



## Magnetic Resonance, Functional (fMRI) - Brain

Functional magnetic resonance imaging (fMRI) measures the small changes in blood flow that occur with brain activity. It may be used to examine the brain's functional anatomy, (determine which parts of the brain are handling critical functions), evaluate the effects of stroke or other disease, or to guide brain treatment. fMRI may detect abnormalities within the brain that cannot be found with other imaging techniques.



Tell your doctor about any health problems, recent surgeries, or allergies, and whether there's a possibility you are pregnant. The magnetic field is not harmful, but it may cause some medical devices to malfunction. Most

orthopedic implants pose no risk, but you should always tell the technologist if you have any devices or metal in your body. Guidelines about eating and drinking before your exam vary between facilities. Unless you are told otherwise, take your regular medications as usual and try to maintain your typical habits for drinking caffeinated beverages (especially coffee). For example, if you normally drink coffee every morning, try not to skip it on the day of your exam. If you rarely drink coffee, try to avoid it on the day of your exam. If you rarely drink coffee, try to avoid it on the day of your exam. Leave jewelry at home and wear loose, comfortable clothing. You may be asked to wear a gown. If you have claustrophobia or anxiety, you may want to ask your doctor for a mild sedative prior to the exam.

## What is Functional MR Imaging (fMRI) - Brain?

Magnetic resonance imaging (MRI) is a noninvasive medical test that physicians use to diagnose medical conditions.

MRI uses a powerful magnetic field, radio frequency pulses and a computer to produce detailed pictures of organs, soft tissues, bone and virtually all other internal body structures. MRI does not use ionizing radiation (x-rays).

Detailed MR images allow physicians to evaluate various parts of the body and determine the presence of certain diseases. The images can then be examined on a computer monitor, transmitted electronically,

printed or copied to a CD or uploaded to a digital cloud server.

Functional magnetic resonance imaging (fMRI) uses MR imaging to measure the tiny changes in blood flow that take place in an active part of the brain.

## What are some common uses of the procedure?

fMRI is becoming the diagnostic method of choice for learning how a normal, diseased or injured brain is working, as well as for assessing the potential risks of surgery or other invasive treatments of the brain.

Physicians perform fMRI to:

- examine the functional anatomy of the brain.
- determine which part of the brain is handling critical functions such as thought, speech, movement and sensation, which is called brain mapping
- help assess the effects of stroke, trauma, or degenerative disease (such as Alzheimer's) on brain function.
- monitor the growth and function of brain tumors.
- guide the planning of surgery, radiation therapy, or other invasive treatments for the brain.

## How should I prepare?

You may be asked to wear a gown during the exam or you may be allowed to wear your own clothing if it is loose-fitting and has no metal fasteners.

Guidelines about eating and drinking before an MRI exam vary with the specific exam and with the imaging facility. Unless you are told otherwise, you may follow your regular daily routine and take food and medications as usual.

Some MRI examinations may require you to receive an injection of contrast material into the bloodstream. The radiologist, technologist or a nurse may ask if you have allergies of any kind, such as an allergy to iodine or x-ray contrast material, drugs, food, or the environment, or if you have asthma. The contrast material most commonly used for an MRI exam contains a metal called gadolinium. Gadolinium can be used in patients with iodine contrast allergy. It is far less common for a patient to have an allergy to a gadolinium-based contrast agent used for MRI than the iodine-containing contrast for CT. However, even if it is known that the patient has an allergy to the gadolinium contrast, it may still be possible to use it after appropriate pre-medication. Patient consent will be requested in this instance. For more information on adverse reactions to gadolinium-based contrast agents, please consult the ACR Manual on Contrast Media.

You should also let the radiologist know if you have any serious health problems, or if you have had any recent surgeries. Some conditions, such as severe kidney disease, may prevent you from being given gadolinium contrast for an MRI. If you have a history of kidney disease or liver transplant, it will be necessary to perform a blood test to determine whether the kidneys are functioning adequately.

Women should always inform their physician or technologist if there is any possibility that they are pregnant. MRI has been used for scanning patients since the 1980s with no reports of any ill effects on pregnant women or their unborn babies. However, because the unborn baby will be in a strong magnetic field, pregnant women should not have this exam in the first three to four months of pregnancy unless the potential benefit from the MRI exam is assumed to outweigh the potential risks. Pregnant women should not receive injections of gadolinium contrast material except when absolutely necessary for medical treatment. See the MRI Safety page for more information about pregnancy and MRI.

If you have claustrophobia (fear of enclosed spaces) or anxiety, you may want to ask your physician for a prescription for a mild sedative prior to your scheduled examination.

