing artifacts can be reduced by phase oversampling, or by orienting the phase-encoding direction along the long axis of the finger or toe. Ensuring patient comfort combined with gentle immobilization or sedation when necessary best controls involuntary patient motion [180]. Presaturation pulses and/or gradient moment nulling will reduce ghosting artifacts caused by flowing blood [181,182].

Imaging near metallic implants requires special care to reduce susceptibility to artifacts. Swapping phase and frequency encoding directions based on the specific anatomic structures of interest adjacent to the hardware [183], orienting the long axis of the hardware as parallel to the direction of the main magnetic field [184], avoiding gradient-recalled sequences [165,185], and substituting STIR or Dixon techniques for chemical fat suppression [186] are important. FSE sequences with short interecho spacing, multiple refocusing pulses (long echo trains), and tailored RF pulses will further minimize metallic artifacts [187,188]. Metal artifact is further reduced by using a wide readout bandwidth and small pixel dimensions, which may require more signals averaged to maintain an adequate SNR and are better performed using MRI systems with wider available receiver bandwidths [165,187]. Artifacts from metal implants are less prominent on low-field systems compared with high-field systems [147]. View-angle tilting techniques and multispectral imaging (MAVRIC, SEMAC) may reduce artifact sizes as well [189-

192].

It is the responsibility of the supervising physician to determine whether additional or unconventional pulse sequences or imaging techniques would confer added benefit for the diagnosis and management of the patient. Examinations that use techniques not approved by the Food and Drug Administration—such as the intra-articular injection of gadolinium chelates (direct MR arthrography) [193] should be considered only when they are judged to be medically appropriate.

VI. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [194].

At a minimum, the report should address any abnormalities in the bone marrow and cortex, tendons, and joints. In selected cases, a description of findings in ligaments, articular cartilage, growth cartilage, physes, synovium, plantar or volar plates, sesamoid bones, tendon sheaths, annular pulleys, extensor hoods, neurovascular structures, bursae, and nail beds would be appropriate. Whenever possible, the report should use standard anatomic nomenclature and precise terms and anatomic localization for describing identified abnormalities.

VII. 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 radiofrequency 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](#) [195].

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 QC & 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>).

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 [136,188,189]. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination [190].

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Guidelines and Technical Standards* on the ACR website (<https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards>) by the Committee on Body Imaging (Musculoskeletal) of the ACR Commission on Body Imaging and the Committee on Practice Parameters—Pediatric Radiology of the ACR Commissions on Body Imaging and Pediatric Radiology in collaboration with the SPR and the SSR.

Writing Committee—members represent their societies in the initial and final revision of this practice parameter

ACR

SPR

SSR

Miriam A. Bredella, MD, Chair

Richard Jones, MD

Kambiz Motamedi, MD

Terry L. Levin, MD, FACR

Jie C. Nguyen, MD

Tetyana Gorbachova, MD

Alex Rosioreanu, MD

Jonathan Samet, MD

Daniel M. Walz, MD

Cody Young, DO

Committee on Body Imaging – Musculoskeletal

(ACR Committee responsible for sponsoring the draft through the process)

Naveen Subhas, MD, Chair

Soterios Gyftopoulos, MD

Miriam Bredella, MD

Douglas Mintz, MD

Connie Y. Chang, MD

Carlos A. Rivera, BSc

Hillary W. Garner, MD

Jonathan D. Samet, MD

Felix Gonzalez, MD

Jonelle Thomas, MD

Elaine S. Gould, MD, FACR

Fangbai Wu, MD

Committee on Practice Parameters – Pediatric Radiology

(ACR Committee responsible for sponsoring the draft through the process)

