RESOLUTION NO. 19

BE IT RESOLVED,

that the American College of Radiology adopt the ACR–ASNR–SPR Practice Guideline for the Performance of Magnetic Resonance Imaging (MRI) of the Head and Neck

Sponsored By: ACR Council Steering Committee

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

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines 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 physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, 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 the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially

different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also 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 these guidelines 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 sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

This guideline was ~~developed~~ **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, ~~assessment of severity~~ and follow-up of diseases of the head and neck. Head and neck MRI should be performed only for a valid medical reason.

The choice of MRI **over ultrasound and computed tomography (CT) for assessing** a head ~~or~~ **and** neck lesion requires ~~an analysis of the strengths of MRI versus its~~ **assessment of MRI's** suitability for ~~the particular~~ each **individual** patient, and **of each** particular clinical situation. ~~For suspected lesions requiring a technique to detect subtle soft-tissue contrast, to provide a three-dimensional depiction of a lesion, and to image other than with ionizing radiation, or in a patient with an allergy to iodinated contrast and a need for contrast, MRI might be the procedure of choice provided that the patient does not have a contraindication to MRI (see section V below). Due to the time and patient positioning required for MR imaging, the patient must be able to fully cooperate for a prolonged period of time~~

Benefits of MRI over ultrasound include three-dimensional depiction of a lesion, assessment of bone marrow, detection of subtle soft tissue contrast, and assessment of deep tissue planes. Advantages of MRI over CT include lack of ionizing radiation, ability to image patients with iodinated contrast allergies, and improved soft tissue resolution. General disadvantages of MRI include certain scenarios that may require sedation, contraindications to magnetic field exposure (see section V below), artifacts from metallic objects in the head and neck, and long scan times relative to CT for emergent indications.

CT may be a better option ~~if any~~ ~~existing~~ than **MRI if there are** limitations such as ~~severe~~ **significant** claustrophobia, altered mentation, or an underlying medical condition such as congestive **heart** failure or a breathing disorder that makes lying flat difficult.

~~cannot be adequately addressed prior to the procedure~~ ~~Neck~~ **CT may also be the procedure of choice for evaluating neck** lesions associated with production of excessive secretions, or **emergent** clinical conditions, ~~that require a quick and procedure and answer~~ such as ~~a~~ fulminant infection **or rapid clinical decline, that require imaging studies and results to be provided within a very short time [1].** ~~may contraindicate MRI as an imaging choice. MR images may also not provide valuable information due to the location of internal metal, such as dental fillings or devices in the teeth adjacent to a potential floor of mouth lesion. In addition, if~~ **Orthodontic and other dental hardware can significantly degrade images of the oropharynx, nasopharynx, orbits, and sinonasal cavities. If** detection of ~~subtle bone erosion or~~ calcification **or bone erosion** is important to answer a clinical question, ~~then~~ CT scanning ~~becomes~~ **may be** a better ~~option~~ **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.**

In the pediatric population, the majorities of neck masses are benign and are congenital/developmental, acquired inflammatory or vascular origin. After detailed physical examination, imaging evaluation should usually begin with conventional and color Doppler ultrasound due to its ease, 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; however, MRI is more desirable in evaluating lesions involving soft tissues/muscles, salivary glands, vascular malformations, trans-spatial lesions, and congenital lesions like encephalocele. In addition, in the pediatric population, neck MRI can be considered when cross-sectional imaging of the neck is indicated, due to concerns about radiation exposure with CT [2].

II. SAFETY GUIDELINES AND POSSIBLE CONTRAINDICATONS

See the ACR Practice Guideline for Performing and Interpreting Magnetic Resonance Imaging (MRI)**, the ACR Manual on Contrast Media [3],** and the ACR Guidance Document for Safe MR Practices [4].

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

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Guideline for Performing and Interpreting Magnetic Resonance Imaging (MRI).

