Cohere Medicare Advantage Policy - Magnetic Resonance Imaging (MRI), Brain

Clinical Guidelines for Medical Necessity Review

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Important Notices

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Other Notices:

Guideline Information:

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Medical Necessity Criteria

Service: Magnetic Resonance Imaging (MRI), Brain

Benefit Category

Diagnostic Services in Outpatient Hospital
Diagnostic Tests (other)

Please Note: This may not be an exhaustive list of all applicable Medicare benefit categories for this item or service.[1-7]

Related CMS Documents

Please refer to CMS Medicare Coverage Database for the most current applicable CMS National Coverage.[1-7]

- National Coverage Determination (NCD). Magnetic resonance imaging (MRI)(220.2)
- Local Coverage Determination (LCD). MRI and CT Scans of the Head and Neck (L37373)
- Billing and Coding: MRI and CT Scans of the Head and Neck (A57204)
- Local Coverage Determination (LCD). MRI and CT Scans of the Head and Neck (L35175)
- Billing and Coding: MRI and CT Scans of the Head and Neck (A57215)
- Local Coverage Determination (LCD). Multiple Imaging in Oncology, (L35391)
- Billing and Coding: Multiple Imaging in Oncology (A56848)

Recommended Clinical Approach

Imaging analysis utilizing magnetic resonance imaging (MRI) brain can be performed alone or with magnetic resonance angiography (MRA) head based on clinical suspicion of disease presence or exclusion to direct value-based care. Contrast may or may not be necessary depending upon the clinical indication at the referring physician's request and the discretion of the supervising radiologist.

Evaluation of Clinical Harms and Benefits

Cohere Health uses the criteria below to ensure consistency in reviewing the conditions to be met for coverage of magnetic resonance imaging (MRI) of the brain. This process helps to prevent both incorrect denials and inappropriate approvals of medically necessary services. Specifically, limiting incorrect approvals reduces the risks associated with unnecessary procedures, such as complications from surgery, infections, and prolonged recovery times.

The potential clinical harms of using these criteria may include:

- The use of contrast agents (e.g., gadolinium-based contrast agents) cause side effects in a few patients. These may include nausea, headache, and pain at the site of injection. Rarely, patients experience hives, itchy eyes, or other allergic reactions to the contrast material.[8]
- Dynamic magnetic fields during MRI scanning create loud knocking noises which may harm hearing or cause ringing of the ears (tinnitus) if adequate ear protection is not used. They may also cause peripheral muscle or nerve stimulation that may feel like a twitching sensation.[8]
- MRI scanning could lead to heating of the body and thermal injuries, particularly during long scans, due to radiofrequency energy used in the procedure.[8]
- Increased healthcare costs and complications from the inappropriate use of emergency services and additional treatments.

The clinical benefits of using these criteria include:

- MRI, a non-invasive imaging technology that provides detailed three-dimensional anatomical images, is useful in the diagnosis, treatment, and monitoring of Alzheimer's disease, Parkinson's disease, stroke, multiple sclerosis, tumors, amyotrophic lateral sclerosis (ALS), Huntington's disease, and dementia.[9-13]
- MRI of the brain offers insights into the etiology, prognosis, and treatment of intracerebral hemorrhage (ICH). Using echo-planar gradient-echo or susceptibility-weighted sequences, MRI shows sensitivity and specificity in identifying ICH and in differentiating its primary and secondary causes. Moreover, MRI can assess hemorrhage

age, secondary lesions, and progression of perihematomal edema, thereby guiding tailored therapeutic strategies.[14]

- Different MRI imaging biomarkers measure different aspects of the tissues in the brain. For example, T_1 tissue properties help differentiate between white and gray matter while T_2 tissue properties highlight water content of the brain. This helps in the identification of lesions, edemas, and other abnormalities. T^*_2 properties can detect hemorrhagic strokes.[15]
- Enhanced overall patient satisfaction and healthcare experience.

This policy includes provisions for expedited reviews and flexibility in urgent cases to mitigate risks of delayed access. Evidence-based criteria are employed to prevent inappropriate denials, ensuring that patients receive medically necessary care. The criteria aim to balance the need for effective treatment with the minimization of potential harms, providing numerous clinical benefits in helping avoid unnecessary complications from inappropriate care.

In addition, the use of these criteria is likely to decrease inappropriate denials by creating a consistent set of review criteria, thereby supporting optimal patient outcomes and efficient healthcare utilization.