Terry L. Levin, MD, FACR, Chair

Jane Sun Kim, MD

John B. Amodio, MD, FACR

Jessica Kurian, MD

Tara M. Catanzano, MB, BCh

Helen R. Nadel, MD

Committee on Practice Parameters – Pediatric Radiology

Harris L. Cohen, MD, FACR

Erica Poletto, MD

Kassa Darge, MD, PhD

Richard B. Towbin, MD, FACR

Dorothy L. Gilbertson-Dahdal, MD

Andrew T. Trout, MD

Lauren P. Golding, MD

Esben S. Vogelius, MD

Adam Goldman-Yassen, MD

Jason Wright, MD

Safwan S. Halabi, MD

Andrew B. Rosenkrantz, MD, FACR, Chair, Commission on Body Imaging

Richard A. Barth, MD, FACR, Chair, Commission on Pediatric Radiology

David B. Larson, MD, MBA, FACR, Chair, Commission on Quality and Safety

Mary S. Newell, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee

Dan Gridley, MD, FACR -CSC Chair

Terry L. Levin, MD, FACR

Juan Battle, MD-CSC Co-Chair

Mary S. Newell, MD, FACR

Nicholas M Beckmann, MD

Jie C. Nguyen, MD

Miriam A. Bredella, MD

Sakura Noda, MD

Timothy A. Crummy, MD, MHA, FACR

Andrew B Rosenkrantz, MD

Tetyana Gorbachova, MD

Alex Rosioreanu, MD

Richard Jones, MD

Jonathan Samet, MD

Comments Reconciliation Committee

Vaibhav Khasgiwala, MD

Naveen Subhas, MD

Amy L. Kotsenas, MD, FACR

Daniel M. Walz, MD

David A. Larson, MD

Roland Wong, ScM

Paul A. Larson, MD, FACR

Cody Young, DO

Kambiz Motamedi, MD

REFERENCES

1. American College of Radiology. ACR–SPR–SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging (MRI) of the Ankle and Hindfoot. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-AnkleHindFoot.pdf>. Accessed February 3, 2022.
2. American College of Radiology. ACR–SABI–SPR–SSR practice parameter for the performance of magnetic resonance imaging (mri) of the wrist. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Wrist.pdf>. Accessed December 13, 2022.
3. Iyer RS, Thapa MM. MR imaging of the paediatric foot and ankle. *Pediatr Radiol* 2013;43 Suppl 1:S107-19.
4. Burge AJ, Gold SL, Potter HG. Imaging of sports-related midfoot and forefoot injuries. *Sports Health* 2012;4:518-34.
5. Nouh MR, Khalil AA. Forefoot: a basic integrated imaging perspective for radiologists. *Clin Imaging* 2014;38:397-409.
6. Datir A. MRI of the hand and fingers. *Top Magn Reson Imaging* 2015;24:109-23.
7. Melamud K, Drape JL, Hayashi D, Roemer FW, Zentner J, Guermazi A. Diagnostic imaging of benign and malignant osseous tumors of the fingers. *Radiographics* 2014;34:1954-67.
8. Gorbachova T. Midfoot and Forefoot Injuries. *Top Magn Reson Imaging* 2015;24:215-21.
9. Ma GM, Ecklund K. MR Imaging of the Pediatric Foot and Ankle: What Does Normal Look Like? *Magn Reson Imaging Clin N Am* 2017;25:27-43.
10. Tsai P, Beredjikian PK. Physical diagnosis and radiographic examination of the thumb. *Hand Clin* 2008;24:231-7, v.
11. Kawata S, Imaizumi M, Kako Y, Oku N. Clinical impact of "true whole-body" (18)F-FDG PET/CT: lesion frequency and added benefit in distal lower extremities. *Ann Nucl Med* 2014;28:322-8.
12. Kim JY, Choi YY, Kim YH, Park SB, Jeong MA. Role of (18)F-fluoride PET/CT over dual-phase bone scintigraphy in evaluation and management of lesions causing foot and ankle pain. *Ann Nucl Med* 2015;29:302-12.
13. Eutsler EP, Khanna G. Whole-body magnetic resonance imaging in children: technique and clinical applications. *Pediatr Radiol* 2016;46:858-72.
14. Wittoek R, Jans L, Lambrecht V, Carron P, Verstraete K, Verbruggen G. Reliability and construct validity of ultrasonography of soft tissue and destructive changes in erosive osteoarthritis of the interphalangeal finger joints: a comparison with MRI. *Ann Rheum Dis* 2011;70:278-83.
15. Baek HJ, Lee SJ, Cho KH, et al. Subungual tumors: clinicopathologic correlation with US and MR imaging findings. *Radiographics* 2010;30:1621-36.
16. Wakefield RJ, O'Connor PJ, Conaghan PG, et al. Finger tendon disease in untreated early rheumatoid arthritis: a comparison of ultrasound and magnetic resonance imaging. *Arthritis Rheum* 2007;57:1158-64.
17. Santiago FR, Plazas PG, Fernandez JM. Sonography findings in tears of the extensor pollicis longus tendon

- and correlation with CT, MRI and surgical findings. *Eur J Radiol* 2008;66:112-6.
18. Scheel AK, Hermann KG, Ohrndorf S, et al. Prospective 7 year follow up imaging study comparing radiography, ultrasonography, and magnetic resonance imaging in rheumatoid arthritis finger joints. *Ann Rheum Dis* 2006;65:595-600.
 19. Sharp RJ, Wade CM, Hennessy MS, Saxby TS. The role of MRI and ultrasound imaging in Morton's neuroma and the effect of size of lesion on symptoms. *J Bone Joint Surg Br* 2003;85:999-1005.
 20. Horcajadas AB, Lafuente JL, de la Cruz Burgos R, et al. Ultrasound and MR findings in tumor and tumor-like lesions of the fingers. *European radiology* 2003;13:672-85.
 21. Klauser A, Frauscher F, Bodner G, et al. Finger pulley injuries in extreme rock climbers: depiction with dynamic US. *Radiology* 2002;222:755-61.
 22. Swen WA, Jacobs JW, Hubach PC, Klasens JH, Algra PR, Bijlsma JW. Comparison of sonography and magnetic resonance imaging for the diagnosis of partial tears of finger extensor tendons in rheumatoid arthritis. *Rheumatology* 2000;39:55-62.
 23. Hergan K, Mittler C, Oser W. Pitfalls in sonography of the Gamekeeper's thumb. *European radiology* 1997;7:65-9.
 24. Donovan A, Rosenberg ZS, Bencardino JT, et al. Plantar tendons of the foot: MR imaging and US. *Radiographics* 2013;33:2065-85.
 25. Theumann NH, Pfirrmann CW, Drape JL, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers: part I. Conventional MR imaging and MR arthrographic findings in cadavers. *Radiology* 2002;222:437-45.
 26. Ahn JM, Sartoris DJ, Kang HS, et al. Gamekeeper thumb: comparison of MR arthrography with conventional arthrography and MR imaging in cadavers. *Radiology* 1998;206:737-44.
 27. Lepage-Saucier M, Linda DD, Chang EY, et al. MRI of the metatarsophalangeal joints: improved assessment with toe traction and MR arthrography. *AJR Am J Roentgenol* 2013;200:868-71.
 28. Faccioli N, Foti G, Barillari M, Atzei A, Mucelli RP. Finger fractures imaging: accuracy of cone-beam computed tomography and multislice computed tomography. *Skeletal Radiol* 2010;39:1087-95.
 29. Berthold LD, Peter A, Ishaque N, Mauermann F, Bohringer G, Klose KJ. Measurement of torsion angles of long finger bones using computed tomography. *Skeletal Radiol* 2001;30:579-83.
 30. Sunagawa T, Ikuta Y, Ishida O, Ishiburo M, Yasunaga Y, Ochi M. Arteriovenous malformation of the ring finger. Pre- and postoperative evaluation using three-dimensional computed tomography angiography. *J Comput Assist Tomogr* 2003;27:820-3.
 31. McConnell B, 3rd, Dell PC. Localization of an osteoid osteoma nidus in a finger by use of computed tomography: a case report. *J Hand Surg Am* 1984;9A:139-41.
 32. Umans HR. Imaging sports medicine injuries of the foot and toes. *Clin Sports Med* 2006;25:763-80.
 33. Desai MA, Peterson JJ, Garner HW, Kransdorf MJ. Clinical utility of dual-energy CT for evaluation of tophaceous gout. *Radiographics* 2011;31:1365-75; discussion 76-7.
 34. Fritz J, Henes JC, Fuld MK, Fishman EK, Horger MS. Dual-Energy Computed Tomography of the Knee, Ankle, and Foot: Noninvasive Diagnosis of Gout and Quantification of Monosodium Urate in Tendons and Ligaments. *Semin Musculoskelet Radiol* 2016;20:130-6.
 35. Peterson JJ, Bancroft LW. Injuries of the fingers and thumb in the athlete. *Clin Sports Med* 2006;25:527-42, vii-viii.
 36. Drape JL, Tardif-Chastenot de Gery S, Silbermann-Hoffman O, et al. Closed ruptures of the flexor digitorum tendons: MRI evaluation. *Skeletal Radiol* 1998;27:617-24.
 37. Kumar BA, Tolat AR, Threepuraneni G, Jones B. The role of magnetic resonance imaging in late presentation of isolated injuries of the flexor digitorum profundus tendon in the finger. *Journal of hand surgery* 2000;25:95-7.
 38. Ragheb D, Stanley A, Gentili A, Hughes T, Chung CB. MR imaging of the finger tendons: normal anatomy and commonly encountered pathology. *Eur J Radiol* 2005;56:296-306.
 39. Tabbal GN, Bastidas N, Sharma S. Closed mallet thumb injury: a review of the literature and case study of the use of magnetic resonance imaging in deciding treatment. *Plast Reconstr Surg* 2009;124:222-6.
 40. Tafur M, Iwasaki K, Statum S, Chung CB, Szeverenyi NM, Bydder GM. Magnetic resonance imaging of the pulleys of the flexor tendons of the toes at 11.7 T. *Skeletal Radiol* 2015;44:87-95.
 41. Linklater JM. Imaging of sports injuries in the foot. *AJR Am J Roentgenol* 2012;199:500-8.
 42. Gupta P, Lenchik L, Wuertzer SD, Pacholke DA. High-resolution 3-T MRI of the fingers: review of anatomy

