ACR–ASNR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF MAGNETIC RESONANCE IMAGING (MRI) OF THE HEAD AND NECK

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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 collaboratively by the American College of Radiology (ACR), the American Society of Neuroradiology (ASNR), and the Society for Pediatric Radiology (SPR).

Magnetic resonance imaging (MRI) of the head and neck is a proven and useful tool for the diagnosis, evaluation, and follow-up of diseases of the head and neck.

The choice of MRI over ultrasound and computed tomography (CT) for assessing a head and neck lesion requires assessment of the appropriateness of MRI for each individual patient and of each particular clinical situation.

Benefits of MRI over ultrasound include assessment of bone marrow, detection of subtle soft-tissue contrast differences, and better assessment of tissue planes and anatomic detail in the deeper neck. Advantages of MRI over CT include absence of ionizing radiation, ability to image patients with an allergy to iodinated contrast, more accurate evaluation of intracranial extension of disease and perineural tumor spread, and improved discrimination of different soft tissues and tissue invasion. General disadvantages of MRI include scenarios that may require sedation, contraindications to magnetic field exposure (see section V below), artifacts from metallic objects in the head and neck, sensitivity to motion, and long scan times relative to CT.

CT may be a better option than MRI if there are patient limitations such as significant claustrophobia, altered mentation, or an underlying medical condition that makes lying flat for longer times difficult, such as congestive heart failure or a breathing disorder. CT may also be the procedure of choice for emergent clinical conditions, such as fulminant infection or rapid clinical decline, that require imaging studies and results to be provided within a short time [1]. With MRI, orthodontic and other dental hardware can significantly degrade image quality of the suprahyoid neck and CT may be better in these situations. For dental amalgam however MRI may be better than CT in evaluation of the suprahyoid neck. If detection of calcification or cortical bone erosion is important to answer a clinical question, CT scanning may be a better choice than MRI. In certain clinical scenarios, such as skull-base neoplasia, both MRI and CT may be required to address all clinical and management issues and provide the best lesion characterization.

In the pediatric population, the majority of neck masses are benign and are congenital/developmental, acquired inflammatory or of vascular origin. After detailed physical examination, imaging evaluation should usually begin with conventional and color Doppler ultrasound especially for superficial lesions because of its ease of use, absence of ionizing radiation, and noninvasive ability to depict structures. Ultrasound can help define the size and extent of a mass, confirm whether the mass is cystic or solid, and assess the vascularity to help guide further appropriate imaging if needed. Both CT and MRI can provide further imaging with multiplanar capabilities. If there are clinical concerns for deep space neck infection, contrast-enhanced CT neck is usually the preferred first line imaging modality as the sensitivity of ultrasound is poor in this setting and CT is more amenable to urgent evaluation than MR. MRI is more useful in evaluating soft tissues/muscles, salivary glands, vascular malformations, trans-spatial lesions, and congenital lesions, and is often preferred as the primary modality when evaluating potential malignancies . In addition, in the pediatric population, neck MRI can be considered when cross-sectional imaging of the neck is indicated but there are concerns about radiation exposure with CT [2]. Nevertheless, there are many clinical scenarios in which CT of the head and neck is appropriate in children, particularly when pediatric dose-reduction strategies are employed.

II. INDICATIONS AND CONTRAINDICATIONS

Indications for MRI of the head and neck include, but are not limited to, the following:

1. Tumor characterization
2. Assessing tumor extent and invasion into adjacent structures including perineural tumor spread
3. Deep neck infections
4. Congenital/developmental abnormalities (including vascular anomalies)
5. Neck trauma (as an adjunct to CT neck for suspected soft tissue)
6. Cranial neuropathies

7. Inflammatory processes

Contraindications to MRI have evolved over time. All patients must be screened for potential contraindications to MRI. Patients with implanted devices may require a physician to perform a risk-benefit analysis and may require modified scanning protocols to be compliant with best safety practices. For further information, see the ACR Manual on MR Safety [3].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [4].

IV. SPECIFICATIONS OF THE EXAMINATION

The supervising physician must have complete understanding of the indications, risks, and benefits of the examination as well as alternative imaging procedures. The physician must be familiar with the potential hazards associated with MRI, such as risks related to exposure to strong magnetic fields, as well as potential adverse reactions/events related to contrast media and sedation. The supervising physician should be familiar with relevant ancillary studies that the patient may have undergone and that may impact the interpretation of the MRI study. The physician performing the MRI interpretation must have a clear understanding and knowledge of the patient's clinical history, as well as the anatomy and pathophysiology relevant to the MRI examination [5].

