Anthem

Clinical UM Guideline

Subject: Magnetic Source Imaging and Magnetoencephalography
Guideline #: CG-MED-76
Status: Revised

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Description

This document addresses magnetic source imaging (MSI) and magnetoencephalography (MEG).

Note: Please see the following related document for additional information:

- CG-MED-46 Electroencephalography and Video Electroencephalographic Monitoring

Clinical Indications

Medically Necessary:

Magnetoencephalography (MEG) is considered **medically necessary** for:

A. Preoperative evaluation of individuals with intractable focal epilepsy to identify and localize area(s) of epileptiform activity when other techniques are indeterminate; **or**
B. Preoperative localization of eloquent cortex prior to surgical resection of any of the following:
    1. Brain tumor in order to maximize preservation of eloquent cortex;**or**
    2. Vascular malformations in order to maximize preservation of eloquent cortex.

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Not Medically Necessary:

Magnetoencephalography (MEG) and magnetic source imaging (MSI) are considered **not medically necessary** for all other indications.

Coding

The following codes for treatments and procedures applicable to this guideline are included below for informational purposes. Inclusion or exclusion of a procedure, diagnosis or device code(s) does not constitute or imply member coverage or provider reimbursement policy. Please refer to the member's contract benefits in effect at the time of service to determine coverage or non-coverage of these services as it applies to an individual member.

When services may be Medically Necessary when criteria are met:

CPT	
95965	Magnetoencephalography (MEG), recording and analysis; for spontaneous brain magnetic activity (eg, epileptic cerebral cortex localization)
95966	Magnetoencephalography (MEG), recording and analysis; for evoked magnetic fields, single modality (eg, sensory, motor, language, or visual cortex localization)
95967	Magnetoencephalography (MEG), recording and analysis; for evoked magnetic fields, each additional modality (eg, sensory, motor, language, or visual cortex localization)
HCPCS	
S8035	Magnetic source imaging
ICD-10 Diagnosis	
C71.0-C71.9	Malignant neoplasm of brain
C72.20-C72.59	Malignant neoplasm of cranial nerves
C75.1-C75.3	Malignant neoplasm of pituitary gland and craniopharyngeal duct, pineal gland
C79.31	Secondary malignant neoplasm of brain
D09.3	Carcinoma in situ of thyroid and other endocrine glands [specified as pituitary or pineal gland]
D33.0-D33.3	Benign neoplasm of brain, cranial nerves
D35.2-D35.4	Benign neoplasm of pituitary gland, craniopharyngeal duct, pineal gland
D43.0-D43.3	Neoplasm of uncertain behavior of brain, cranial nerves
D44.3-D44.5	Neoplasm of uncertain behavior of pituitary gland and craniopharyngeal duct, pineal gland
D49.6	Neoplasm of unspecified behavior of brain
D49.7	Neoplasm of unspecified behavior of endocrine glands and other parts of nervous system [specified as pituitary gland, pineal gland]
G40.011-G40.019	Localization-related (focal) (partial) idiopathic epilepsy and epileptic syndromes with seizures of localized onset, intractable, with/without status epilepticus
G40.111-G40.119	Localization-related (focal) (partial) symptomatic epilepsy and epileptic syndromes with simple partial seizures, intractable, with/without status epilepticus
G40.211-G40.219	Localization-related (focal) (partial) symptomatic epilepsy and epileptic syndromes with complex partial seizures, intractable, with/without status epilepticus

G40.803-G40.804	Other epilepsy, intractable, with/without status epilepticus
G40.813-G40.814	Lennox-Gastaut syndrome, intractable, with/without status epilepticus
G40.833-G40.834	Dravet syndrome
G40.911-G40.919	Epilepsy, unspecified, intractable, with/without status epilepticus
I66.01-I66.9	Occlusion and stenosis of cerebral arteries, not resulting in cerebral infarction
I67.0-I67.9	Other cerebrovascular diseases
Q28.2	Arteriovenous malformation of cerebral vessels
Q28.3	Other malformations of cerebral vessels

When services are Not Medically Necessary:
For the procedure and diagnosis codes listed above when criteria are not met or for all other diagnoses not listed.