- and common tendon and ligament injuries. *AJR Am J Roentgenol* 2015;204:W314-23.
43. Crain JM, Phancao JP. Imaging of Turf Toe. *Radiol Clin North Am* 2016;54:969-78.
 44. Umans RL, Umans BD, Umans H, Elsinger E. Predictive MRI correlates of lesser metatarsophalangeal joint plantar plate tear. *Skeletal Radiol* 2016;45:969-75.
 45. Nery C, Baumfeld D, Umans H, Yamada AF. MR Imaging of the Plantar Plate: Normal Anatomy, Turf Toe, and Other Injuries. *Magn Reson Imaging Clin N Am* 2017;25:127-44.
 46. Dinoa V, von Ranke F, Costa F, Marchiori E. Evaluation of lesser metatarsophalangeal joint plantar plate tears with contrast-enhanced and fat-suppressed MRI. *Skeletal Radiol* 2016;45:635-44.
 47. Perry MT, Pierce JL. Imaging of Turf Toe. *Clin Sports Med* 2021;40:755-64.
 48. Gabl M, Rangger C, Lutz M, Fink C, Rudisch A, Pechlaner S. Disruption of the finger flexor pulley system in elite rock climbers. *Am J Sports Med* 1998;26:651-5.
 49. Hauger O, Chung CB, Lektrakul N, et al. Pulley system in the fingers: normal anatomy and simulated lesions in cadavers at MR imaging, CT, and US with and without contrast material distention of the tendon sheath. *Radiology* 2000;217:201-12.
 50. Schoffl VR, Schoffl I. Injuries to the finger flexor pulley system in rock climbers: current concepts. *J Hand Surg Am* 2006;31:647-54.
 51. Guntern D, Goncalves-Matoso V, Gray A, Picht C, Schnyder P, Theumann N. Finger A2 pulley lesions in rock climbers: detection and characterization with magnetic resonance imaging at 3 Tesla--initial results. *Invest Radiol* 2007;42:435-41.
 52. Goncalves-Matoso V, Guntern D, Gray A, Schnyder P, Picht C, Theumann N. Optimal 3-T MRI for depiction of the finger A2 pulley: comparison between T1-weighted, fat-saturated T2-weighted and gadolinium-enhanced fat-saturated T1-weighted sequences. *Skeletal Radiol* 2008;37:307-12.
 53. Hoff MN, Greenberg TD. MRI sport-specific pulley imaging. *Skeletal Radiol* 2018;47:989-92.
 54. Schellhammer F, Vantorre A. Semi-dynamic MRI of climbing-associated injuries of the finger. *Skeletal Radiol* 2019;48:1435-37.
 55. Pfirrmann CW, Theumann NH, Botte MJ, Drape JL, Trudell DJ, Resnick D. MR imaging of the metacarpophalangeal joints of the fingers: part II. Detection of simulated injuries in cadavers. *Radiology* 2002;222:447-52.
 56. Kichouh M, Vanhoenacker F, Jager T, et al. Functional anatomy of the dorsal hood of the hand: correlation of ultrasound and MR findings with cadaveric dissection. *Eur Radiol* 2009;19:1849-56.
 57. Matloub HS, Muoneke VN, Prevel CD, Sanger JR, Yousif NJ. Glomus tumor imaging: use of MRI for localization of occult lesions. *J Hand Surg Am* 1992;17:472-5.
 58. Constantinesco A, Arbogast S, Foucher G, Vinee P, Choquet P, Brunot B. Detection of glomus tumor of the finger by dedicated MRI at 0.1 T. *Magn Reson Imaging* 1994;12:1131-4.
 59. Drape JL, Idy-Peretti I, Goettmann S, et al. Subungual glomus tumors: evaluation with MR imaging. *Radiology* 1995;195:507-15.
 60. Dalrymple NC, Hayes J, Bessinger VJ, Wolfe SW, Katz LD. MRI of multiple glomus tumors of the finger. *Skeletal Radiol* 1997;26:664-6.
 61. Boudghene FP, Gouny P, Tassart M, Callard P, Le Breton C, Vayssairat M. Subungual glomus tumor: combined use of MRI and three-dimensional contrast MR angiography. *J Magn Reson Imaging* 1998;8:1326-8.
 62. Kim DH. Glomus tumor of the finger tip and MRI appearance. *Iowa Orthop J* 1999;19:136-8.
 63. Theumann NH, Goettmann S, Le Viet D, et al. Recurrent glomus tumors of fingertips: MR imaging evaluation. *Radiology* 2002;223:143-51.
 64. Pérez-Palma L, Manzanares-Céspedes MC, de Veciana EG. Subungual Exostosis (Systematic Review and Meta-Analysis). *J Am Podiatr Med Assoc* 2018;108:320-33.
 65. Johnson JM, Higgins TJ, Lemos D. Appearance of the delta phalanx (longitudinally bracketed epiphysis) with MR imaging. *Pediatr Radiol* 2011;41:394-6.
 66. Lee J, Ahn JK, Choi SH, Koh EM, Cha HS. MRI findings in Kirner deformity: normal insertion of the flexor digitorum profundus tendon without soft-tissue enhancement. *Pediatr Radiol* 2010;40:1572-5.
 67. Marjelund S, Tikkakoski T, Isokangas M, Raisanen S. Magnetic resonance imaging and radiographic findings of seal finger. *Acta Radiol* 2006;47:1058-62.
 68. Sammak B, Abd El Bagi M, Al Shahed M, et al. Osteomyelitis: a review of currently used imaging techniques. *European radiology* 1999;9:894-900.

