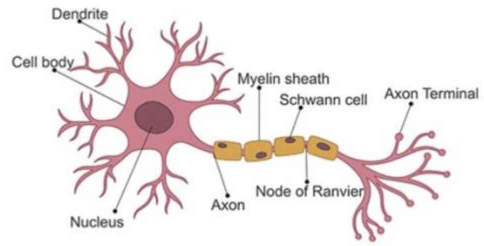
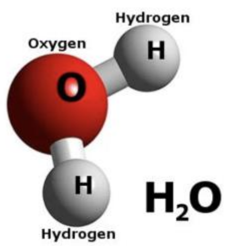
September 2022 Newsletter

MRI Basics

Magnetic resonance imaging (MRI) is a noninvasive scan that uses strong magnetic fields, radio waves and computers to create detailed images of the brain, spinal cord or other parts of the body. It is the preferred imaging method to help diagnose MS, and to monitor disease activity and the effectiveness of treatment.



The central nervous system mainly consists of neurons, which are specialized cells that send and receive signals from the brain via electrical and chemical signals. All neurons have three essential parts – the cell body, axon and dendrite. Most axons are insulated with a sleeve of fatty tissue called myelin, which helps with the conduction of signals. The myelinated axons are bundled into tracts deep in the white matter of the brain (named for its relatively light appearance resulting from the lipid content of myelin). In MS, the immune system attacks the myelin coating surrounding nerves and the resulting damage is seen on MRI as lesions in the white matter. Information processing occurs in the gray matter, which is the darker tissue on the surface of the brain that consists mainly of nerve cell bodies, dendrites and bare (unmyelinated) axons. According to a recent study, brain atrophy (the gradual loss in brain volume over time) occurs faster in people with MS than healthy adults. Brain volume is typically measured using MRI images of the gray matter.



Unlike an X-ray or a computed tomography (CT) scan, MRI does not rely on radiation. It is based on the fact that the body is made up of about 60% water and this water is magnetic. The MRI scanner is essentially a large, strong magnet. Water is made up of hydrogen and oxygen, and the hydrogen atoms are sensitive to magnetic fields. When a person lies inside of an MRI scanner, all of their water atoms align with its magnetic field (like a compass needle aligning to the magnetic field of the Earth). Once aligned, a radio wave is used to disturb the atoms. When the radio wave is turned off, the atoms return to the alignment. While going back they emit a signal which is transmitted to a computer, analyzed and converted into an image. Because the myelin sheath surrounding nerves is fatty, it repels water. In the areas where the myelin has been damaged by MS, the fat is stripped away. With the fat gone, the area holds more water, and shows up on an MRI scan as either a bright white spot or a darkened area depending on the type of scan that is used.

There are several different types of MRI scans. Sometimes gadolinium, a contrast agent, is given intravenously prior to the scan. Because gadolinium is a large molecule, it normally cannot pass through the blood-brain barrier. However, when there is active inflammation, the blood brain barrier is disrupted and gadolinium can enter and highlight inflamed areas.

Common MRI scans used in MS:

T-1 weighted without gadolinium

- Shows dark areas (hypointensities) that are thought to indicate areas of permanent brain damage.

T-1 weighted with gadolinium

- Shows bright areas (enhancing lesions) that indicate areas of active inflammation.

T-2 weighted

- Shows the total number of lesions, both old and new.

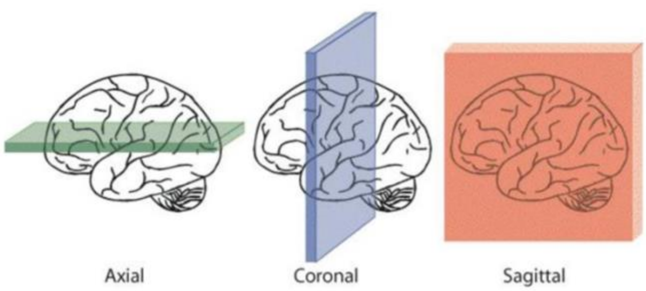
FLAIR (Fluid Attenuated Inversion Recovery)

- Shows MS activity by reducing interference from the spinal fluid.

* The terms T-1 and T-2 refer to the time between the magnetic pulses and when the image is taken.

Most MRI scans take 30 to 60 minutes, depending on the area being scanned and the number of images taken. MRI requires a person to lie flat on a bed (which is moved inside the scanner) and keep as still as possible for the duration of the scan. Although the procedure is painless, the machine itself can be very noisy. Most imaging centers provide foam ear plugs as hearing protection. An intravenous line (IV) may be inserted if contrast dye is being used.