The supervising physician must be familiar with the wide spectrum of MRI pulse sequences that can be used in head and neck imaging and their effects on the appearance of the images, including image artifacts. Standard imaging protocols should be established and may be optimized on a case-by-case basis as necessary. These protocols should be reviewed and updated periodically. The supervising physician should use pertinent clinical information and relevant ancillary imaging studies in order to select the appropriate imaging protocol for any given patient and clinical setting.

The written or electronic request for MRI of the head and neck 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 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)

IV. SPECIFICATIONS OF THE EXAMINATION

A. Patient Selection

The physician responsible for the examination should supervise patient selection and preparation (eg, appropriateness of indication and selection of protocol) and be available in person or by phone for consultation. Patients (or guardians when applicable) must be screened and interviewed prior to the examination to exclude individuals who may be at risk by exposure to the MR environment. Such screening may be performed by the MR technologist, a radiologist, or nurse, provided that they are familiar with the potential hazards of MRI and contrast media.

Certain indications require administration of intravenous (IV) contrast media. IV contrast administration 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 [6].)

Pediatric patients or patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Administration of moderate sedation and 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 [7].

IV. SPECIFICATIONS OF THE EXAMINATION

B. Facility Requirements

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

IV. SPECIFICATIONS OF THE EXAMINATION

C. Examination Technique

Because of the complexity of the anatomy from the skull base through the neck and the many available imaging choices, clear communication of the patient's symptoms and physical examination findings by the referring clinician to the supervising and interpreting radiologists is of critical importance in designing the best imaging procedure and protocol to address the patient's problem and to facilitate accurate interpretation.

The multiple technical options developed for MRI should be used when their individual strengths serve the clinical question to be answered. T1-weighted images (short repetition time [TR]/short echo time [TE]) remain best for delineating fine anatomic detail when the structure in question is surrounded by soft tissue or when fat-containing tissue is present [8]. The hyperintensity from abundant fat in the neck on these images facilitate lesion localization to specific neck spaces by assessing displacement patterns. For structures surrounded by cerebrospinal fluid, such as the cranial nerves in the cisterns and internal auditory canals, thin, 3-D heavily T2-weighted images provide excellent delineation of detail [9]. Fast spin-echo (FSE) T2-weighted imaging (long TR/long TE FSE) or equivalent sequences demonstrate greater detail in a shorter time than conventional T2-weighted imaging and are favored in the head and neck as physiologic and gross patient motion commonly degrade images [10,11]. As fat remains hyperintense on T2-weighted FSE images, and because of the amount of fat in the head and neck, using fat-suppression techniques such as frequency-selective fat saturation, chemical selective partial inversion recovery (SPIR), Dixon-type fat- suppression techniques, or short tau inversion recovery (STIR) produces images with better delineation of some pathologies such as edema [10,12,13]. Diffusion-weighted imaging can be included and may offer additional tissue characterization [14-16].

Many types of pathology in the head and neck exhibit enhancement following the administration of a gadolinium-based contrast agents, and their enhancement characteristics may help narrow the differential diagnosis. T1-weighted, contrast-enhanced images should, in most cases, be obtained with fat suppression to increase conspicuity of the enhancing lesion from intrinsically T1 hyperintense adjacent fat. Since fat suppression enhances and can be hindered by magnetic susceptibility artifacts, the presence of metallic material in the area of interest may obscure pathology [17]. In such cases, T1 weighting without fat suppression may offer better evaluation of the pathology. Similarly, fat suppression techniques may fail in portions of the neck because of local magnetic field inhomogeneity, and in these instances, T1-weighted imaging without fat suppression may be used as well. STIR based fat suppression should not be employed for acquisition of post contrast T1-weighted images due to the inadvertent suppression of enhancing soft tissues whose T1 recovery times can overlap with that of fat. Dixon-type fat-suppression techniques can generate both non-fat suppressed and fat suppressed images in the same acquisition and may be superior to other techniques such as spectral fat suppression [18,19].