69. Ledermann HP, Morrison WB, Schweitzer ME. Is soft-tissue inflammation in pedal infection contained by fascial planes? MR analysis of compartmental involvement in 115 feet. *AJR Am J Roentgenol* 2002;178:605-12.
70. Ledermann HP, Morrison WB. Differential diagnosis of pedal osteomyelitis and diabetic neuroarthropathy: MR Imaging. *Semin Musculoskelet Radiol* 2005;9:272-83.
71. Kapoor A, Page S, Lavalley M, Gale DR, Felson DT. Magnetic resonance imaging for diagnosing foot osteomyelitis: a meta-analysis. *Arch Intern Med* 2007;167:125-32.
72. Schweitzer ME, Daffner RH, Weissman BN, et al. ACR Appropriateness Criteria on suspected osteomyelitis in patients with diabetes mellitus. *J Am Coll Radiol* 2008;5:881-6.
73. Donovan A, Schweitzer ME. Use of MR imaging in diagnosing diabetes-related pedal osteomyelitis. *Radiographics* 2010;30:723-36.
74. McCarthy E, Morrison WB, Zoga AC. MR Imaging of the Diabetic Foot. *Magn Reson Imaging Clin N Am* 2017;25:183-94.
75. Leone A, Cassar-Pullicino VN, Semprini A, Tonetti L, Magarelli N, Colosimo C. Neuropathic osteoarthropathy with and without superimposed osteomyelitis in patients with a diabetic foot. *Skeletal Radiol* 2016;45:735-54.
76. Klarlund M, Ostergaard M, Jensen KE, Madsen JL, Skjodt H, Lorenzen I. Magnetic resonance imaging, radiography, and scintigraphy of the finger joints: one year follow up of patients with early arthritis. The TIRA Group. *Ann Rheum Dis* 2000;59:521-8.
77. Conaghan P, Bird P, Ejbjerg B, et al. The EULAR-OMERACT rheumatoid arthritis MRI reference image atlas: the metacarpophalangeal joints. *Ann Rheum Dis* 2005;64 Suppl 1:i11-21.
78. Ghanem N, Uhl M, Pache G, Bley T, Walker UA, Langer M. MRI in psoriatic arthritis with hand and foot involvement. *Rheumatol Int* 2007;27:387-93.
79. Wieners G, Detert J, Streitparth F, et al. High-resolution MRI of the wrist and finger joints in patients with rheumatoid arthritis: comparison of 1.5 Tesla and 3.0 Tesla. *European radiology* 2007;17:2176-82.
80. Healy PJ, Groves C, Chandramohan M, Helliwell PS. MRI changes in psoriatic dactylitis--extent of pathology, relationship to tenderness and correlation with clinical indices. *Rheumatology* 2008;47:92-5.
81. Tan YM, Ostergaard M, Doyle A, et al. MRI bone oedema scores are higher in the arthritis mutilans form of psoriatic arthritis and correlate with high radiographic scores for joint damage. *Arthritis Res Ther* 2009;11:R2.
82. Eshed I, Feist E, Althoff CE, et al. Tenosynovitis of the flexor tendons of the hand detected by MRI: an early indicator of rheumatoid arthritis. *Rheumatology* 2009;48:887-91.
83. Tamai M, Kawakami A, Uetani M, et al. A prediction rule for disease outcome in patients with undifferentiated arthritis using magnetic resonance imaging of the wrists and finger joints and serologic autoantibodies. *Arthritis Rheum* 2009;61:772-8.
84. Ostergaard M, McQueen F, Wiell C, et al. The OMERACT psoriatic arthritis magnetic resonance imaging scoring system (PsAMRIS): definitions of key pathologies, suggested MRI sequences, and preliminary scoring system for PsA Hands. *J Rheumatol* 2009;36:1816-24.
85. Iwamoto N, Kawakami A, Tamai M, et al. Magnetic resonance imaging of wrist and finger joints distinguishes secondary Sjogren's syndrome with rheumatoid arthritis from primary Sjogren's syndrome with articular manifestations. *Clin Exp Rheumatol* 2011;29:1062-3.
86. Tan AL, Fukuba E, Halliday NA, Tanner SF, Emery P, McGonagle D. High-resolution MRI assessment of dactylitis in psoriatic arthritis shows flexor tendon pulley and sheath-related enthesitis. *Ann Rheum Dis* 2015;74:185-9.
87. Greaser MC. Foot and Ankle Stress Fractures in Athletes. *Orthop Clin North Am* 2016;47:809-22.
88. Dakkak YJ, Jansen FP, DeRuiter MC, Reijnierse M, van der Helm-van Mil AHM. Rheumatoid Arthritis and Tenosynovitis at the Metatarsophalangeal Joints: An Anatomic and MRI Study of the Forefoot Tendon Sheaths. *Radiology* 2020;295:146-54.
89. Royle LN, Muthee BW, Rosenbaum DG. Inflammatory conditions of the pediatric hand and non-inflammatory mimics. *Pediatr Radiol* 2022;52:104-21.
90. Biedert R. Which investigations are required in stress fracture of the great toe sesamoids? *Arch Orthop Trauma Surg* 1993;112:94-5.
91. Burton EM, Amaker BH. Stress fracture of the great toe sesamoid in a ballerina: MRI appearance. *Pediatr Radiol* 1994;24:37-8.