Medical Necessity Criteria

Indications

➔ **Magnetic resonance imaging (MRI), brain** is considered appropriate if **ANY** of the following is **TRUE**[16-17]:

◆ Neoplastic conditions for **ANY** of the following (with limitations as defined in the non-indications section below):

- Initial staging; **OR**
- Treatment planning; **OR**
- Response assessment; **OR**
- Surveillance, and **ANY** of the following is **TRUE**[6-7,20-22]:
    - The patient is assumed to have either no known disease or disease that is stable or clinically insignificant (every 6-12 months for an overall duration [e.g., 5 years]); **OR**
    - Suspected recurrence/progression; **OR**
    - Evaluation of response to treatment when a change

in therapy is contemplated (no more often than after 2 cycles of chemotherapy and/or 6-8 weeks since the prior imaging evaluation); **OR**

- The patient has **ANY** of the following infections or infectious disorders[23]:
  - Suspected brain abscess or brain infection with **ANY** of the following:
    - Acute altered mental status; **OR**
    - Positive lab findings (e.g., elevated WBCs or abnormal CSF analysis); **OR**
    - Follow-up assessment during or after treatment completed; **OR**
    - Endocarditis with suspected septic emboli; **OR**
    - Neurosarcoidosis with **ANY** of the following:
      - For initial evaluation with **ANY** of the following:
        - Suspected based on neurological sign(s), symptom(s), and lab work (e.g., angiotensin-converting enzyme (ACE], cerebrospinal fluid (CSF) analysis); **OR**
        - Known history of sarcoidosis with neurological signs or symptoms; **OR**
      - Follow-up of known neurosarcoidosis for **ANY** of the following reasons:
        - To assess treatment response; **OR**
        - Worsening signs or symptoms; **OR**
- The patient has a trauma-related condition, as indicated by **ANY** of the following[24]:
  - Assessment of unexplained post-traumatic neurological deficits; **OR**
  - Post-traumatic brain injury or persistent symptoms following initial imaging (e.g., dizziness, headache); **OR**
  - Post-concussive syndrome if persistent or disabling symptoms and MRI has not been performed; **OR**
  - Subacute or chronic traumatic brain injury with new cognitive and/or neurologic deficit; **OR**
- The patient has a vascular condition including **ANY** of the following:

- Acute ischemic stroke or transient ischemic attack (TIA)[25]; **OR**
- Known or suspected stroke with any acute, new, or fluctuating symptoms or deficits (e.g., sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes); **OR**
- Suspected stroke with a personal or first-degree family history (e.g., brother, sister, parent, or child) of an aneurysm or known coagulopathy or on anticoagulation; **OR**
- Symptoms of TIA that are episodic with neurologic symptoms (e.g., sensory deficits, limb weakness, speech difficulties, visual loss, lack of coordination, or mental status changes); **OR**
- Evaluation of suspected acute subarachnoid hemorrhage (SAH); **OR**
- Follow-up for known hemorrhage, hematoma, or vascular abnormalities; **OR**
- Follow-up imaging of known cerebral cavernous malformations (CCM) should be done only to guide treatment decisions or to investigate new symptoms - includes first-degree relatives of patients with one family member with a CCM should have a screening MRI as well as genetic counseling; **OR**
- Suspected central venous thrombosis; **OR**
- Screening for silent cerebral infarcts in early school-age children and adults with HbSS sickle cell disease or HbSβ0 thalassemia; **OR**
- Suspected temporal arteritis in a patient greater than 50 years old with **ANY** of the following:
    - Temporal headache; **OR**
    - Abrupt visual changes; **OR**
    - Jaw claudication; **OR**
    - Temporal artery tenderness; **OR**
    - Constitutional symptoms; **OR**
    - Elevated erythrocyte sedimentation rate (ESR); **OR**
- Evaluation of neurological signs or symptoms in a patient with sickle cell disease; **OR**

- High stroke risk in sickle cell patients (2 to 16 years of age) with a transcranial Doppler velocity greater than 200 cm/sec[26]; **OR**
- **ANY** of the following chronic vascular diseases[27]:
    - Headaches with a family history of aneurysm/AVM, including **ANY** of the following[28-31]:
        - One first-degree relative with a history of aneurysm/AVM if symptomatic or there is clinical concern for aneurysm; **OR**
        - Two or more relatives with a history of aneurysm/AVM (repeat imaging in 5 years); **OR**
    - Arterial or venous/dural venous sinus abnormalities such as **ANY** of the following:
        - Acquired thrombosis/occlusion; **OR**
        - Venous sinus stenosis; **OR**
    - Central nervous system (CNS) involvement in patients with known or suspected vasculitis or autoimmune disease with abnormal inflammatory markers or autoimmune antibodies; **OR**
    - Immunocompromised patients (e.g., transplant recipients, HIV with CD4 less than 200, primary immunodeficiency syndromes, hematologic malignancies) with focal neurologic symptoms, headaches, behavioral, cognitive or personality changes; **OR**
    - Evaluation of neurological signs or symptoms in vaso-occlusive disease (e.g., sickle cell disease, moyamoya, etc.); **OR**