For questions concerning vascular invasion or abnormal vessels, MR angiography and/or venography (MRA/MRV), either unenhanced or dynamic contrast-enhanced, may be useful [20]. Time-resolved MR angiography that tracks the contrast bolus in a temporal manner mimics the evaluation obtained with a catheter angiogram and can be useful for assessment of vascular tumor and vascular malformations.

The choice of imaging planes depends on the anatomy to be demonstrated. For most head and neck lesions, axial and coronal imaging suffice, although sagittal images may be useful for tongue-base, palate, nasopharynx, and airway lesions and are critical in central skull-base evaluation. Oblique imaging along anatomic structures in off-axis orientations, such as the temporo-mandibular joint [21,22] and the optic nerves [23], may better depict anatomic detail.

With advances in MRI coil design and phased array technology, head and neck imaging is usually performed with standard brain or head/neck/spine coils that produce the high-quality, thin-section images needed to display head and neck anatomy and pathology [24,25]. Surface coils are rarely required to provide the detail needed to detect pathology in the skull base and neck but may in some cases allow additional high-resolution detail [26]. The choice of a head or neck coil depends on the suspected extent of pathology [27] and the extent of coverage of the available coils. The number of averages, the field of view, matrix size, and interslice distance should be adjusted to provide ample signal-to-noise ratio and maximal detail with a pixel width of 1 mm or less, while considering the need for short scanning times to avoid motion degradation of the images.

Whenever possible, imaging should be performed prior to a biopsy to avoid misinterpretation due to distortions from altered morphology and/or signal intensities by an invasive procedure and surgical material, eg, hemorrhage, edema or hardware susceptibility [28,29].

IV. SPECIFICATIONS OF THE EXAMINATION

D. Specialized Techniques and Indications

MRI is the procedure of choice to identify intracranial or perineural spread from a head or neck primary tumor, particularly those arising in the nasopharynx, sinonasal cavity, or temporal bone. MRI is also helpful for characterizing the primary pathology in these locations, allowing one to narrow the differential diagnosis.

1. Orbits

   MRI is, in general, the technique of choice for orbital imaging because of the absence of ionizing radiation, the excellent contrast resolution of structures, and superior demonstration of associated intracranial pathology [30-32]. CT is preferred for evaluation of trauma; foreign bodies, especially those with unknown ferromagnetic properties [32]; lesions that might be calcified [8,33]; and localized infection. CT is no longer recommended for evaluation of retinoblastoma (RB); ultrasound and MRI are preferred [34,35].
   Head coils are usually adequate to study the orbits. Thin-section, fat-suppressed T2-weighted, or STIR coronal images should be obtained to visualize signal changes in the optic nerves [23,32,36]. Coronal and axial T1-weighted images, and T2-weighted scans with fat suppression in at least one plane, usually coronal, may be supplemented by sagittal (oblique) and axial oblique scans for detailed depiction of the optic nerves [23,27,31,37]. Contrast-enhanced T1-weighted images are useful for examining neoplastic, infectious, inflammatory, ischemic, vascular [31], demyelinating [33], and infiltrative [38] processes, as well as for evaluating the intracranial extent of a lesion [30,39]. The contrast-enhanced images require fat suppression in at least one plane because of the amount of intraorbital fat [8,27,31,33,37]. One enhanced plane without fat suppression might be useful if pathology is suspected in or adjacent to an area subject to susceptibility artifact, such as an air-filled sinus cavity or dental metal [40]. Imaging of orbital detail usually requires small field-of-view imaging and slice thickness of 3-mm or less [33] with pixels no larger than 1 mm. Thin slices with minimal or no interslice gaps are especially useful for studies of the globes and optic nerves [36,37].
   If the cranial nerves are involved, 3-D high-resolution heavily T2-weighted techniques are useful [41]; this can also be helpful in evaluation of ocular pathologies such as RB [42]. Additionally, if the brain or subarachnoid space is involved, dedicated imaging of the brain should be considered. Diffusion-weighted imaging of the orbits can helpful for the diagnosis of hypercellular tumors, such as orbital lymphoma, and ischemic lesions, such as posterior ischemic optic neuropathy.