92. Ashman CJ, Klecker RJ, Yu JS. Forefoot pain involving the metatarsal region: differential diagnosis with MR imaging. *Radiographics* 2001;21:1425-40.
93. Biedert R, Hintermann B. Stress fractures of the medial great toe sesamoids in athletes. *Foot Ankle Int* 2003;24:137-41.
94. Mellado JM, Ramos A, Salvado E, Camins A, Danus M, Sauri A. Accessory ossicles and sesamoid bones of the ankle and foot: imaging findings, clinical significance and differential diagnosis. *European radiology* 2003;13 Suppl 6:L164-77.
95. Zanetti M, Weishaupt D. MR imaging of the forefoot: Morton neuroma and differential diagnoses. *Semin Musculoskelet Radiol* 2005;9:175-86.
96. Wall J, Feller JF. Imaging of stress fractures in runners. *Clin Sports Med* 2006;25:781-802.
97. Riley GM. Magnetic resonance imaging in the evaluation of sports injuries of the foot and ankle: a pictorial essay. *J Am Podiatr Med Assoc* 2007;97:59-67.
98. Erickson SJ, Canale PB, Carrera GF, et al. Interdigital (Morton) neuroma: high-resolution MR imaging with a solenoid coil. *Radiology* 1991;181:833-6.
99. Terk MR, Kwong PK, Suthar M, Horvath BC, Colletti PM. Morton neuroma: evaluation with MR imaging performed with contrast enhancement and fat suppression. *Radiology* 1993;189:239-41.
100. Zanetti M, Strehle JK, Zollinger H, Hodler J. Morton neuroma and fluid in the intermetatarsal bursae on MR images of 70 asymptomatic volunteers. *Radiology* 1997;203:516-20.
101. Zanetti M, Strehle JK, Kundert HP, Zollinger H, Hodler J. Morton neuroma: effect of MR imaging findings on diagnostic thinking and therapeutic decisions. *Radiology* 1999;213:583-8.
102. Weishaupt D, Treiber K, Kundert HP, et al. Morton neuroma: MR imaging in prone, supine, and upright weight-bearing body positions. *Radiology* 2003;226:849-56.
103. Espinosa N, Schmitt JW, Saupe N, et al. Morton neuroma: MR imaging after resection--postoperative MR and histologic findings in asymptomatic and symptomatic intermetatarsal spaces. *Radiology* 2010;255:850-6.
104. Torreggiani WC, Munk PL, Al-Ismael K, et al. MR imaging features of bizarre parosteal osteochondromatous proliferation of bone (Nora's lesion). *Eur J Radiol* 2001;40:224-31.
105. Narvaez JA, Martinez S, Dodd LG, Brigman BE. Acral myxoinflammatory fibroblastic sarcomas: MRI findings in four cases. *AJR Am J Roentgenol* 2007;188:1302-5.
106. Oca Pernas R, Prada Gonzalez R, Santos Armentia E, et al. Benign soft-tissue lesions of the fingers: radiopathological correlation and clinical considerations. *Skeletal Radiol* 2015;44:477-90.
107. Hochman MG, Wu JS. MR Imaging of Common Soft Tissue Masses in the Foot and Ankle. *Magn Reson Imaging Clin N Am* 2017;25:159-81.
108. Lee SK, Kim JY, Jeong HS. Benign peripheral nerve sheath tumor of digit versus major-nerve: Comparison of MRI findings. *PLoS One* 2020;15:e0230816.
109. American College of Radiology. ACR-SPR-SSR Practice Parameter for the Performance and Interpretation of Magnetic Resonance Imaging (MRI) of Bone and Soft Tissue Tumors. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-SoftTissue-Tumors.pdf>. Accessed February 3, 2022.
110. Mlsna J, Hanel DP, Kneeland B. Complex volar metacarpalphalangeal joint dislocation: pathologic anatomy as viewed by MRI. *Orthopedics* 1993;16:1350-2.
111. Nanno M, Sawaizumi T, Ito H. Irreducible palmar dislocation of the proximal interphalangeal joint of a finger evaluated by magnetic resonance imaging: a case report. *Hand Surg* 2004;9:253-6.
112. Theumann NH, Pessis E, Lecompte M, et al. MR imaging of the metacarpophalangeal joints of the fingers: evaluation of 38 patients with chronic joint disability. *Skeletal Radiol* 2005;34:210-6.
113. Anderson SE, Steinbach LS, De Monaco D, Bonel HM, Hurtienne Y, Voegelin E. "Baby wrist": MRI of an overuse syndrome in mothers. *AJR Am J Roentgenol* 2004;182:719-24.
114. Taylor JA, Sartoris DJ, Huang GS, Resnick DL. Painful conditions affecting the first metatarsal sesamoid bones. *Radiographics* 1993;13:817-30.
115. Karasick D, Schweitzer ME. Disorders of the hallux sesamoid complex: MR features. *Skeletal Radiol* 1998;27:411-8.
116. Kiter E. The fibrocartilage sesamoid. *European radiology* 2005;15:397-8; author reply 99.
117. Sanders TG, Rathur SK. Imaging of painful conditions of the hallucal sesamoid complex and plantar capsular structures of the first metatarsophalangeal joint. *Radiol Clin North Am* 2008;46:1079-92, vii.
118. Masson JA, Golimbu CN, Grossman JA. MR imaging of the metacarpophalangeal joints. *Magnetic resonance*