Discussion/General Information

MEG and MSI are non-invasive functional imaging techniques. In MEG, the weak magnetic forces associated with the electrical activity of the brain are monitored externally on the scalp to follow changes in the activity of the brain. This information can then be superimposed onto an anatomic image of the brain from a magnetic resonance imaging (MRI) scan to produce a functional image of the brain. This procedure is referred to as MSI. The proposed advantage of MSI is that, while the measurement of electrical activities is affected by surrounding brain structures, magnetic fields are not; therefore, it is possible to obtain accurate measures. The resulting image also has a very high resolution. These procedures have been proposed as methods that may effectively be used to evaluate individuals with tumors, epilepsy, and other neurologic conditions.

The most thoroughly studied clinical application of MSI is localization of the pre- and post-central gyri as a guide to surgical planning in those scheduled to undergo neurosurgery. The gyri contain the "eloquent" sensorimotor areas of the brain, the preservation of which is considered critical during any type of brain surgery. In normal situations these areas can be identified anatomically by MRI, but frequently the anatomy is distorted by underlying disease processes. In addition, the location of the eloquent functions is variable even among normal individuals. Therefore, localization of the eloquent cortex often requires such intraoperative invasive functional techniques as cortical stimulation under local anesthesia or somatosensory evoked responses on electrocorticography (ECoG). While these techniques can be done at the same time as the planned resection, they are cumbersome and can add up to 45 minutes of anesthesia time. Furthermore, sometimes these techniques can be limited by the small surgical field.

MSI can be performed on an outpatient basis and is comprised of two portions. The MEG functional mapping portion takes approximately 1 hour to complete, and the MRI portion may take an additional 30 minutes. However, for individuals with refractory epilepsy (presurgical evaluation of these individuals is one of the more common uses of this procedure), the MEG portion may take longer depending on the frequency of occurrence of epileptic activity.

Epilepsy
Epilepsy surgery has been an accepted form of treatment for over 50 years when medicines fail to control seizures. The seizure-producing areas of the brain are surgically removed. The decision for surgery relies on finding the seizure-producing areas and this can be accomplished by several diagnostic procedures.

Conventional neuroimaging methods include:

- Electroencephalogram (EEG) – standard technique for evaluating the electrical activity of the brain
- Positron Emission Tomography (PET) and single photon emission computed tomography (SPECT) – traditional functional neuroimaging procedures
- MRI and computed tomography (CT) – anatomic imaging modalities

Nevertheless, each of these indications has limitations, notably the ability to evaluate only functional or anatomic components, not a combination. To properly evaluate different neurologic conditions, there is a need to understand how the functional and anatomic components relate to one another.

Sutherling (2008) reported results of a clinical study in which MSI changed surgical decisions. Sixty-nine individuals diagnosed with partial epilepsy had video-EEG and imaging. MSI gave nonredundant information in 23 individuals (33%) and changed their surgical decision. Invasive intracranial electroencephalogram (ICEEG) electrodes were added to 13% (9 individuals) and surgical decision was changed in another 20% (14 individuals). Knowlton (2008) compared the predictive and prognostic value of MSI, PET and SPECT to ICEEG. After studying 77 individuals who had completed ICEEG, the researchers obtained sensitivity, specificity and predictive values for MSI, PET and SPECT. Using ICEEG as the gold-standard test, they computed the sensitivity, specificity and predictive values for each modality (MSI, PET and SPECT) alone and in combination. The sensitivities for both PET and SPECT were low (40% and 48%, respectively) when compared with MSI (60% and 64%). The combination of PET and MSI or SPECT and MSI increased the sensitivity to 80%. The additive sensitivity shows a lack of redundancy between MSI and either SPECT or PET. The studies conclude that MSI is not a stand-alone test and not meant to replace current modalities, but to supplement or enhance the results of current imaging.

In a 2008 systematic review, Lau and colleagues found that MEG was ineffective in impacting epilepsy surgery outcome. However, in May 2009, the American Academy of Neurology approved a model medical policy for MEG that supports the use of MEG for both presurgical evaluation of intractable epileptic foci and for assessment of eloquent cortex. This document explains MEG, outlines indications for MEG, shares limitations of MEG and provides an evaluation of MEG as a diagnostic tool. It stresses that MEG cannot replace intracranial EEG, but may guide the placement of electrodes, and in some cases may avoid unnecessary intracranial EEG. Also, the document stresses that MEG is not a first-line test, but one of several advanced presurgical technologies, and it should be used less frequently than other modalities such as surface EEG and anatomic imaging studies. MEG is not proposed as a stand-alone test, and presurgical assessment must be undertaken in the context of a comprehensive team approach.