◆ The patient has **ANY** of the following autoimmune or inflammatory conditions[32-33]:

- Atypical trigeminal neuralgia, defined by **ANY** of the following symptoms[34]:
    - Bilateral hearing loss; **OR**
    - Dizziness/vertigo; **OR**
    - Visual changes; **OR**
    - Sensory loss or numbness; **OR**
    - Pain greater than 2 minutes; **OR**
    - Pain outside trigeminal nerve distribution and

progression; **OR**

- Refractory trigeminal neuralgia when done for surgical planning; **OR**
- Suspected multiple sclerosis (MS), and **ANY** of the following is **TRUE**:
    - For evaluation of patients with neurologic symptoms or deficits suspicious for MS with **ANY** of the following:
        - A clinically isolated syndrome (e.g., optic neuritis, transverse myelitis, or brain stem syndrome); **OR**
        - Recurrent episodes of variable neurological signs or symptoms not attributable to another cause; **OR**
    - To demonstrate dissemination in time for diagnosis (every 6-12 months); **OR**
    - For evaluation of known multiple sclerosis (MS) and **ANY** of the following is **TRUE**:
        - To establish a new baseline and **ANY** of the following is **TRUE**:
            - No recent imaging; **OR**
            - Postpartum; **OR**
            - 3-6 months after switching disease-modifying therapy; **OR**
        - Before starting or switching disease-modifying therapy; **OR**
        - 6-month repeat scan in patients with MRI disease activity that is not associated with new clinical symptoms on a routine follow-up scan (e.g., radiographically isolated syndrome); **OR**
        - Every 1-2 years while on disease-modifying therapy to assess for subclinical disease activity, less frequently when stable for 2-3 years; **OR**
        - New signs or symptoms suggested an exacerbation or unexpected clinical worsening; **OR**
        - Progressive multifocal leukoencephalopathy (PML) surveillance for patients on natalizumab

(Tysabri) and **ANY** of the following is **TRUE**:

- 12 months after the start of treatment in all patients; **OR**
- Brain MRI every 3–4 months for up to 12 months, in high-risk patients who switch from natalizumab to other therapeutics; **OR**
- Further surveillance MRI scanning timing is based on risk, and **ANY** of the following is **TRUE**:
    - Annually, if the anti-JCV antibody is negative; **OR**
    - Every 3-4 months, if high-risk of PML occurrence and **ANY** of the following is **TRUE**:
        - Seropositive for JC virus and have been treated with natalizumab for greater than or equal to 18 months; **OR**
        - High anti-JC virus antibody index values (greater than 0.9); **OR**
        - Previously treated with immunosuppressive therapies; **OR**

◆ In the pediatric population, a similar scan frequency for disease and therapeutic monitoring should be used - the frequency should be increased (e.g., every 6 months) if the child has a highly active disease or when imaging will change management; **OR**

◆ Evaluation of **ANY** of the following miscellaneous pathologies:

- Acute, new, or fluctuating neurologic symptoms or deficits, including **ANY** of the following:
    - Sensory deficits; **OR**
    - Limb weakness; **OR**
    - Abnormal reflexes (pathological, asymmetric, hyperreflexia); **OR**

    - Speech difficulties; **OR**
    - Visual loss; **OR**
    - Lack of coordination; **OR**
    - Mental status changes; **OR**
- Brain structural abnormality identified or suspected on prior imaging; **OR**
- Chronic disequilibrium with signs of cerebellar ataxia[35]; **OR**
- Pathology involving the cranial nerve[36]; **OR**
- Dizziness (including vertigo) with **ANY** of the following:
    - Signs or symptoms suggestive of a CNS lesion (ataxia, visual loss, double vision, weakness, or a change in sensation); **OR**
    - Progressive unilateral hearing loss; **OR**
    - Risk factors for cerebrovascular disease with concern for stroke; **OR**
    - Acute persistent vertigo with normal neurologic examination and HINTS examination is consistent with peripheral vertigo[35]; **OR**
    - Acute persistent vertigo with abnormal neurologic examination or HINTS examination is consistent with central vertigo[35]; **OR**
    - Chronic recurrent vertigo that is associated with unilateral hearing loss or tinnitus[35]; **OR**
    - Chronic recurrent vertigo that is associated with other brainstem neurologic deficits[35]; **OR**
    - Episodic vertigo with or without associated hearing loss or aural fullness[37]; **OR**
    - Persistent vertigo with or without neurological symptoms (central vertigo)[37]; **OR**
- Epilepsy, known or suspected, and **ANY** of the following is **TRUE**:
    - New onset of seizures or newly identified change in seizure activity/pattern; **OR**
    - Known seizure disorder without prior imaging; **OR**
    - Medically refractory epilepsy; **OR**
- Neurodegenerative disorders (congenital or acquired), including dementia[38-39]; **OR**
- Movement disorders including **ANY** of the following[38,40-42]; **OR**