- imaging clinics of North America 1995;3:313-25.
119. Schein AJ, Skalski MR, Patel DB, et al. Turf toe and sesamoiditis: what the radiologist needs to know. *Clin Imaging* 2015;39:380-9.
 120. Torriani M, Thomas BJ, Bredella MA, Ouellette H. MRI of metatarsal head subchondral fractures in patients with forefoot pain. *AJR Am J Roentgenol* 2008;190:570-5.
 121. Azouz EM, Babyn PS, Mascia AT, Tuuha SE, Decarie JC. MRI of the abnormal pediatric hand and wrist with plain film correlation. *J Comput Assist Tomogr* 1998;22:252-61.
 122. Brune T, Schiborr M, Maintz D, Marquardt T, Frosch M, Harms E. Kirner's deformity of all fingers in a 5-year-old girl: soft-tissue enhancement with normal bones on contrast-enhanced MRI. *Pediatr Radiol* 2003;33:709-11.
 123. Lee J, Ahn JK, Choi SH, Koh EM, Cha HS. MRI findings in Kirner deformity: normal insertion of the flexor digitorum profundus tendon without soft-tissue enhancement. *Pediatr Radiol* 2010;40:1572-5.
 124. Sanders AP, Weijers RE, Snijders CJ, Schon LC. Three-dimensional reconstruction of magnetic resonance images of a displaced flexor hallucis longus tendon in hallux valgus. *J Am Podiatr Med Assoc* 2005;95:401-4.
 125. Wang YC, Jeng CM, Marcantonio DR, Resnick D. Macrodystrophia lipomatosa. MR imaging in three patients. *Clin Imaging* 1997;21:323-7.
 126. Smith RD, O'Leary ST, McCullough CJ. Trigger wrist and flexor tenosynovitis. *Journal of hand surgery* 1998;23:813-4.
 127. Chang EY, Chen KC, Chung CB. MR imaging findings of trigger thumb. *Skeletal Radiol* 2015;44:1201-7.
 128. Boyd N, Brock H, Meier A, Miller R, Mlady G, Firoozbakhsh K. Extensor hallucis capsularis: frequency and identification on MRI. *Foot Ankle Int* 2006;27:181-4.
 129. Drape JL, Silbermann-Hoffman O, Houvet P, et al. Complications of flexor tendon repair in the hand: MR imaging assessment. *Radiology* 1996;198:219-24.
 130. Salon A, Journeau P, Drape JL. Post-traumatic distal interphalangeal finger joint reconstruction using a free hemi-joint transfer from the fifth toe middle phalanx. *J Pediatr Orthop B* 2005;14:116-9.
 131. Beall DP, Ritchie ER, Campbell SE, et al. Magnetic resonance imaging appearance of the flexor carpi radialis tendon after harvest in ligamentous reconstruction tendon interposition arthroplasty. *Skeletal Radiol* 2006;35:144-8.
 132. Lohman M, Vasenius J, Nieminen O, Kivisaari L. MRI follow-up after free tendon graft reconstruction of the thumb ulnar collateral ligament. *Skeletal Radiol* 2010;39:1081-6.
 133. Deshmukh S, Carrino JA, Feinberg JH, Wolfe SW, Eagle S, Sneag DB. Pins and Needles From Fingers to Toes: High-Resolution MRI of Peripheral Sensory Mononeuropathies. *AJR Am J Roentgenol* 2017;208:W1-W10.
 134. Burge AJ, Gold SL, Kuong S, Potter HG. High-resolution magnetic resonance imaging of the lower extremity nerves. *Neuroimaging Clin N Am* 2014;24:151-70.
 135. Sung J, Kim JY, Yoo C. Intravascular papillary endothelial hyperplasia: magnetic resonance imaging of finger lesions. *Skeletal Radiol* 2016;45:235-42.
 136. Tetsunaga T, Endo H, Fujiwara K, Tetsunaga T, Ozaki T. Microgeodic Disease Affecting the Fingers and Toes in Childhood: A Case Report. *Open Orthop J* 2016;10:500-04.
 137. American College of Radiology. ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI). Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Perf-Interpret.pdf>. Accessed February 3, 2022.
 138. American College of Radiology. ACR Manual on MR Safety. Available at: <https://www.acr.org/-/media/ACR/Files/Radiology-Safety/MR-Safety/Manual-on-MR-Safety.pdf>. Accessed February 3, 2022.
 139. American College of Radiology. ACR Manual on Contrast Media. Available at: https://www.acr.org/-/media/ACR/Files/Clinical-Resources/Contrast_Media.pdf. Accessed February 3, 2022.
 140. Shellock FG. *Reference Manual for Magnetic Resonance Safety, Implants, and Devices*. 2012 ed. Los Angeles: Biomedical Research Publishing Company; 2012.
 141. American College of Radiology. ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IVCM.pdf>. Accessed February 3, 2022.
 142. American College of Radiology. ACR–SIR Practice Parameter for Sedation/Analgesia. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Sed-Analgesia.pdf>. Accessed February 3, 2022.
 143. Rutt BK, Lee DH. The impact of field strength on image quality in MRI. *J Magn Reson Imaging* 1996;6:57-62.

