Froedtert & Medical College of Wisconsin

Magnetoencephalography (MEG)

for Patients with Epilepsy or Brain Tumors

The most relied-upon techniques for mapping normal and abnormal areas in the brain require neurosurgical procedures. In epilepsy, accurate determination of the areas from which seizures arise is performed with electrical recordings directly from the surface of the brain. These same electrodes can also be used to electrically map functional areas. Electrical mapping of the brain can also be done during neurosurgical procedures for removing tumors after exposure of the brain surface.

The relationship between abnormal areas that need to be targeted for surgery and surrounding functional tissue, and the feasibility of successful surgery, is only clear after the patient has undergone an invasive test that involves major surgery, several days of hospitalization and substantial surgical risks.

A non-invasive test that provides much of the same information can be extremely valuable for providing a better assessment of the risks and benefits of surgical treatment.

Mapping the Brain with MEG

Magnetoencephalography (MEG) is a non-invasive diagnostic tool that can help neurologists and neurosurgeons evaluate and map brain activity before surgery. MEG offers a way to localize brain activity with a high spatial and temporal resolution, and represents a significant advance in the care of patients with brain tumors or severe epilepsy. A MEG scan is performed as an outpatient procedure. For some patients, MEG can replace invasive testing done in the ICU or in the operating room.

Froedtert & The Medical College of Wisconsin (*froedtert.com*) are the first in Wisconsin to offer MEG in a clinical setting. In addition to clinical uses for neurosurgical planning, Froedtert & The Medical College will also be conducting research studies using MEG to further develop this technology. Children receiving care for a brain tumor or epilepsy at Children's Hospital of Wisconsin (*chw.org*) will also benefit from the availability of MEG for surgical planning.

How does MEG Work?

MEG uses extremely sensitive and sophisticated sensors to record magnetic fields over the surface of the head. These fields are generated by the tiny electrical currents that flow between neurons inside the brain. MEG scans these magnetic fields in the brain millisecond by millisecond.

MEG moves beyond existing technology in its ability to pinpoint in space and time normal and abnormal brain activity. By measuring the magnetic fields, the cell assemblies that produce each field can be located with an unprecedented millisecond temporal resolution.

For patients with brain tumors or for epilepsy patients who require surgery, MEG can help precisely identify the areas to be removed, while identifying cerebral tissue that must be spared to preserve important brain functions. This also enhances the possibility of surgical success for patients whose tumor or epilepsy is considered inoperable.

(continued on reverse)

- **Using MEG in epilepsy patients** — about one-third of the estimated 30,000 people with epilepsy in Wisconsin are unable to achieve satisfactory control of seizures with medication alone. Epilepsy surgery can be an effective treatment for many patients with drug-resistant partial seizures. However, successful surgical treatment depends on accurately determining the region of seizure onset — the epileptogenic zone — and its relationship to functionally important brain areas.

  Often, the feasibility of surgery can be confirmed only after an invasive procedure — an intracranial EEG (iEEG) recording of seizures and electrical stimulation mapping of cortical functions. An iEEG involves surgery to place electrodes directly on the brain surface after opening the skull. An iEEG study has limited spatial coverage of suspected epiletogenic zones and has risks and costs related to surgery and hospitalization. Therefore, non-invasive techniques to locate the epileptogenic zone and functional cortex can be of enormous value in guiding epilepsy surgery.

  MEG provides a non-invasive way to localize the areas of the brain that show evidence of electrical irritability with a high spatial precision. The high temporal resolution of MEG also allows the epileptologists to distinguish between areas from which abnormal electrical discharges originate and those to which they propagate. MEG can also identify areas important for motor function, language or vision, and their relationship to abnormal areas.

  In epilepsy patients, a MEG study can:

  - Make it unnecessary to perform an invasive recording of brain electrical activity in some patients, thereby decreasing hospital stays.
  - Identify potential areas of electrical abnormalities, and thereby allow better placement of intracranial electrodes in other patients.
  - Allow patients to make better-informed decisions about pursuing surgical treatment, given the relationship between abnormal areas and important brain functions identified non-invasively using MEG.

- **Using MEG in brain tumor patients** — MEG can map the exact location of normally functioning areas near the tumor, so that surgery can be planned to minimize the loss of brain function. Tumors also often produce seizures from their effect on surrounding brain. In these instances, MEG may be sufficient to identify the relationship between the tumor and area of seizure onsets, so that along with the tumor, the abnormal areas region producing the seizures can also be targeted for surgical removal.

How is MEG different from EEG?
MEG measures magnetic fields, and EEG measures electrical potentials generated by the electrical activity of the brain. An important difference is that the skull and tissue surrounding the brain don't affect the magnetic fields measured by MEG, while they strongly affect the electrical potentials measured by EEG.

When electrical signals from the brain pass through the skull and scalp, they are distorted and severely weakened. These same tissues, however, are transparent to the magnetic fields generated in the brain. Therefore, MEG offers a more accurate spatial estimate of brain activity than EEG. Compared to EEG, MEG allows for more usable and reliable localization of brain function. MEG can localize brain activity with a much higher spatial resolution than EEG, with the same millisecond scale time-resolution as EEG.

How are the results used?
Trained MEG technologists ensure that MEG recordings provide the optimal quality of data. They work in coordination with the MEG physicists to provide in-depth analysis of the MEG recordings, possibly in conjunction with the MRI scan. After several days, a detailed report is subsequently provided to the patient's physician.

Does health insurance cover a MEG scan?
Medicare covers MEG diagnostic scans for patients with epilepsy and brain tumors. In other cases, a pre-authorization request will be sent to your health insurance provider by Froedtert Hospital in coordination with your referring physician.

For information on patient preparation for a MEG exam and what happens during a MEG exam, please visit *froedtert.com* (keyword MEG).