A 2012 retrospective study by Jeong compared SPECT, PET, video EEG, and MEG with intracranial EEG to determine the value of the individual modalities to surgical decisions. A total of 23 participants were included. All had intractable epilepsy, no abnormal MRI results and all underwent MEG exam and surgery. Each test was then compared with the ictal onset zone defined by intracranial EEG. MEG had the highest hemispheric concordance rate at 83%, video EEG had a hemispheric concordance rate of 78%, PET had a hemispheric concordance rate of 70% and SPECT had a hemispheric concordance rate of 57%. The epileptogenic spikes were also analyzed and compared to the MEG clustered areas with the surgically resected area as determined by a postoperative MRI. Participants were evaluated following surgery for at least 1 year. Five participants had postoperative seizure outcome of Engel class I (free of disabling seizures), 3 had Engel class II (rare disabling seizures), 10 had Engel class III (worthwhile improvement), and 5 had Engel class IV (no worthwhile improvement). The authors concluded that the participants who had resection of MEG clusters had a better surgical outcome than those without such resection. This study does have limitations including its retrospective design, bias toward surgery, and influence of intracranial EEG placement based on the results of presurgical tests.

In another retrospective study by Almubarak and colleagues in 2014, the authors sought to evaluate how MEG, in anatomical concordance with ICEEG, impacts the presurgical evaluation in individuals with intractable epilepsy. A total of 50 participants had MEG and ICEEG correlations. Anatomical concordance was found in 33 participants, anatomical discordance was found in 17 participants. Based on the presurgical evaluation, 36 participants had surgery. The mean follow-up time following surgery was 12 months. Of the participants who had surgery, 19 of them had a seizure-free outcome and 17 participants had seizure recurrence. Of the 36 participants who had surgery, 27 of them had anatomical concordance of MEG and ICEEG. Of the 27 participants with anatomical concordance, 18 of them had seizure-free outcome, 9 of them had seizure recurrence, and 9 participants had anatomical discordance. While this study had limitations including its retrospective design and small sample size, the authors concluded that the anatomical concordance of MEG and ICEEG increased the chance of a seizure-free outcome after epilepsy surgery.

Rampp (2019) described a retrospective cohort study involving 1000 subjects with epilepsy who underwent MEG for evaluation of possible surgical intervention. A total of 405 subjects proceeded to surgery and the remaining 595 did not undergo surgery. The sensitivity of MEG for interictal epileptic activity was 72% with significant differences between temporal and extra-temporal lobe epilepsy. MEG was concordant with the presurgical consensus in 51% and showed additional or more focal involvement in an additional 32% of cases. Subjects who proceeded to surgery had a significantly higher percentage of monofocal MEG results. Complete resection of MEG-identified area was associated with significantly higher rate of seizure relief in the short and long-term. The diagnostic accuracy was significant in temporal and extra-temporal lobe cases but was significantly higher in extra-temporal lobe epilepsy (diagnostic odds ratios [ORs] of 4.4 and 41.6). ORs were also higher in non-lesional vs. lesional cases (42.0 vs. 6.2). The authors concluded that their “results show that magnetoencephalography provides non-redundant information, which significantly contributes to patient selection, focus localization and ultimately long-term seizure freedom after epilepsy surgery. Specifically in extra-temporal lobe epilepsy and non-lesional cases, magnetoencephalography provides excellent accuracy.”

He and others (2019) published a retrospective cohort study involving 121 subjects with drug resistant epilepsy who underwent MEG followed by surgical intervention. Subjects were stratified into those who had MEG results in concordance with clinically identified epileptogenic zones (n=73) and those that were discordant (n=48). The authors reported that favorable outcomes were achieved in 79.45% (n=58) of subjects in the concordant group vs. 62.50% (30 of 48) in the discordant group. MEG results were seizure free within the 2-10 year follow-up period. The differences of seizure-free rate between the concordant group and the discordant group were statistically significant. The authors concluded that for subjects with concordant MEG results, bilateral lesions on MRI are the only independent predictor of unfavorable seizure outcomes. For those with discordant MEG results, duration of seizures is the only independent predictor of unfavorable seizure outcomes.