    - Acute onset of a movement disorder with concern for stroke or hemorrhage (brain MRI recommended over brain CT); **OR**
    - For evaluation of Parkinson's disease with atypical features or other movement disorders (e.g., suspected Huntington's disease, chorea, parkinsonian syndromes, hemiballismus, atypical dystonia) to exclude an underlying structural lesion; **OR**
- Headaches as indicated by **ANY** of the following[18]:
    - In a pediatric patient with severe headaches who is less than 6 years old; **OR**
    - In a pediatric patient who is greater than or equal to 6 years old with severe headaches and a known underlying condition (e.g., sickle cell, cancer, immune deficiency); **OR**
    - Immediate imaging is required and the patient is considered high-risk with **ANY** of the following symptoms[18]:
        - Intracranial hypertension (e.g., papilledema, pulsatile tinnitus, visual symptoms worse on Valsalva); **OR**
        - Intracranial hypotension (e.g., positional, worse when upright, better when lying down); **OR**
        - **ANY** of the following "red flags":
            - Age of onset is 50 years or older; **OR**
            - Fever or neurologic deficit; **OR**
            - History of cancer or immunocompromise; **OR**
            - Increasing frequency or severity; **OR**
            - Posttraumatic onset with no prior imaging; **OR**
        - Headache with new onset or pattern during pregnancy or peripartum period; **OR**
        - Primary trigeminal autonomic cephalalgias (e.g., cluster headache); **OR**
    - Persistent headaches that have failed physician-directed conservative treatment; **OR**

- Hearing loss (e.g., acquired sensorineural, mixed conductive, sensorineural)[37]; **OR**
- Acoustic neuroma including **ANY** of the following[43]:
    - Initial evaluation for suspected acoustic neuroma; **OR**
    - Monitoring of a known, symptomatic acoustic neuroma when surgery is not performed; **OR**
    - Post-surgical management; **OR**
- Metabolic, nutritional, and dysmyelinating disorders[44]; **OR**
- **ANY** of the following types of tinnitus[45]:
    - Pulsatile tinnitus, unilateral or bilateral without retro tympanic lesion on otoscopy; **OR**
    - Nonpulsatile tinnitus, unilateral without hearing loss, neurologic deficit, or trauma; **OR**
- **ANY** of the following visual conditions[46]:
    - Nontraumatic orbital asymmetry, exophthalmos, or enophthalmos; **OR**
    - Ophthalmoplegia or diplopia**; OR**
    - Suspected orbital cellulitis, uveitis, or scleritis; **OR**
    - Suspected optic neuritis; **OR**
    - Traumatic visual defect; **OR**
    - Vision loss with intraocular mass, optic nerve, or visual field defects; **OR**
    - Vision loss, nonischemic, with visual field defects; **OR**

◆ The patient requires **ANY** of the following preoperative, postoperative, or pre-treatment evaluations:

- Follow-up of treatment, including iatrogenic sequelae such as radiation necrosis[47]; **OR**
- The patient has acquired conductive hearing loss (secondary to cholesteatoma or neoplasm) with suspected intracranial or inner ear extension, for **ANY** of the following purposes[37]:
    - Surgical planning; **OR**
    - Monitoring when surgery is not performed; **OR**
    - Post-surgical management; **OR**
- The patient has congenital hearing loss, total deafness, or is a cochlear implant candidate for **ANY** of the following[37]:
    - Surgical planning; **OR**
    - Post-surgical management; **OR**

- The patient has a known or suspected congenital abnormality with any acute, new, or fluctuating neurologic, motor, or mental status changes, including **ANY** of the following:
  - Craniosynostosis and other head deformities; **OR**
  - Hydrocephalus (congenital or acquired)[18,48-49]; **OR**
  - Idiopathic intracranial hypertension; **OR**
  - Intracranial hypotension; **OR**
- Repeat imaging (defined as repeat request following recent imaging of the same anatomic region with the same modality), in the absence of established guidelines, will be considered reasonable and necessary if **ANY** of the following is **TRUE**:
  - New or worsening symptoms, such that repeat imaging would influence treatment; **OR**
  - One-time clarifying follow-up of a prior indeterminate finding; **OR**
  - In the absence of change in symptoms, there is an established need for monitoring which would influence management.