Jewelry and other accessories should be left at home, if possible, or removed prior to the MRI scan. Because they can interfere with the magnetic field of the MRI unit, metal and electronic items are not allowed in the exam room. In addition to affecting the MRI images, these objects can become projectiles within the MRI scanner room and may cause you and/or others nearby harm. These items include:

- jewelry, watches, credit cards and hearing aids, all of which can be damaged
- pins, hairpins, metal zippers and similar metallic items, which can distort MRI images
- removable dental work
- pens, pocket knives and eyeglasses
- body piercings

In most cases, an MRI exam is safe for patients with metal implants, except for a few types. People with the following implants cannot be scanned and should not enter the MRI scanning area:

- cochlear (ear) implant
- some types of clips used for brain aneurysms
- some types of metal coils placed within blood vessels
- nearly all cardiac defibrillators and pacemakers

You should tell the technologist if you have medical or electronic devices in your body. These objects may interfere with the exam or potentially pose a risk, depending on their nature and the strength of the MRI magnet. Many implanted devices will have a pamphlet explaining the MRI risks for that particular device. If you have the pamphlet, it is useful to bring that to the attention of the scheduler before the exam and bring it to your exam in case the radiologist or technologist has any questions. Some implanted devices require a short period of time after placement (usually six weeks) before being safe for MRI examinations. Examples include but are not limited to:

- artificial heart valves
- implanted drug infusion ports
- artificial limbs or metallic joint prostheses
- implanted nerve stimulators
- metal pins, screws, plates, stents or surgical staples

If there is any question of their presence, an x-ray may be taken to detect and identify any metal objects. In general, metal objects used in orthopedic surgery pose no risk during MRI. However, a recently placed artificial joint may require the use of another imaging procedure.

Patients who might have metal objects in certain parts of their bodies may also require an x-ray prior to an

MRI. You should notify the technologist or radiologist of any shrapnel, bullets, or other pieces of metal that may be present in your body due to prior accidents. Foreign bodies near and especially lodged in the eyes are particularly important because they may move during the scan, possibly causing blindness. Dyes used in tattoos may contain iron and could heat up during an MRI scan, but this is rare. Tooth fillings and braces usually are not affected by the magnetic field, but they may distort images of the facial area or brain, so you should let the radiologist know about them.

## What does the equipment look like?

The traditional MRI unit is a large cylinder-shaped tube surrounded by a circular magnet. You will lie on a moveable examination table that slides into the center of the magnet.

Some MRI units, called short-bore systems, are designed so that the magnet does not completely surround you. Some newer MRI machines have a larger diameter bore which can be more comfortable for larger size patients or patients with claustrophobia. Other MRI machines are open on the sides (open MRI). Open units are especially helpful for examining larger patients or those with claustrophobia. Newer open MRI units provide very high quality images for many types of exams. Older open MRI units may not provide this same image quality. Certain types of exams cannot be performed using open MRI. For more information, consult your radiologist.

The computer workstation that processes the imaging information is located in a separate room from the scanner.

## How does the procedure work?

Unlike conventional x-ray examinations and computed tomography (CT) scans, MRI does not utilize ionizing radiation. Instead, radiofrequency pulses re-align hydrogen atoms that naturally exist within the body. This does not cause any chemical changes in the tissues. As the hydrogen atoms return to their usual alignment, they emit different amounts of energy depending on the type of body tissue they are in. The MR scanner captures this energy and creates a picture of the tissues scanned based on this information.

The magnetic field is produced by passing an electric current through wire coils in most MRI units. Other coils, located in the machine and in some cases, placed around the part of the body being imaged, send and receive radio waves, producing signals that are detected by the coils. The electric current does not come in contact with the patient.

A computer then processes the signals and generates a series of images, each of which shows a thin slice of the body. The images can then be studied from different angles by the interpreting radiologist.

Frequently, the differentiation of abnormal (diseased) tissue from normal tissues is better with MRI than with other imaging modalities such as x-ray, CT and ultrasound.

In an fMRI examination, you will perform one or more tasks during the imaging process, such as tapping your fingers or toes, pursing your lips, wiggling your tongue, reading, viewing pictures, listening to

speech and/or playing simple word games. This will cause increased metabolic activity in the areas of the brain responsible for these tasks. This activity, which includes expanding blood vessels, chemical changes and the delivery of extra oxygen, can then be recorded on MRI images.

## How is the procedure performed?

MRI examinations may be performed on outpatients or inpatients.

You will be positioned on the moveable examination table. Straps and bolsters may be used to help you stay still and maintain the correct position during imaging.

Devices that contain coils capable of sending and receiving radio waves may be placed around or adjacent to the area of the body being studied.

For fMRI, your head may be placed in a brace designed to help hold it still. This brace may include a mask that is created especially for you. You may be given special goggles and/or earphones to wear, so that audio-visual stimuli (for example, a projection from a computer screen or recorded sounds) may be administered during the scan.

If a contrast material will be used in the MRI exam, a physician, nurse or technologist will insert an intravenous (IV) catheter, also known as an IV line, into a vein in your hand or arm. A saline solution may be used to inject the contrast material. The solution will drip through the IV to prevent blockage of the IV catheter until the contrast material is injected.

You will be placed into the magnet of the MRI unit and the radiologist and technologist will perform the examination while working at a computer outside of the room.

When the examination is complete, you may be asked to wait until the technologist or radiologist checks the images in case additional images are needed.

Your intravenous line will be removed.

MRI exams generally include multiple runs (sequences), some of which may last several minutes.

The entire examination is usually completed within one hour.