The American College of Radiology addresses MEG for seizures and epilepsy in their 2019 Appropriateness Criteria® and states that MEG can “be useful as a complementary modality in assessment of location of seizures in preoperative brain mapping as well as identification of eloquent cortex to determine safe resection margins.” MSI has also contributed to the presurgical evaluation of individuals with epilepsy. MEG allows for complete brain coverage and overlay of source information on magnetic source images (MSIs). MEG should be complementary to EEG and not be used as a frontline tool for the evaluation of epilepsy. While the use and utility of MEG are growing, it has the most value when used by experienced users in epilepsy referral centers.

Brain Tumors and Arteriovenous Malformations
While MSI has principally been evaluated as a non-invasive alternative to invasive monitoring, MSI has also been used as a tool in the assessment of head trauma, brain plasticity and disorders of language, memory and cognition. Neurosurgical procedures are associated with risk because of the damage they can cause to functionally important structures that are adjacent to areas targeted for surgery. Characterization of the functional anatomy is important prior to surgery.

Korvenoja (2006) compared MEG to functional MRI in localizing the central sulcus in 15 individuals. MEG identified the central sulcus correctly in all 15 individuals which was verified at intraoperative mapping. Functional MRI correctly identified the central sulcus in 11 individuals. Preservation of the eloquent areas of the brain (language and memory areas) is especially important also. Pelletier (2007) compared the intracarotid amobarbital test to other neuroimaging techniques. The Wada test has been the most widely used test in the presurgical evaluation of language lateralization and memory functions. However, the test is invasive. MEG provides a non-invasive alternative.

Other Conditions
For diagnosis of post-traumatic stress disorder (PTSD), studies have demonstrated a correlation between MEG-derived synchronous neural interactions and the presence or absence of PTSD in a group of affected and control subjects. While accuracy seemed to be as high as 90%, additional studies are required, but have not yet been published, to determine whether such testing using MEG improves the clinical outcomes of individuals with PTSD (Georgopoulos, 2007; Georgopoulos, 2010; Huang, 2014).

Currently there is a paucity of peer-reviewed, published literature to support the use of MEG or MSI for other neurological conditions.

Definitions

Electroencephalography (EEG): A test that involves recording of the electrical activity of the brain (brain waves).

Epilepsy: A condition of the brain where an individual is prone to repeated seizures.

Magnetoencephalography (MEG) (Also referred to as Magnetic Source Imaging [MSI]): A noninvasive measurement of the magnetic fields generated by brain activity.

Seizure: An excessive surge of electrical activity in the brain, usually lasting from a few seconds up to a few minutes, causing a wide range of symptoms or effects depending on which parts of the brain are involved in the abnormal electrical activity.

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Government Agency, Medical Society, and Other Authoritative Publications:

1. American Academy of Neurology. Model Coverage Policy. Magnetoencephalography (MEG). (2009). Available at: https://www.aan.com/siteassets/home-page/tools-and-resources/practicing-neurologist--administrators/billing-and-coding/model-coverage-policies/16megmodelpolicy_tr.pdf. Accessed on March 22, 2023.
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Magnetic Source Imaging
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History

Status	Date	Action
Revised	05/11/2023	Medical Policy & Technology Assessment Committee (MPTAC) review. Removed "designed to localize a focus" indication A and reformatted bullets to alphanumeric in Clinical Indications section. Updated References section.
Reviewed	05/12/2022	MPTAC review. Updated References section.
Reviewed	05/13/2021	MPTAC review. Updated References section. Reformatted Coding section.
	10/01/2020	Updated Coding section with 10/01/2020 ICD-10-CM changes; added G40.833-G40.834.
Reviewed	05/14/2020	MPTAC review. Updated Discussion/General Information and References sections. Added Definitions section.
Reviewed	06/06/2019	MPTAC review.
New	07/26/2018	MPTAC review. Initial document development. Moved content of RAD.00019 Magnetic Source Imaging and Magnetoencephalography to new clinical utilization management guideline document with the same title.