Non-Indications

➔ **Magnetic resonance imaging (MRI), brain** is not considered appropriate if **ANY** of the following is **TRUE**:

- Esophagus, oropharynx, and prostate, and non-melanoma skin cancer in the absence of symptoms of brain involvement[4]; **OR**
- If contrast is used, history of anaphylactic allergic reaction to gadolinium contrast media with detailed guidelines for use in patients with renal insufficiency; **OR**
- The patient has metallic clips on vascular aneurysms; **OR**
- Incompatible implantable devices (e.g., pacemakers, defibrillators, cardiac valves); **OR**
- Metallic foreign body in orbits/other critical area(s) or within the field of view and obscuring area of concern; **OR**
- Imaging of cortical bone and calcification; **OR**
- Procedures involving spatial resolution of bone or calcification; **OR**
- In the pediatric population, imaging is not indicated in simple febrile seizures or in idiopathic focal or generalized epilepsy with typical features of benign epilepsy with centro-temporal spikes (BECTS), childhood absence epilepsy (CAE), juvenile absence epilepsy (JAE), and juvenile myoclonic epilepsy (JME).

*NOTE: MRI in patients with claustrophobia should be requested at the discretion of the ordering provider.
**NOTE: MRI in pregnant patients should be requested at the discretion of the ordering provider and obstetric care provider.

Level of Care Criteria

Inpatient or Outpatient

Procedure Codes (CPT/HCPCS)

CPT/HCPCS Code	Code Description
70551	Magnetic resonance imaging (MRI) (e.g., proton), brain (including brain stem); without contrast material
70552	Magnetic resonance imaging (MRI) (e.g., proton), brain (including brain stem); with contrast material(s)
70553	Magnetic resonance imaging (MRI) (e.g., proton), brain (including brain stem); without contrast material, followed by contrast material(s) and further sequences

Disclaimer: G, S, I, and N Codes are non-covered per CMS guidelines due to their experimental or investigational nature.

Medical Evidence

Wangaryattawanich et al. (2023) review the imaging spectrum, clinical significance, and management of brain MRI. Rapid advancements have been made in imaging technology and accessibility. Consequently, radiologists discover incidental findings during brain MRI scans for unrelated reasons. These unexpected findings can range from clinically insignificant to requiring further investigation or treatment, leading to patient anxiety. Incidental findings encompass a diverse range, including asymptomatic brain infarcts, age-related white matter changes, microhemorrhages, intracranial tumors, intracranial cystic lesions, and anatomic variants.[50]

Maas et al. (2022) analyze facets of managing traumatic brain injury (TBI), including imaging. An initial normal CT scan does not rule out the presence of structural traumatic abnormalities. Structural traumatic abnormalities seen on MRI (2–3 weeks post-injury) were observed in approximately 30% of patients with mild TBI who initially had a normal CT scan. Advanced MRI techniques, such as diffusion tensor imaging and volumetric analyses, can reveal further injuries that may not be discernible through visual examination of conventional clinical MR images. Emerging blood biomarkers, such as glial fibrillary acidic protein (GFAP), aid in refining decisions regarding the necessity of CT scans for patients with mild TBI or the requirement of an MRI if the initial CT scan is normal. Integrating biomarkers, quantitative CT, and MRI findings facilitates the identification of patients at-risk of persistent symptoms, enabling more tailored and frequent follow-up care.[51]

Tekes et al. (2018) review the use of brain MRI in pediatric patients beyond shunted hydrocephalus. In the study period, 800 patients had undergone a previous ultrafast brain MRI scan. Patients diagnosed with ventriculomegaly, macrocephaly, or intracranial cysts were included (n=101). The findings support the use of ultrafast brain MRI to assess these conditions. Given its radiation-free and sedation-free nature, ultrafast brain MRI may be appropriate as a primary screening neuroimaging modality for these indications.[52]

References

1. Centers for Medicare & Medicaid Services. National Coverage Determination. Magnetic Resonance Imaging, 220.2. Published April 10, 2018. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/ncd.aspx?ncdid=177&ncdver=6&keywordtype=starts&keyword=Magnetic%20resonance%20imaging&bc=0
2. Centers for Medicare & Medicaid Services. Local Coverage Determination. MRI and CT Scans of the Head and Neck, L37373. Published October 8, 2018. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/lcd.aspx?lcdid=37373&ver=37&bc=0
3. Centers for Medicare & Medicaid Services. Local Coverage Determination. Billing and Coding: MRI and CT Scans of the Head and Neck, A57204. Published October 1, 2019. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/article.aspx?articleId=57204&ver=30
4. Centers for Medicare & Medicaid Services. Local Coverage Determination. MRI and CT Scans of the Head and Neck, L35175. Published October 1, 2015. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/lcd.aspx?lcdid=35175&ver=63&bc=0
5. Centers for Medicare & Medicaid Services. Local Coverage Determination. Billing and Coding: MRI and CT Scans of the Head and Neck, A57215. Published October 1, 2019. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/article.aspx?articleId=57215&ver=33
6. Centers for Medicare & Medicaid Services. Local Coverage Determination. Multiple Imaging in Oncology, L35391. Published October 1, 2015. Accessed September 24, 2024. https://www.cms.gov/medicare-coverage-database/view/lcd.aspx?lcdid=35391&ver=17&bc=0
7. Centers for Medicare & Medicaid Services. Local Coverage Determination. Billing and Coding: Multiple Imaging in Oncology, A56848. Published October 1, 2015. Accessed September 24, 2024.