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 potential hazards associated with MRI, including 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)

~~The supervising physician must also understand the pulse sequences to be employed 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~~

A. Patient Selection

The physician responsible for the examination ~~shall~~ **should** supervise patient selection and preparation, and be available in person or by phone for consultation. Patients ~~shall~~ **must** be screened and interviewed prior to 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 Practice Guideline for the Use of Intravascular Contrast Media.)

Pediatric patients or patients suffering from anxiety or claustrophobia may require sedation or additional assistance. Administration of moderate sedation ~~or~~ **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 Guideline for Sedation/Analgesia.

B. Facility Requirements

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

C. Examination Technique

Due to the complexity of the anatomy from the skull base through the neck, and the many available imaging choices, ~~a detailed clinical examination of the patient, with~~ clear communication of the ~~results of the examination~~ **patient's symptoms and physical examination findings by the referring clinician** to the **supervising and interpreting** radiologist**s** is of critical importance in designing the best imaging procedure 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 [6]. For structures surrounded by cerebrospinal fluid, such as the cranial nerves in the cisterns and internal auditory canals, thin, 3D T2-weighted images provide excellent delineation of detail [7]. Fast-spin-echo (FSE) T2-weighted imaging (long TR/long TE FSE) demonstrates greater detail in a shorter time than conventional T2-weighted imaging and is favored in the head and neck as physiologic and gross patient motion commonly degrade images [8-9]. Because fat remains hyperintense on T2-weighted FSE images, and due to the amount of fat ~~about and between many~~ **in the** head and neck, ~~structures~~ using fat-suppression techniques such as chemical ~~shift~~ **selective partial inversion recovery (SPIR)** or **short tau inversion recovery (**STIR**)** produces images with better delineation of pathology [8]. **Diffusion weighted imaging, while not routinely included in head and neck MRI protocols, can be included [10-12].**

Many types of pathology in the head and neck exhibit contrast enhancement, and the degree to which a lesion enhances may narrow its differential diagnosis. T1-weighted,

contrast-enhanced images should, in most cases, be obtained with fat suppression so that an enhancing lesion will not be rendered difficult to differentiate from surrounding hyperintense fat. ~~But~~ **Since** fat suppression ~~increases~~ **enhances** magnetic susceptibility artifacts, the presence of ~~a~~ metallic ~~device~~ **material** in the area of interest could obscure pathology **[13]**. In such cases, T1 weighting without fat suppression may **offer better evaluation of the pathology.** ~~might be used. Gradient-echo imaging be useful where detection of blood becomes important, as FSE imaging is not as sensitive for detecting paramagnetic forms of blood as is gradient-echo or conventional spin-echo imaging~~
For questions concerning vascular invasion or abnormal vessels, **dynamic contrast-enhanced or unenhanced** MR angiography **and/**or venography may be useful [14].

The choice of imaging planes depends on the anatomy to be demonstrated. For most head and neck lesions, axial and coronal imaging ~~may~~ suffice, although sagittal images are useful for tongue base, palate, nasopharynx, and airway lesions and are critical in temporo-mandibular joint ~~evaluations~~ **and central skull base evaluation.** Oblique imaging along anatomic structures in off-axis orientations, such as the temporo-mandibular joint [15-16] and the optic nerves [17], **may** better depict local detail.

With advances in MRI coil design and phased array technology, head and neck imaging is usually performed with standard brain and head/neck coils that produce high quality, thin section images needed to display head and neck anatomy and pathology [18-19]. Surface coils are rarely required to provide the ~~fine~~ detail needed to detect pathology in the skull base and neck but may allow improved high-resolution detail **[20]**. The choice of a head or neck coil depends on the suspected extent of pathology [21] 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 maximum **signal-to-noise ratio and maximal** detail ~~and~~ **with** a pixel width of 1 mm or less, while considering the need for short scanning times to avoid motion degradation of the images.