MR spectroscopy, which provides additional information on the chemicals present in the body's cells, may also be performed during the MRI exam and may add approximately 15 minutes to the total exam time.

## What will I experience during and after the procedure?

Most MRI exams are painless. However, some patients find it uncomfortable to remain still during MR imaging. Others experience a sense of being closed-in (claustrophobia) while in the MRI scanner. Therefore, sedation can be arranged for those patients who anticipate anxiety, but fewer than one in 20 require medication.

It is normal for the area of your body being imaged to feel slightly warm, but if it bothers you, notify the radiologist or technologist. It is important that you remain perfectly still while the images are being recorded, which is typically only a few seconds to a few minutes at a time. For some types of exams, you may be asked to hold your breath. You will know when images are being recorded because you will hear tapping or thumping sounds when the coils that generate the radiofrequency pulses are activated. You will be able to relax between imaging sequences, but will be asked to maintain your position as much as possible.

You will usually be alone in the exam room during the MRI procedure. However, the technologist will be able to see, hear and speak with you at all times using a two-way intercom. Many MRI centers allow a friend or parent to stay in the room as long as they are also screened for safety in the magnetic environment.

You may be offered or you may request earplugs to reduce the noise of the MRI scanner, which produces loud thumping and humming noises during imaging. MRI scanners are air-conditioned and well-lit. Some scanners have music to help you pass the time.

When the contrast material is injected, it is normal to feel coolness and a flushing sensation for a minute or two. The intravenous needle may cause you some discomfort when it is inserted and once it is removed, you may experience some bruising. There is also a very small chance of irritation of your skin at the site of the IV tube insertion.

If you have not been sedated, no recovery period is necessary. You may resume your usual activities and normal diet immediately after the exam. A few patients experience side effects from the contrast material, including nausea and local pain. Very rarely, patients are allergic to the contrast material and experience hives, itchy eyes or other reactions. If you experience allergic symptoms, a radiologist or other physician will be available for immediate assistance.

## Who interprets the results and how do I get them?

A radiologist, a physician specifically trained to supervise and interpret radiology examinations, will analyze the images and send a signed report to your primary care or referring physician, who will share the results with you.

## What are the benefits vs. risks?

### Benefits

- MRI is a noninvasive imaging technique that does not involve exposure to ionizing radiation.
- MRI can help physicians evaluate both the structure of an organ and how it is working.
- MRI enables the discovery of abnormalities that might be obscured by bone with other imaging methods.
- fMRI enables the detection of abnormalities of the brain, as well as the assessment of the normal functional anatomy of the brain, which cannot be accomplished with other imaging techniques.



## Risks

- The MRI examination poses almost no risk to the average patient when appropriate safety guidelines are followed.
- If sedation is used, there are risks of excessive sedation. However, the technologist or nurse will monitor your vital signs to minimize this risk.
- Although the strong magnetic field is not harmful in itself, implanted medical devices that contain metal may malfunction or cause problems during an MRI exam.
- Nephrogenic systemic fibrosis is currently a recognized, but rare, complication of MRI believed to be caused by the injection of high doses of gadolinium-based contrast material in patients with very poor kidney function. Careful assessment of kidney function before considering a contrast injection minimizes the risk of this very rare complication.
- There is a very slight risk of an allergic reaction if contrast material is injected. Such reactions are usually mild and easily controlled by medication. If you experience allergic symptoms, a radiologist or other physician will be available for immediate assistance.
- Manufacturers of intravenous contrast indicate mothers should not breastfeed their babies for 24-48 hours after contrast medium is given. However, both the American College of Radiology (ACR) and the European Society of Urogenital Radiology note that the available data suggest that it is safe to continue breastfeeding after receiving intravenous contrast. For further information please consult the ACR Manual on Contrast Media and its references.

## What are the limitations of fMRI of the Brain?

High-quality images are assured only if you are able to remain perfectly still and follow breath-holding instructions while the images are being recorded. If you are anxious, confused or in severe pain, you may find it difficult to lie still during imaging.

A person who is very large may not fit into the opening of certain types of MRI machines.

The presence of an implant or other metallic object sometimes makes it difficult to obtain clear images due to streak artifacts from the metallic objects. Patient movement can have the same effect.

A very irregular heartbeat may affect the quality of images obtained using techniques that time the imaging based on the electrical activity of the heart, such as electrocardiography (EKG).

MRI generally is not recommended for patients who have been acutely injured; however, this decision is based on clinical judgment. This is because traction devices and many types of life support equipment may distort the MR images and as a result, must be kept away from the area to be imaged. Furthermore, the examination takes longer than other imaging modalities (typically x-ray and CT) and the results may not be immediately available, as is often necessary in trauma situations.

Although there is no reason to believe that magnetic resonance imaging harms the fetus, pregnant women usually are advised not to have an MRI exam during the first trimester unless medically necessary.

MRI typically costs more and may take more time to perform than other imaging modalities.

Functional MRI is still evolving and improving. While it appears to be as accurate in finding the location of brain activity as any other method, overall there is less experience with fMRI than with many other MRI techniques. Your physician may recommend additional tests to confirm the results of fMRI if there are critical decisions to make (such as in planning brain surgery).

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