https://www.cms.gov/medicare-coverage-database/view/article.aspx?articleId=56848&ver=13
8. United States Food and Drugs Administration. (MRI) Magnetic Resonance Imaging. Benefits and Risks. Updated December 9, 2017. Accessed September 24, 2024. https://www.fda.gov/radiation-emitting-products/mri-magnetic-resonance-imaging/benefits-and-risks
9. Oh J, Airas L, Harrison D, et al. Neuroimaging to monitor worsening of multiple sclerosis: advances supported by the grant for multiple sclerosis innovation. *Front Neurol*. 2023;14:1319869. Published 2023 Dec 1. doi:10.3389/fneur.2023.1319869
10. Welton T, Hartono S, Shih YC, et al. Ultra-high-field 7T MRI in Parkinson's disease: ready for clinical use?-a narrative review. *Quant Imaging Med Surg*. 2023;13(11):7607-7620. doi:10.21037/qims-23-509
11. Sin MK, Zamrini E, Ahmed A, Nho K, Hajjar I. Anti-Amyloid Therapy, AD, and ARIA: Untangling the Role of CAA. *J Clin Med*. 2023;12(21):6792. Published 2023 Oct 27. doi:10.3390/jcm12216792
12. Altaf A, Shakir M, Malik MJA, et al. Intraoperative use of low-field magnetic resonance imaging for brain tumors: A systematic review. *Surg Neurol Int*. 2023;14:357. Published 2023 Oct 6. doi:10.25259/SNI_510_2023
13. Onda K, Chavez-Valdez R, Graham EM, et al. Quantification of Diffusion Magnetic Resonance Imaging for Prognostic Prediction of Neonatal Hypoxic-Ischemic Encephalopathy. *Dev Neurosci*. 2024;46(1):55-68. doi:10.1159/000530938
14. Penckofer M, Kazmi KS, Thon J, Tonetti DA, Ries C, Rajagopalan S. Neuro-imaging in intracerebral hemorrhage: updates and knowledge gaps. *Front Neurosci*. 2024;18:1408288. Published 2024 May 9. doi:10.3389/fnins.2024.1408288
15. Monga A, Singh D, de Moura HL, et al. Emerging Trends in Magnetic Resonance Fingerprinting for Quantitative Biomedical Imaging Applications: A Review. *Bioengineering (Basel)*. 2024;11(3):236. Published 2024 Feb 28. doi:10.3390/bioengineering11030236
16. American College of Radiology (ACR), American Society of Neuroradiology (ASNR), Society for Pediatric Radiology (SPR). ACR–ASNR–SPR practice parameter for the performance and interpretation of magnetic resonance imaging (MRI) of the brain (resolution 17). Updated 2019. Accessed February 6, 2024.