~~For fine detail of small body parts, such as the globe or temporo-mandibular joint, a small, specialized coils have been recommended, although studies with such coils may require longer imaging times and are easily degraded by motion [22], especially when the coils are placed on the skin rather than fixed a short distance away [23]. With advances in coil design and phased array technology, the use of brain and head and neck surface coils may produce the good quality thin images needed to display head and neck anatomy and pathology to best advantage [18-19]~~

~~Whatever technique is required for optimal demonstration of an area~~ MRI should be performed, whenever possible, before a biopsy to avoid misinterpretation due to distortions ~~produced~~ **from altered morphology and/or signal intensities** by an invasive procedure **and surgical material** [24-25].

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 evaluating intracranial complications of infections and inflammatory conditions of the sinonasal, middle ear **cavity,** and mastoid ~~cavities~~ **air cells.**

1. Orbits

MRI is, in general, the ~~procedure~~ **technique** of choice for orbital imaging because of its lack of ionizing radiation, **its** fine delineation of detail, and **its** excellent demonstration of associated intracranial pathology [26-28]. CT is ~~reserved~~ **preferred** for evaluation of trauma; foreign bodies, especially those with unknown ferromagnetic properties [28]; lesions that might ~~calcify~~ **be calcified** [6,29]; and localized infection, such as orbital involvement by ~~an~~ adjacent aggressive sinus **pathology.** ~~infection both for the rapidity of the examination and for its evaluation of bone involvement~~

Head ~~surface~~ coils are ~~required~~ **usually adequate** to study the **orbits.** ~~globes optimally, with smaller coils occasionally useful to examine the globes in greater detail~~ Thin section, fat-suppressed T2-weighted ~~images~~ or ~~short T1 tau inversion recovery~~ STIR coronal images should be obtained to visualize signal changes in the optic nerves [17,28,30]. Sagittal, 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 [17,21,27,31]. ~~Proper windowing of the images is important, especially on T1-weighted images, to avoid obscuration of detail by hyperintense fat [6]~~ Contrast-enhanced T1-weighted images are useful for examining neoplastic, infectious, inflammatory, ischemic, vascular [27], demyelinating [29], and infiltrative [22] processes, as well as for evaluating the intracranial extent of a lesion [26,32]. The contrast-enhanced images require fat suppression in at least one plane due to the amount of intraorbital fat [6,21,27,29,31]. 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 [33]. Imaging of orbital detail usually requires small field of view imaging, and 3 mm ~~image widths~~ **slice thickness** [29], with pixels no larger than 1 mm. ~~Small section widths~~ **Thin slices** with **minimal** or no interslice gaps are especially useful for studies of the globes and optic nerves [30-31].

If the cranial nerves are involved or if the lesion is likely to involve the brain or subarachnoid space, ~~such as a retinoblastoma, melanoma, or optic glioma~~ **then** long TR images of the brain at least in the axial plane [34], and ~~T1-weighted~~ contrast-enhanced **T1-weighted i**mages [32] **of the brain** are needed. Section widths of 4 to 5 mm, with minimal pixel size [29] and a slightly larger field of view (FOV) (~~i.e.~~ 18 to 20 mm), provide better signal-to-noise ratios [35]. ~~In cases of suspected optic neuritis, inclusion of fluid-attenuated inversion-recovery (FLAIR) imaging of the brain is of value to detect associated demyelination [30]~~