2. Paranasal sinuses and nasal cavity

   CT is the imaging modality of choice for evaluation of inflammatory disorders of the paranasal sinuses and

nasal cavity, with MRI reserved for evaluating complications of inflammatory and neoplastic sinus disease [43-45], including orbital, skull base, perineural, and intracranial extension [29,32,46-48]. For all suspected neoplasms, and to distinguish tumors from mucosal thickening and secretions, contrast-enhanced MRI is the study of choice [29,39,49,50]. Perineural, intraorbital, and intracranial/meningeal extensions of tumor are best studied with MRI using a head coil and slice thickness of 3-mm or less with a narrow gap (1 mm or less) [29,51]. Unenhanced T1-weighted, fat-suppressed T2-weighted images, and fat-suppressed enhanced T1-weighted images in at least one plane (coronal or axial) [49,51] demonstrate excellent soft-tissue detail [52].

3. Suprahyoid neck

MRI is the procedure of choice for most nonemergent neoplastic pathology of the suprahyoid neck, which includes the skull base, nasopharynx, oral cavity, and oropharynx [1,21,28,53,54].
In the suprahyoid neck, infiltration of the medullary space in bone by soft-tissue lesions may be detected earlier by MRI than by CT [21,55-57]. However, subtle cortical erosion, especially without infiltration of the medullary cavity, and detail of small bones may be better demonstrated by CT [11,58-61].
Contrast-enhanced MRI best depicts intracranial extension of tumor from the neck and skull base, including perineural extension [29,62]. Sagittal and axial T1-weighted, axial fat-suppressed T2-weighted, and fat-suppressed enhanced T1-weighted sequences in the axial and/or coronal planes, with small FOVs, small interslice gaps, and high matrix imaging provide detailed images of the skull base and nasopharynx [11,53,62-65]. Non-contrast CT is superior to MR for detecting small sialoliths. MR is superior to CT for evaluating the extent of aggressive infections and neoplasms of the parotid and submandibular glands [66]. MR sialography can be a useful adjunct in the evaluation of parotid and submandibular duct pathology, utilizing a heavily T2-weighted 3-D image combined with obstruction of the duct with gauze [67].
Oral cavity masses are frequently best demonstrated by MRI because of its superior contrast resolution and reduced dental amalgam artifacts [68] relative to CT. Sagittal and/or coronal fat-suppressed T2-weighted scans are useful to demonstrate the tumor thickness of base-of-tongue lesions and in evaluation of the palate. For infections in adults, contrast-enhanced CT is preferred as it allows evaluation of the soft tissues as well as the detection of small calculi and subcutaneous air, as well as the ability to evaluate the integrity of the mandibular cortex [47]. MRI may be useful in selected cases for early detection of bone marrow involvement/osteomyelitis [68,69].
For imaging of the oropharynx and hypopharynx, instructing the patient to breathe quietly may improve image quality [64]. The use of saturation pulses is helpful to reduce vascular flow artifacts in the area.

4. Infrahyoid neck

Newer and faster imaging techniques resulting in motion artifact reduction have improved the quality of MRI in imaging the infrahyoid neck. CT remains more rapid than MRI; therefore, it is less sensitive to motion related to breathing and swallowing. CT scans have higher spatial resolution than MR scans, while MRI has superior soft-tissue contrast [15] compared to CT. Both CT and MRI offer multiplanar and volumetric capabilities in the era of multislice CT, challenging MRI's former advantage in producing images in multiple planes [70]. MRI provides better soft-tissue contrast and is more sensitive and specific than CT in defining laryngeal cartilage invasion as evidenced by cortical disruption and alteration of cartilage signal [28]; thin-section T1-weighted images, fat-suppressed T2-weighted FSE or STIR images, and postgadolinium T1-weighted images with fat suppression in the axial and/or coronal planes are typically used to assess the extent of lesions of the larynx and to attempt to distinguish reactive or inflammatory changes in laryngeal cartilage from tumor infiltration [71]. MRI is the study of choice for neoplasms of the infrahyoid neck, a notable exception being small, early-stage laryngeal tumors that may only be seen on very thin-section, high-resolution CT images. CT is also often the study of choice for infections involving the infrahyoid neck that have the potential to extend into the upper mediastinum. Pathology of the brachial plexus is optimally imaged with MRI, and CT plays a limited role in brachial plexus imaging. Though CT myelography has been useful in the evaluation of avulsion injuries of the brachial plexus, advances in high-resolution, heavily T2-weighted MR imaging sequences provide excellent delineation of traumatic injuries without requiring an invasive procedure [72]. In addition, high resolution T2-weighted imaging can also help identify sinus tracts associated with branchial apparatus anomalies, both in the infrahyoid and suprahyoid neck.
MRI of the infrahyoid neck requires the use of dedicated coils [68] not supported by the neck itself to avoid

motion artifacts [73]; these are typically anterior neck or neurovascular coils. A small FOV and large enough matrix to produce detailed images while maintaining short scanning times are additional requirements [74]. The neck should be slightly hyperextended, with the larynx parallel to the tabletop [73] and with the patient breathing quietly [75]. Inferior and superior saturation pulses may be a valuable addition to minimize vascular flow artifacts [76].