MRI can show the brain and spinal cord in many different orientations. Typically, the brain is "sliced" into sections in one of three possible ways. **Axial slices** are horizontal slices taken from top to bottom or from bottom to top. **Coronal slices** are face-forward slices taken from front to back or from back to front. **Sagittal slices** are side-view slices taken from left to right or from right to left. Using these different orientations allows MS lesions to be seen from different points of view, giving a better sense of where the lesions are related to other brain or spinal cord structures. Sequential images allow one to literally scroll through the brain. For the best visualization, it's important to minimize the gap between images. MRI "slices" can also have a certain thickness. Minimizing this thickness is optimal as less tissue in each slice results in less blur of tissues when they are lying over each other.



Just like with any picture, resolution is an important aspect of MRI. The strength of the magnet used in the MRI machine is important in this regard. Generally, the more powerful the magnet, the better the resolution of the image produced by the MRI scan. The strength of MRI magnets is measured by a unit called Tesla (T). One Tesla is equal to approximately 20,000 times the strength of the Earth's magnetic field at its surface. Most MRI scanners used in clinics have magnets of 1.5 or 3T. MRI machines used for research purposes have a much higher magnet strength.

In 2021, experts from Magnetic Resonance Imaging in MS, the Consortium of MS Centers and North American Imaging in MS Cooperative met to update guidelines on how and

when to use MRI for MS diagnosis and treatment monitoring. These recommendations contain standardized MRI protocols that define the optimal magnet strength, slice thickness, image resolution and coverage. According to these guidelines, MRI scanning is recommended when starting or changing treatment and, again, 3 to 6 months after treatment has begun. MRI should be done annually after the first few years of treatment, with longer intervals for clinically stable individuals. Where possible, follow-up scans should be obtained on the same scanner, so that it's easier to make comparisons from one scan to the next. Gadolinium is recommended for a person's first MRI, when starting or changing treatments, and for monitoring disease activity if the presence of an enhancing lesion would change management. The administration of contrast agents should be done at least 5 minutes, and ideally 10 minutes, before the scan. Spinal cord imaging is recommended in some cases (for example, people with few brain lesions or worsening symptoms that aren't explained by brain MRI) to detect active spinal cord lesions and to exclude other health conditions involving the spine. The guidelines also state that MRI should also be used for drug safety monitoring (for example, before using medications that have a high risk for progressive multifocal leukoencephalopathy, or PML).

MRI is generally considered a very safe procedure. Scanning may be more difficult for obese individuals, or those that cannot lie on their back for extended periods of time. Some people may feel claustrophobic during their scan. Anti-anxiety medications are often helpful, if this is a problem. There are no known risks associated with exposure to strong magnetic fields, however they can affect metal that is in or on the body. Therefore, it's important to remove any worn metal (jewelry, eyeglasses, etc.) before a scan. Secured lockers are available at most facilities to store personal possessions. People with certain metal implants should not undergo an MRI scan. Although the use of gadolinium-based contrast agents (GBCAs) is generally considered safe, they do involve some risk. In rare cases, specifically in those with impaired kidney or liver function, GBCAs can increase the risk of nephrogenic systemic fibrosis, a serious condition marked by fibrosis (scarring) throughout the body. Recent research shows that GBCAs can be retained in deposits in the brain and other body tissues. These deposits have not been linked to any overt health problems, but more research is needed to better understand their clinical relevance. In 2017, the Food and Drug Administration issued a communication on the use of GBCAs and made recommendations for the types of gadolinium that are less likely to be retained in the body.

It's important to note that while MRI is gold standard for identifying and monitoring neurodegenerative changes in the brain and spinal cord, it isn't foolproof in the diagnosis and management of MS. A small percentage of people with the disease don't have abnormalities on MRI. Therefore, a normal scan doesn't completely rule out MS. In addition, these scans don't always explain a person's symptoms. Lesions may be in locations that don't produce symptoms. Some areas of damage that are causing symptoms may be too small to see on the scan. It's also possible for the brain to develop a work around to compensate for nerve damage, which makes the task of correlating what is seen on an MRI scan and clinical signs even more difficult. It's important to note that not all people with brain lesions have MS. Small areas that resemble MS are often seen on MRI in healthy people over the age of 50, but are actually related to the aging process. Also, people with other health conditions, such as stroke and migraine, may have abnormal areas on the MRI that resemble MS lesions.

MRI is an important clinical tool for diagnosing and monitoring MS. It is also invaluable to MS researchers. Are you interested in learning more? Listen to Episode 6 of our Chat with Chat webinar, entitled "Brain Scans in MS: relevance and patient experiences," now with closed captioning! Stay tuned as our series on diagnostic tools in MS continues next month with an article on lumbar puncture!