2. ~~Sinonasal cavities~~ **Paranasal sinuses and nasal cavity**

Computed tomography is the imaging modality of choice for ~~cases of inflammation~~ **inflammatory disorders** of the ~~sinonasal cavities~~ **paranasal sinuses and nasal cavity,** with MRI reserved for evaluating complications of inflammatory **and neoplastic** sinus disease [36-38], including orbital, skull base, and intracranial extension [25,28,39-41]. For all suspected neoplasms, and to distinguish tumors ~~and polyps~~ from mucosal thickening and secretions, MRI with contrast enhancement is the study of choice [25,32,42-43]. Perineural**, intra-orbital, and intracranial/meningeal** extensions of tumor ~~and meningeal spread~~ are ~~preferably~~ **best** studied with ~~enhanced~~ MRI ~~Surface coils, most commonly~~ **using** a head coil ~~are used~~ and 3 mm ~~image widths~~ **thick sections** with a narrow gap (~~preferably~~ 1 mm or less) ~~are suggested~~ [25,44]. **Unenhanced** T1-weighted, ~~and~~ **fat-suppressed** T2-weighted FSE ~~fat-suppressed~~ images, and **fat-suppressed enhanced** T1-weighted ~~enhanced scans, employing fat suppression~~ **images** in at least one plane **(coronal or axial)** [42,44]~~, with imaging in at least coronal and axial planes~~ demonstrate **excellent soft tissue** detail **[45]**. ~~adequately. Associated septic venous thrombosis might be detected with magnetic resonance venography (MRV) techniques [42]~~

3. Suprahyoid neck

MRI is the procedure of choice for most pathology of the suprahyoid neck, which includes the skull base, nasopharynx, **oral cavity,** and oropharynx [1,15,24,46-47].

In the suprahyoid neck, bone infiltration by soft tissue lesions may be detected earlier by MRI than by CT [15,48-50]. ~~which relies on bone erosion, a later event [51]~~ **However, s**ubtle cortical erosion, especially without infiltration of the medullary cavity, and detail of small bones ~~and foramina are~~ **may** ~~however~~ **be** better demonstrated by CT [9,51-54].

Contrast-enhanced MRI best depicts intracranial extension of tumor from the ~~head~~ **neck** and ~~neck~~ **skull base,** including perineural extension [25,55]. **Sagittal and axial** T1-weighted, ~~and~~ axial fat suppressed T2-weighted, ~~images~~ and fat-suppressed **enhanced** T1-weighted sequences in ~~at least~~ **the** axial and coronal planes, with small fields of view, small interslice gaps, and high matrix imaging provide ~~adequately~~ detailed images of the skull base and nasopharynx [9,47,55-58].

~~In the oral~~ **Oral** cavity masses are **frequently** best demonstrated by MRI due to its superior contrast resolution and ~~the less severe effect of~~ **reduced** dental amalgam artifacts [59] relative to CT. ~~studies~~ Sagittal fat-suppressed ~~long TR~~ **T2-weighted** scans are useful to demonstrate the depth of invasion of base of tongue lesions, and ~~sagittal imaging~~ may complement coronal scans in evaluation of the palate. ~~especially its posterior aspect~~ For infections in adults, contrast

enhanced CT is preferred to detect small calculi and to determine the integrity of the mandibular cortex [41]. ~~but MR is of value~~ **MRI may be useful** in ~~the~~ **selected cases for** early detection of ~~acute medullary~~ bone **marrow** involvement**/osteomyelitis** [59-60]. ~~in mandibular and maxillary osteomyelitis, and in planning surgery for chronic~~

For imaging of the oropharynx and hypopharynx, ~~slightly hyperextending the neck and~~ instructing the patient to breathe quietly ~~are useful techniques to~~ **may** improve image quality [56]. The use of saturation pulses is helpful to reduce vascular flow artifacts in the area. ~~MR imaging, with MR angiography and venography as needed, is helpful to delineate vascular invasion and compromise [61-62]~~