Nodal imaging can be accomplished with ultrasound, CT, PET/CT, MRI or PET/MRI. Imaging coverage should extend from the skull base to the aortic arch (or to the aortopulmonary window in cases of recurrent laryngeal nerve pathology). The MRI coil should be able to cover this area in its entirety [48,77]. For evaluation of cervical lymph nodes, T1-weighted, fat-suppressed T2-weighted FSE or STIR [78,79], and fat-suppressed, contrast-enhanced T1-weighted imaging are necessary [80]. Diffusion-weighted imaging can be considered as an adjunctive method.

5. Thyroid and parathyroid

In the evaluation of thyroid nodules, ultrasound (often accompanied by fine-needle aspiration [FNA]) is the primary imaging modality [81-83]. In those patients who meet the ultrasound guidelines for tissue sampling, ultrasound-guided FNA is performed to establish a diagnosis. If a differentiated thyroid carcinoma is detected, ultrasound is performed to assess the central and lateral necks in patients with clinically negative necks. If CT or MR imaging is indicated prior to definitive therapy, such as in the setting of palpable neck adenopathy to aid in planning neck dissection [77], in the setting of a fixed thyroid mass in which extracapsular spread of tumor into the surrounding neck structures is suspected, or in the case of initial evaluation of a mass in the thyroid area of uncertain etiology [81], then MRI with contrast is useful as it not only delineates the pathology but also avoids delays in radioiodine therapy that can result if iodinated contrast is used for a CT study. If radioiodine therapy is not a consideration, then CT scanning [77] may be used, reducing image degradation from breathing and vascular pulsation often seen with MRI.

In the setting of suspected recurrent thyroid cancer/rising thyroglobulin, ultrasound and nuclear medicine studies again play primary roles. In the setting of rising thyroglobulin in the treated neck with clinically and ultrasound N0 necks, CT or MRI may be useful to detect occult neck nodes [84], and coverage should include the retropharyngeal lymph nodes.

In the evaluation of the patient with hyperparathyroidism, neck ultrasound, and neck and/or whole-body scintigraphy play primary roles, but if a parathyroid adenoma or adenomas cannot be identified by these methods, then cross-section imaging is indicated. Multiphase CT has been shown to be useful in this setting, as has dynamic MRI [85-87].

For parathyroid-pathology in which CT or MRI is indicated, imaging should extend inferiorly to include the carina for complete demonstration of potentially involved areas [77,81].

6. Temporal bone

While CT and MRI play complementary roles in temporal bone evaluation, MRI is the primary imaging modality for evaluating the nonosseous components of the temporal bone region [46], including evaluation of suspected retrocochlear pathology [29] and cranial nerve dysfunction, most commonly sensorineural hearing loss [9,88,89]. CT is often the first line imaging modality for suspected otomastoiditis, although MRI is useful to determine if temporal bone pathology, such as infection or neoplasm, involves the intracranial compartment. CT is favored if a labyrinthine or cochlear bony lesion is suspected [90,91], although lesions such as cochlear schwannomas or labyrinthine hemorrhages are better detected by MRI. In the evaluation of subjective pulsatile tinnitus, either CT with CTA/CTV or MRI with MRA/MRV is a reasonable first-line study [9,92], while MRI and MRA/MRV followed by conventional catheter angiography may be more appropriate in the evaluation of objective pulsatile tinnitus (audible bruit). CT is also the modality of choice for evaluation of the middle ear ossicles.

MRI of the temporal bones requires a head coil and should include axial T1-weighted images, typically with and without contrast enhancement, and coronal T1-weighted enhanced scans. There is growing evidence to support noncontrast only protocols in certain clinical situations, including the evaluation of congenital hearing loss and in the screening of patients for sensorineural hearing loss [93]. Fat suppression in at least one enhanced plane is useful to eliminate confusion of fat with enhancement, especially in the area of the petrous apex [46]. A maximum section width of 3 mm with a minimal or no interslice gap and a small FOV are needed to produce images able to depict the fine detail required to detect pathology in this area.