https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Brain.pdf.
17. American College of Radiology (ACR). ACR practice parameter for performing and interpreting magnetic resonance imaging (MRI) (resolution 8). Updated 2022. Accessed February 2, 2024. https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Perf-Interpret.pdf.
18. Expert Panel on Neurologic Imaging, Utukuri PS, Shih RY, et al. ACR appropriateness criteria - headache. Revised 2022. Accessed February 6, 2024. https://acsearch.acr.org/docs/69482/Narrative/.
19. Nguyen TB, Cron GO, Bezzina K, et al. Correlation of tumor immunohistochemistry with dynamic contrast-enhanced and DSC-MRI parameters in patients with gliomas. *AJNR Am J Neuroradiol*. 2016 Dec;37(12):2217-2223. doi: 10.3174/ajnr.A4908. PMID: 27585700; PMCID: PMC7963881.
20. Ackman JB, Chung JH, et al. ACR appropriateness criteria - imaging of mediastinal masses. *J Am Coll Radiol*. 2021;18(5S):S37-S51. doi: 10.1016/j.jacr.2021.01.007. PMID: 33958117.
21. de Groot PM, Chung JH, et al. ACR appropriateness criteria - noninvasive clinical staging of primary lung cancer. *J Am Coll Radiol*. 2019;16(5S):S184-S195. doi: 10.1016/j.jacr.2019.02.008. PMID: 31054745.
22. Raptis CA, Goldstein A, et al. ACR appropriateness criteria - staging and follow-up of esophageal cancer. *J Am Coll Radiol*. 2022;19(11S): S462-S472. doi: 10.1016/j.jacr.2022.09.008. PMID: 36436970.
23. Expert Panel on Neurological Imaging, Luttrull MD, Boulter DJ, et al. ACR appropriateness criteria - acute mental status change, delirium, and new onset psychosis. *J Am Coll Radiol*. 2019 May;16(5S):S26-S37. doi: 10.1016/j.jacr.2019.02.024. PMID: 31054753.
24. Expert Panel on Neurological Imaging, Shih RY, Burns J, et al. ACR appropriateness criteria - head trauma: 2021 update. J Am Coll Radiol. 2021 May;18(5S):S13-S36. doi: 10.1016/j.jacr.2021.01.006. PMID: 33958108.
25. Catanese L, Tarsia J, Fisher M. Acute ischemic stroke therapy overview. *Circ Res*. 2017 Feb 3;120(3):541-558. doi: 10.1161/CIRCRESAHA.116.309278. PMID: 28154103.
26. National Heart, Lung, Blood Institute (NHLBI). Evidence-based management of sickle cell disease: Expert panel report. Published 2014. Accessed September 24, 2024. https://www.nhlbi.nih.gov/sites/default/files/media/docs/sickle-cell-disease-report%20020816_0.pdf.
27. Expert Panel on Neurologic Imaging, Ledbetter LN, Burns J, et al. ACR appropriateness criteria - cerebrovascular diseases, aneurysm, vascular malformation, and subarachnoid hemorrhage. J Am Coll

Radiol. 2021 Nov;18(11S):S283-S304. doi: 10.1016/j.jacr.2021.08.012. PMID: 34794589.
28. Magnetic Resonance Angiography in Relatives of Patients with Subarachnoid Hemorrhage Study Group. Risks and benefits of screening for intracranial aneurysms in first-degree relatives of patients with sporadic subarachnoid hemorrhage. *N Engl J Med*. Oct 28 1999;341(18):1344-50. doi: 10.1056/nejm199910283411803. PMID: 10536126.
29. Rinkel GJ, Ruigrok YM. Preventive screening for intracranial aneurysms. *Int J Stroke*. Jan 2022;17(1):30-36. doi: 10.1177/17474930211024584. PMID: 34042530; PMCID: PMC8739572.
30. Bederson JB, Awad IA, Wiebers DO, et al. Recommendations for the management of patients with unruptured intracranial aneurysms: A statement for healthcare professionals from the Stroke Council of the American Heart Association. *Circulation*. 2000 Oct 31;102(18):2300-8. doi: 10.1161/01.cir.102.18.2300. PMID: 11056108.
31. Brown RD, Jr., Huston J, Hornung R, et al. Screening for brain aneurysm in the Familial Intracranial Aneurysm study: frequency and predictors of lesion detection. *J Neurosurg*. Jun 2008;108(6):1132-8. doi: 10.3171/jns/2008/108/6/1132. PMID: 18518716; PMCID: PMC4190025.
32. Expert Panel on Neurological Imaging, Agarwal V, Shah LM, et al. ACR appropriateness criteria - myelopathy: 2021 update. *J Am Coll Radiol*. 2021 May;18(5S):S73-S82. doi: 10.1016/j.jacr.2021.01.020. PMID: 33958120.
33. Expert Panel on Neurological and Musculoskeletal Imaging, Boulter DJ, Job J, et al. ACR appropriateness criteria - plexopathy: 2021 update. *J Am Coll Radiol*. 2021 Nov;18(11S):S423-S441. doi: 10.1016/j.jacr.2021.08.014. PMID: 34794598.
34. Lambru G, Zakrzewska J, Matharu M. Trigeminal neuralgia: a practical guide. *Pract Neurol*. 2021 Oct;21(5):392-402. doi: 10.1136/practneurol-2020-002782. PMID: 34108244; PMCID: PMC8461413.
35. Expert Panel on Neurologic Imaging, Wang LL, Thompson TA, et al. ACR appropriateness criteria - dizziness and ataxia. Published 2023. Accessed September 24, 2024. https://acsearch.acr.org/docs/69477/Narrative/.
36. Expert Panel on Neurological Imaging, Rath TJ, Policeni B, et al. ACR appropriateness criteria - cranial neuropathy. Updated 2022. Accessed February 6, 2024. https://acsearch.acr.org/docs/69509/Narrative/.
37. Expert Panel on Neurologic Imaging, Sharma A, Kirsch CFE, et al. ACR appropriateness criteria - hearing loss and/or vertigo. Published 2018. Accessed January 17, 2024. https://acsearch.acr.org/docs/69488/Narrative/.
38. Expert Panel on Neurological Imaging, Harvey HB, Watson LC, et al.ACR appropriateness criteria - movement disorders and neurodegenerative diseases. *J Am Coll Radiol*. 2020 May;17(5S):S175-S187. doi: 10.1016/j.jacr.2020.01.042. PMID: 32370961.