144. Kwok WE, You Z, Monu J, Seo G, Ritchlin C. High-resolution uniform MR imaging of finger joints using a dedicated RF coil at 3T. *J Magn Reson Imaging* 2010;31:240-7.
145. Ragnarsson JI, Ekelund L, Karrholm J, Hietala SO. Low field magnetic resonance imaging of femoral neck fractures. *Acta Radiol* 1989;30:247-52.
146. Sugimoto H, Hirose I, Miyaoka E, et al. Low-field-strength MR imaging of failed hip arthroplasty: association of femoral periprosthetic signal intensity with radiographic, surgical, and pathologic findings. *Radiology* 2003;229:718-23.
147. Farahani K, Sinha U, Sinha S, Chiu LC, Lufkin RB. Effect of field strength on susceptibility artifacts in magnetic resonance imaging. *Comput Med Imaging Graph* 1990;14:409-13.
148. Tukey TA, Aronen HJ, Karjalainen PT, Makela PJ. Low-field MRI pelvimetry. *European radiology* 1997;7:230-4.
149. Tan AL, Grainger AJ, Tanner SF, et al. High-resolution magnetic resonance imaging for the assessment of hand osteoarthritis. *Arthritis and rheumatism* 2005;52:2355-65.
150. Clavero JA, Alomar X, Monill JM, et al. MR imaging of ligament and tendon injuries of the fingers. *Radiographics* 2002;22:237-56.
151. Meier R, Thuermel K, Noel PB, et al. Synovitis in patients with early inflammatory arthritis monitored with quantitative analysis of dynamic contrast-enhanced optical imaging and MR imaging. *Radiology* 2014;270:176-85.
152. Rubin DA. MRI and ultrasound of the hands and wrists in rheumatoid arthritis. I. Imaging findings. *Skeletal Radiol* 2019;48:677-95.
153. Parellada JA, Balkissoon AR, Hayes CW, Conway WF. Bowstring injury of the flexor tendon pulley system: MR imaging. *AJR Am J Roentgenol* 1996;167:347-9.
154. Seo DK, Na S, Park JH, Choi KW, Lee HB, Han DK. Effectiveness of a silicone device for foot MRI in order to obtain homogeneous fat suppression images. *Acta Radiol* 2015;56:471-6.
155. Hirschmann A, Sutter R, Schweizer A, Pfirrmann CW. MRI of the thumb: anatomy and spectrum of findings in asymptomatic volunteers. *AJR Am J Roentgenol* 2014;202:819-27.
156. Theumann NH, Pfirrmann CW, Mohana Borges AV, Trudell DJ, Resnick D. Metatarsophalangeal joint of the great toe: normal MR, MR arthrographic, and MR bursographic findings in cadavers. *J Comput Assist Tomogr* 2002;26:829-38.
157. Rubin DA, Towers JD, Britton CA. MR imaging of the foot: utility of complex oblique imaging planes. *AJR Am J Roentgenol* 1996;166:1079-84.
158. Zhao L, Madore B, Panych LP. Reduced field-of-view MRI with two-dimensional spatially-selective RF excitation and UNFOLD. *Magnetic Resonance in Medicine* 2005;53:1118-25.
159. Ghazinoor S, Crues JV, 3rd, Crowley C. Low-field musculoskeletal MRI. *J Magn Reson Imaging* 2007;25:234-44.
160. Romaneehsen B, Oberholzer K, Muller LP, Kreitner KF. Rapid musculoskeletal magnetic resonance imaging using integrated parallel acquisition techniques (IPAT)--initial experiences. *Rofo* 2003;175:1193-7.
161. Ramnath RR. 3T MR imaging of the musculoskeletal system (Part I): considerations, coils, and challenges. *Magnetic resonance imaging clinics of North America* 2006;14:27-40.
162. Kneeland JB, Shimakawa A, Wehrli FW. Effect of intersection spacing on MR image contrast and study time. *Radiology* 1986;158:819-22.
163. Sofka CM. Technical Considerations: Best Practices for MR Imaging of the Foot and Ankle. *Magn Reson Imaging Clin N Am* 2017;25:1-10.
164. Rosenberg ZS, Beltran J, Bencardino JT. From the RSNA Refresher Courses. Radiological Society of North America. MR imaging of the ankle and foot. *Radiographics* 2000;20 Spec No:S153-79.
165. Petersilge CA, Lewin JS, Duerk JL, Yoo JU, Ghaneyem AJ. Optimizing imaging parameters for MR evaluation of the spine with titanium pedicle screws. *AJR Am J Roentgenol* 1996;166:1213-8.
166. Zhang W, Xu JR, Lu Q, Ye S, Liu XS. High-resolution magnetic resonance angiography of digital arteries in SSC patients on 3 Tesla: preliminary study. *Rheumatology* 2011;50:1712-9.
167. Bush CH. The magnetic resonance imaging of musculoskeletal hemorrhage. *Skeletal Radiol* 2000;29:1-9.
168. Wolf GL, Joseph PM, Goldstein EJ. Optimal pulsing sequences for MR contrast agents. *AJR Am J Roentgenol* 1986;147:367-71.
169. Allanore Y, Seror R, Chevrot A, Kahan A, Drape JL. Hand vascular involvement assessed by magnetic resonance angiography in systemic sclerosis. *Arthritis Rheum* 2007;56:2747-54.