4. Infrahyoid neck

~~Controversy concerning the role of MRI in infrahyoid neck imaging continues, with advocates for~~ **Newer and faster imaging techniques resulting in motion artifact reduction have decreased the controversy regarding the role of MRI in imaging the infrahyoid neck. Some advocate** CT, ~~in part~~ **largely** due to ~~the prevalence of motion in the area~~ **its rapidity such that there is less sensitivity to motion** related to breathing and swallowing. **CT scans generally have higher resolution than MRIs, while MRI has superior soft tissue contrast [16] compared to CT.** ~~for most pathology. The development of rapid MR~~ **Both CT** and **MRI offer** multiplanar and ~~volume CT~~ **volumetric** capabilities ~~challenges~~ **in the era of multislice CT, challenging** MRI's former advantage in producing images in multiple planes [63]. ~~Although~~ MRI ~~still~~ provides better soft tissue contrast **and is more sensitive and specific** than CT **in defining cartilage invasion [24].** ~~and is more sensitive and specific than CT in defining cartilage invasion [24,64]~~ **MRI for many is the study of choice for neoplasms of the infrahyoid neck, with the notable exception being small, early stage laryngeal tumors that may only be seen on very thin-section, high-resolution CT images. CT is 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, as CT plays a limited role in brachial plexus imaging.**

MRI of the infrahyoid neck requires the use of ~~surface~~ **dedicated** coils [65] not supported by the neck itself to avoid motion artifacts [23]**; these are typically anterior neck or neurovascular coils.** A small **field of view (**FOV) and large enough matrix to produce detailed images while maintaining short scanning times are additional requirements [65]. The neck should be slightly hyperextended, with the larynx parallel to the tabletop [23] and with the patient breathing quietly [66]. Inferior and superior saturation pulses ~~are~~ **may be** a valuable addition to ~~control for~~ **minimize** vascular flow artifacts [67].

~~The detection of lymph node pathology, especially metastatic disease, requires finely detailed imaging with small fields of view and high matrices, with resultant long imaging times and an increased chance of patient motion [68-69]~~

Nodal imaging can be accomplished with CT or MRI. Imaging coverage ~~includes~~ **should extend** from the skull base to ~~at least the supraclavicular fossae so the surface~~ **the AP window. The MRI** coil ~~employed~~ should be able to ~~evaluate~~ **cover** this area in its entirety [40]. For visceral space pathology, especially **in the** thyroid and parathyroid **(see below),** extension of imaging to include the carina is necessary for complete demonstration of potentially involved areas [70]. For ~~detecting~~ **evaluation of cervical** lymph nodes, ~~in the neck~~ **T1-weighted, fat-suppressed** T2-weighted ~~imaging with fat suppression, either~~ FSE or STIR [71-72], ~~is preferred, but for detecting nodal necrosis~~ **and** fat-suppressed, **contrast-**enhanced ~~detailed~~ T1-weighted imaging is necessary [69].

5. Thyroid and parathyroid

In evaluation of the thyroid and parathyroid glands, ultrasound ~~with~~ **(often accompanied by fine needle** aspiration) ~~biopsy~~ and ~~radio~~ scintigraphy play primary roles [73-75]. ~~If a thyroid lesion is found to contain a differentiated carcinoma, and delination of the area is necessary prior to definitive therapy~~ **If a differentiated thyroid carcinoma is detected, ultrasound is performed to assess the lateral necks in patients with clinically negative necks. If imaging is indicated prior to definitive therapy such as in the setting of palpable neck adenopathy to aid in planning neck dissection** [70], or in the case of initial evaluation of a ~~symptomatic~~ mass in the thyroid area of uncertain etiology [76], **then** MRI with contrast is useful as it **not only delineates the pathology but also** avoids delays in ~~therapy with~~ radioiodine **therapy** ~~as would be the case~~ **that can result** if iodinated contrast **were used** for a CT study. ~~were used. However, if~~ **If** radioiodine therapy is not a consideration, ~~better detail of the thyroid and parathyroid glands is usually obtained with~~ **then** CT scanning [70] ~~due to~~ **may be used, reducing image degradation from** breathing and vascular pulsation ~~degradation of MR images. Imaging~~ **often seen** with **MRI.** ~~or CT should include extension inferiorly to include the carina to evaluate the entire area of potential involvement MRI~~