39. Expert Panel on Neurological Imaging, Moonis G, Subramaniam RM, et al. ACR appropriateness criteria - dementia. *J Am Coll Radiol*. 2020 May;17(5S):S100-S112. doi: 10.1016/j.jacr.2020.01.040. PMID: 32370954.
40. Albanese A, Asmus F, Bhatia KP, et al. EFNS guidelines on diagnosis and treatment of primary dystonias. *Eur J Neurol*. Jan 2011;18(1):5-18. doi: 10.1111/j.1468-1331.2010.03042.x. PMID: 20482602.
41. Comella CL, National Organization for Rare Disorders (NORD). Cervical dystonia. Updated July 19, 2019. Accessed June 20, 2024. https://rarediseases.org/rare-diseases/cervical-dystonia/.
42. Sharifi S, Nederveen AJ, Booij J, et al. Neuroimaging essentials in essential tremor: A systematic review. *Neuroimage Clin*. 2014;5:217-31. doi: 10.1016/j.nicl.2014.05.003. PMID: 25068111; PMCID: PMC4110352.
43. Hadjipanayis CG, Carlson ML, Link MJ, et al. Congress of Neurological Surgeons Systematic review and evidence-based guidelines on surgical resection for the treatment of patients with vestibular schwannomas. *Neurosurgery*. 2018 Feb 1;82(2):E40-E43. doi: 10.1093/neuros/nyx512. PMID: 29309632.
44. Expert Panel on Gastrointestinal Imaging, Hindman NM, Arif-Tiwari H, et al. ACR appropriateness criteria - jaundice. *J Am Coll Radiol*. 2019 May;16(5S):S126-S140. doi: 10.1016/j.jacr.2019.02.012. PMID: 31054739.
45. Expert Panel on Neurological Imaging, Jain V, Policeni B, et al. ACR appropriateness criteria - tinnitus: 2023 update. *J Am Coll Radiol*. 2023 Nov;20(11S):S574-S591. doi: 10.1016/j.jacr.2023.08.017. PMID: 38040471.
46. Expert Panel on Neurologic Imaging, Kennedy TA, Corey AS, et al. ACR appropriateness criteria - orbits, vision, and visual loss. J Am Coll Radiol. 2018 May;15(5S):S116-S131. doi: 10.1016/j.jacr.2018.03.023. PMID: 29724415.
47. Expert Panel on Neurologic Imaging, Wippold FJ 2nd. ACR appropriateness criteria - focal neurologic deficit. *AJNR Am J Neuroradiol*. 2008 Nov;29(10):1998-2000. PMID: 19008324; PMCID: PMC8118959.
48. Farb R, Rovira A, Hodler J, et al. Hydrocephalus and CSF disorders. In: Diseases of the brain, head and neck, spine 2020–2023: Diagnostic imaging [Internet]. Cham (CH): Springer; 2020. Chapter 2. DKD Springer Series. 2020 Feb 15. PMID: 32119247; Bookshelf ID: NBK554339.
49. Harper JR, Cherukuri V, O'Reilly T, et al. Assessing the utility of low-resolution brain imaging: Treatment of infant hydrocephalus. *Neuroimage Clin*. 2021:32:102896. doi: 10.1016/j.nicl.2021.102896. PMID: 34911199; PMCID: PMC8646178.
50. Wangaryattawanich P, Rutman AM, Petcharunpaisan S, et al. Incidental findings on brain magnetic resonance imaging (MRI) in adults: A review of imaging spectrum, clinical significance, and management. *Br J Radiol*. 2023 Feb;96(1142):20220108. doi: 10.1259/bjr.20220108. PMID: 35522780; PMCID: PMC9975529.
51. Maas AIR, Menon DK, Manley GT, et al. Traumatic brain injury: Progress and challenges in prevention, clinical care, and research. *Lancet Neurol.*

2022 Nov;21(11):1004-1060. doi: 10.1016/S1474-4422(22)00309-X. Erratum in: *Lancet Neurol*. 2022 Oct 7. PMID: 36183712; PMCID: PMC10427240.
52. Tekes A, Senglaub SS, Ahn ES, et al. Ultrafast brain MRI can be used for indications beyond shunted hydrocephalus in pediatric patients. *AJNR Am J Neuroradiol*. 2018 Aug;39(8):1515-1518. doi: 10.3174/ajnr.A5724. PMID: 30002051; PMCID: PMC7410546.

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