Thin section, 3-D T2-weighted techniques are useful in temporal bone imaging to evaluate the relationship of a vestibular schwannoma or other pathology to the surrounding nerves [94], the patency of labyrinthine structures, the size of the endolymphatic sac, and the extent of cochlear dysplasia in cases of congenital or developmental hearing loss. In children, reformatted oblique sagittal images perpendicular to the long axis of the internal auditory canal are particularly helpful in identifying cranial nerve deficiencies [95,96].
Diffusion-weighted imaging (DWI) can help in differentiating inflammatory/infectious opacification of the middle ear and/or mastoid air cells from cholesteatoma and may be useful in the postoperative setting [97-99]. Ideally this should be nonecho planar DWI in both the axial or coronal planes in order to increase sensitivity for detection of cholesteatoma.
Heavily T2-weighted images, T2 FLAIR images and enhanced T1-weighted images of the brain may be included to assess for intracranial extension of temporal bone pathology and to exclude intracranial processes such as white matter diseases that might produce symptoms similar to those of temporal bone lesions [73].

7. Temporomandibular joints

MRI is the procedure of choice for most clinical presentations of temporomandibular joint (TMJ) pathology [100]. Scanning in an oblique plane perpendicular to the horizontal long axis of the mandibular condyle produces the least distorted images of the menisci in the sagittal plane [101]. Many authors recommend proton density and/or T2-weighted sagittal oblique imaging in open-mouth and closed-mouth positions [22,100,102,103]. The T2-weighted images are preferred to evaluate for joint effusions and capsular inflammation. Coronal oblique imaging with T1 or proton density weighting permits detection of medial and lateral displacements of the menisci [37,69]. Three mm or lower section thicknesses, 0- to 1-mm image gaps, and small FOVs are additional requirements to obtain adequately detailed images [22,100,103-105].
IV contrast is not indicated in most clinical scenarios. In pediatric inflammatory conditions of the TMJ, contrast is helpful in the assessment of synovial inflammation [106]. In addition, performing open- mouth imaging may not always be necessary in certain pediatric conditions such as juvenile idiopathic arthritis [107,108].
Further evaluation of the patient with TMJ dysfunction might include kinematic MRI procedures to obtain functional information, especially in cases of reduced range of motion, malocclusion, mandibular shift, and hypermobility. T1-weighted imaging is typically used, and scans are obtained as the mouth is incrementally opened using a passive positioning device [109-117].

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [118].

For suspected head and neck malignancy, the report should address the presence or absence of a mass, the size of the lesion and its composition, enhancement characteristics, and adenopathy. The anatomic location of a tumor, including its relationship to adjacent muscles, vessels, nerves, and bone, should also be addressed to assist the clinician in staging and planning management. For follow up MRI studies in a patient with a treated head and neck malignancy consider additionally using NI-RADS for guidance on appropriate management.

VI. SAFETY GUIDELINES

See the ACR Practice Parameter for Performing and Interpreting Magnetic Resonance Imaging (MRI) [4], the ACR Manual on Contrast Media [119], and the ACR Manual on MR Safety [3].

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

VII. EQUIPMENT SPECIFICATIONS

Equipment monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Magnetic Resonance (MR) Imaging Equipment [120].

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 magnetic field strength (dB/dt), maximum radiofrequency power deposition (specific absorption rate), and maximum acoustic noise levels.

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 Educ*ation 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 with documentation that is updated annually and compiled under the supervision and direction of the supervising MRI physician. Guidelines that deal with potential hazards associated with the MRI examination of the patient as well as to others in the immediate area should be provided. Screening forms must also be provided to detect those patients who may be at risk for adverse events associated with the MRI examination.

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 Practice Parameters – Neuroradiology of the ACR Commission on Neuroradiology and the Committee on Practice Parameters – Pediatric Radiology of the ACR Commission on Pediatric Radiology, in collaboration with the ASNR and the SPR.

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Development Chronology for this Practice Parameter 2002 (Resolution 7)

Revised 2023 (Resolution 7)

Revised 2007 (Resolution 6)

Revised 2012 (Resolution 19)

Amended 2014 (Resolution 39)

Revised 2018 (Resolution 16)
Revised 2023 (Resolution 7)