In the setting of recurrent thyroid cancer, 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 [77]. For thyroid and parathyroid, CT and MRI should extend to include the carina for complete demonstration of potentially involved areas [70,76]. ~~using T1-weighted and T2-weighted images in at least the axial plane, and with respiratory [67,78] and cardiac compensation [78] helpful to reduce motion artifacts~~

6. Temporal bone

MRI is the primary imaging modality for evaluating the non-osseous components of the temporal bone region [39], ~~which include evaluations~~ **including evaluation** of suspected retrocochlear pathology [25] and cranial nerve dysfunction, most commonly ~~sensory~~ **sensori**neural hearing loss [7,79-80]. ~~It~~ **MRI** is useful to determine if temporal bone pathology, such as infection or ~~tumors involve~~ **neoplasm, involves** the ~~cranial contents, including perineural spread of tumors~~ **intracranial compartment.** CT is favored if a labyrinthine or cochlear lesion is suspected [81-82], although lesions such as cochlear schwannomas or **labyrinthine** hemorrhages are better detected by MRI. ~~CT is frequently more helpful than MR in evaluations for pulsatile tinnitus or a detected retrotympanic mass~~ **In the evaluation of subjective pulsatile tinnitus CT may be the first-line study** [7,83], ~~If tinnitus is abolished by jugular vein pressure, MRV might be useful. If a systolic bruit is audible, MRA [83] or CT angiography might be helpful~~ **while MRI followed by conventional catheter angiography may be more appropriate in the evaluation of objective pulsatile tinnitus (audible bruit).**

MRI of the temporal bones requires a head coil and should include axial T1-weighted images, with and without contrast enhancement, and coronal T1-weighted enhanced scans. 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 [39]. 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, 3D T2-weighted techniques are useful in temporal bone imaging to evaluate the relationship of a vestibular schwannoma or other pathology to the surrounding nerves [84], 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 [85-86].**

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 [87-89].

Long TR **and enhanced T1-weighted** images of the brain should be included to **assess for intracranial extension of temporal bone pathology and to e**xclude intracranial processes such as ~~demyelination~~ **white matter diseases** that might produce symptoms similar to those of temporal bone lesions [69].

7. Temporo-mandibular joints

MRI is the procedure of choice for most clinical presentations of temporo-mandibular joint pathology **[90]**. 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 [93]. Many authors recommend proton density and T2-weighted sagittal oblique imaging in open mouth and closed mouth positions [16,90-92]. 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 [31,60]. Three mm or lower section thicknesses, 0 to 1 mm image gaps, and small FOVs are additional requirements to obtain adequately detailed images [16,90,92,94-95]. **Intravenous contrast is not indicated in most clinical scenarios.**

~~For optimal imaging, small surface coils are suggested as they depict fine detail most accurately. Dual 3 inch coils allow simultaneous imaging of both temporo-mandibular joints resulting in an imaging time reduction [16,90-92]~~

Further evaluation of the patient with temporo-mandibular joint 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 [96-104].

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.

The report should address the presence or absence of a mass, the size of the lesion and its composition, ~~signal intensity~~ and enhancement characteristics. ~~A description of the~~ **The** anatomic location of a tumor, including its relationship to adjacent ~~major~~ muscles, vessels, and nerves, ~~will contribute~~ **should be addressed** to ~~the tumor's grading and~~ **assist the clinician in** staging **and planning management.**

VI. EQUIPMENT SPECIFICATIONS

The MRI equipment specifications and performance ~~shall~~ **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.

VII. 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 web site (http://www.acr.org/guidelines).

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

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

ACKNOWLEDGEMENTS

This guideline was revised according to the process described under the heading *The Process for Developing ACR Practice Guidelines and Technical Standards* on the ACR web site (http://www.acr.org/guidelines) by the Guidelines and Standards Committees of the Commissions on Neuroradiology and Pediatric Radiology in collaboration with ASNR and the SPR.

Collaborative Committee – members represent their societies in the initial and final revision of this guideline

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