170. Rybicki FJ, Chung T, Reid J, Jaramillo D, Mulkern RV, Ma J. Fast three-point dixon MR imaging using low-resolution images for phase correction: a comparison with chemical shift selective fat suppression for pediatric musculoskeletal imaging. *AJR Am J Roentgenol* 2001;177:1019-23.
171. Weinberger E, Shaw DW, White KS, et al. Nontraumatic pediatric musculoskeletal MR imaging: comparison of conventional and fast-spin-echo short inversion time inversion-recovery technique. *Radiology* 1995;194:721-6.
172. Hauger O, Dumont E, Chateil JF, Moinard M, Diard F. Water excitation as an alternative to fat saturation in MR imaging: preliminary results in musculoskeletal imaging. *Radiology* 2002;224:657-63.
173. Bredella MA, Losasso C, Moelleken SC, Huegli RW, Genant HK, Tirman PF. Three-point Dixon chemical-shift imaging for evaluating articular cartilage defects in the knee joint on a low-field-strength open magnet. *AJR Am J Roentgenol* 2001;177:1371-5.
174. Mirowitz SA. Fast scanning and fat-suppression MR imaging of musculoskeletal disorders. *AJR Am J Roentgenol* 1993;161:1147-57.
175. Graichen H, Springer V, Flaman T, et al. Validation of high-resolution water-excitation magnetic resonance imaging for quantitative assessment of thin cartilage layers. *Osteoarthritis Cartilage* 2000;8:106-14.
176. Miese FR, Ostendorf B, Wittsack HJ, et al. [Cartilage quality in finger joints: delayed Gd(DTPA)(2)-enhanced MRI of the cartilage (dGEMRIC) at 3T]. *Rofo* 2010;182:873-8.
177. Williams A, Shetty SK, Burstein D, Day CS, McKenzie C. Delayed gadolinium enhanced MRI of cartilage (dGEMRIC) of the first carpometacarpal (1CMC) joint: a feasibility study. *Osteoarthritis Cartilage* 2008;16:530-2.
178. Crema MD, Roemer FW, Marra MD, et al. Articular cartilage in the knee: current MR imaging techniques and applications in clinical practice and research. *Radiographics* 2011;31:37-61.
179. Lazovic-Stojkovic J, Mosher TJ, Smith HE, Yang QX, Dardzinski BJ, Smith MB. Interphalangeal joint cartilage: high-spatial-resolution in vivo MR T2 mapping--a feasibility study. *Radiology* 2004;233:292-6.
180. Rubin DA, Kneeland JB. MR imaging of the musculoskeletal system: technical considerations for enhancing image quality and diagnostic yield. *AJR Am J Roentgenol* 1994;163:1155-63.
181. Haacke EM, Lenz GW. Improving MR image quality in the presence of motion by using rephasing gradients. *AJR Am J Roentgenol* 1987;148:1251-8.
182. Peh WC, Chan JH. Artifacts in musculoskeletal magnetic resonance imaging: identification and correction. *Skeletal Radiol* 2001;30:179-91.
183. Madoff SD, Kaye J, Newman JS. Postoperative Foot and Ankle MR Imaging. *Magn Reson Imaging Clin N Am* 2017;25:195-209.
184. Lee MJ, Kim S, Lee SA, et al. Overcoming artifacts from metallic orthopedic implants at high-field-strength MR imaging and multi-detector CT. *Radiographics* 2007;27:791-803.
185. Czervionke LF, Daniels DL, Wehrli FW, et al. Magnetic susceptibility artifacts in gradient-recalled echo MR imaging. *AJNR Am J Neuroradiol* 1988;9:1149-55.
186. Stradiotti P, Curti A, Castellazzi G, Zerbi A. Metal-related artifacts in instrumented spine. Techniques for reducing artifacts in CT and MRI: state of the art. *Eur Spine J* 2009;18 Suppl 1:102-8.
187. Tormanen J, Tervonen O, Koivula A, Junila J, Suramo I. Image technique optimization in MR imaging of a titanium alloy joint prosthesis. *J Magn Reson Imaging* 1996;6:805-11.
188. Eustace S, Jara H, Goldberg R, et al. A comparison of conventional spin-echo and turbo spin-echo imaging of soft tissues adjacent to orthopedic hardware. *AJR Am J Roentgenol* 1998;170:455-8.
189. Ai T, Padua A, Goerner F, et al. SEMAC-VAT and MSVAT-SPACE sequence strategies for metal artifact reduction in 1.5T magnetic resonance imaging. *Investigative radiology* 2012;47:267-76.
190. Chang SD, Lee MJ, Munk PL, Janzen DL, MacKay A, Xiang QS. MRI of spinal hardware: comparison of conventional T1-weighted sequence with a new metal artifact reduction sequence. *Skeletal Radiol* 2001;30:213-8.
191. Olsen RV, Munk PL, Lee MJ, et al. Metal artifact reduction sequence: early clinical applications. *Radiographics* 2000;20:699-712.
192. Hargreaves BA, Worters PW, Pauly KB, Pauly JM, Koch KM, Gold GE. Metal-induced artifacts in MRI. *AJR Am J Roentgenol* 2011;197:547-55.
193. Schulte-Altendorneburg G, Gebhard M, Wohlgemuth WA, et al. MR arthrography: pharmacology, efficacy and safety in clinical trials. *Skeletal Radiol* 2003;32:1-12.
194. American College of Radiology. ACR Practice Parameter for Communication of Diagnostic Imaging Findings.

Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CommunicationDiag.pdf>.

Accessed February 3, 2022.

195. American College of Radiology. ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance Imaging (MRI) Equipment. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Equip.pdf>. Accessed February 3, 2022.

*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

Development Chronology for this Practice Parameter 2013 (Resolution 5)

Amended 2014 (Resolution 39)

Revised 2018 (Resolution 5)

Revised 2023 (Resolution 14)