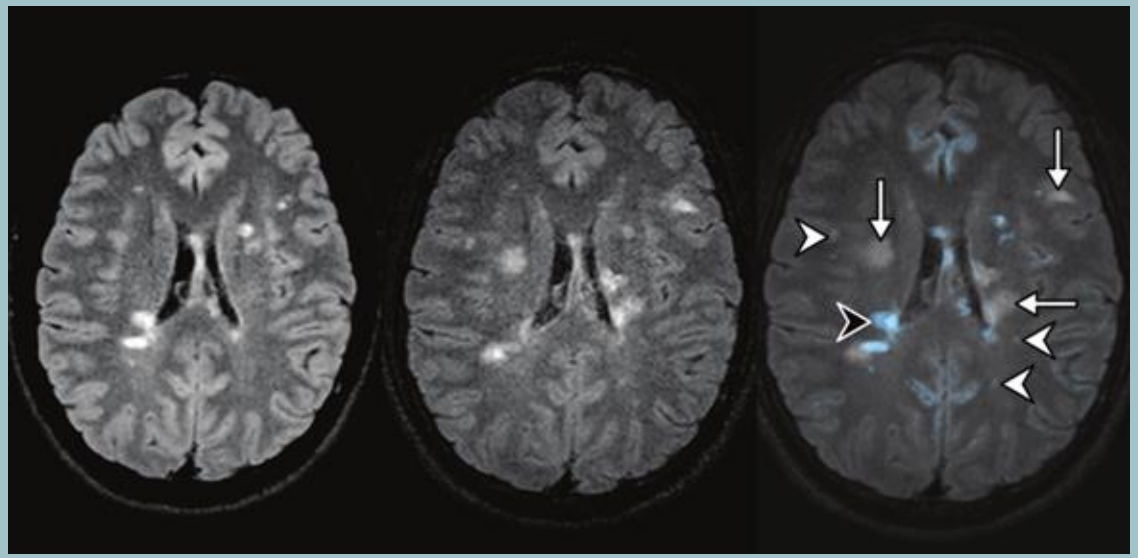
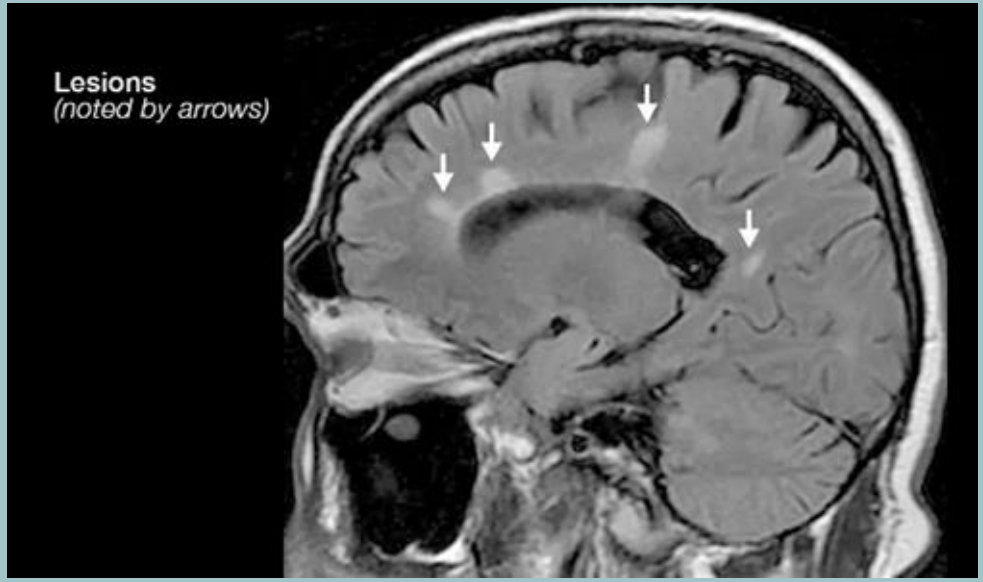
C20 - New Advances in Radiology for Multiple Sclerosis



Objectives

- What is Multiple Sclerosis and what causes it
- Different types
- History
- Treatments
- New technology
  - MRI based imaging
  - Quantitative susceptibility mapping
  - Diffusion Basis Spectrum imaging
  - Kappa Free light chain testing
  - AI



"Department of Neurology." *Symptoms of MS | USF Health*, health.usf.edu/medicine/neurology/multiple-sclerosis/symptoms-ms. Accessed 22 Jan. 2026.

Introduction

- Multiple Sclerosis or more commonly called MS is a chronic, immune-mediated disease that targets the central nervous system, leading to demyelination, and a wide range of neurological symptoms.

- Because its early presentation often mimics other disorders, which has caused it to be commonly misdiagnosed.

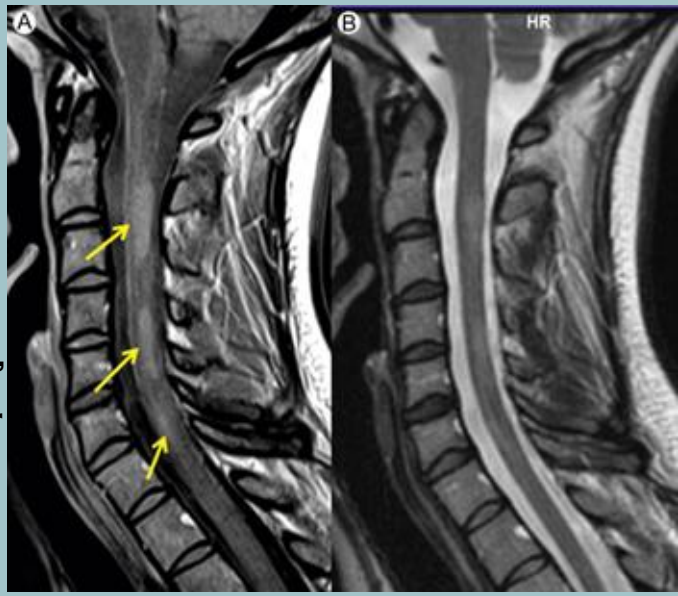
- Advances in radiologic technology have significantly improved diagnostic accuracy and reduced time in diagnosing.

https://www.sciencedirect.com/science/article/pii/S0887217116300245#f0010

A) Does not show focal spot lesions
B) Shows focal spot lesions

Introduction

- This presentation will review the causes, types, and historical understanding of diagnosing multiple sclerosis, highlighting developments
- Like MRI-based imaging, the McDonald criteria, and the increasing role of technology in radiology.
- Including 7-tesla MRI, Quantitative Susceptibility Mapping, and Diffusion Basis Spectrum Imaging. To provide greater sensitivity for identifying lesions, measuring myelin integrity, and distinguishing multiple sclerosis from similar neurological diseases. Additionally, Artificial Intelligence now enhances the detection of lesions, predicts disease progression, and supports personalized treatment planning for individuals



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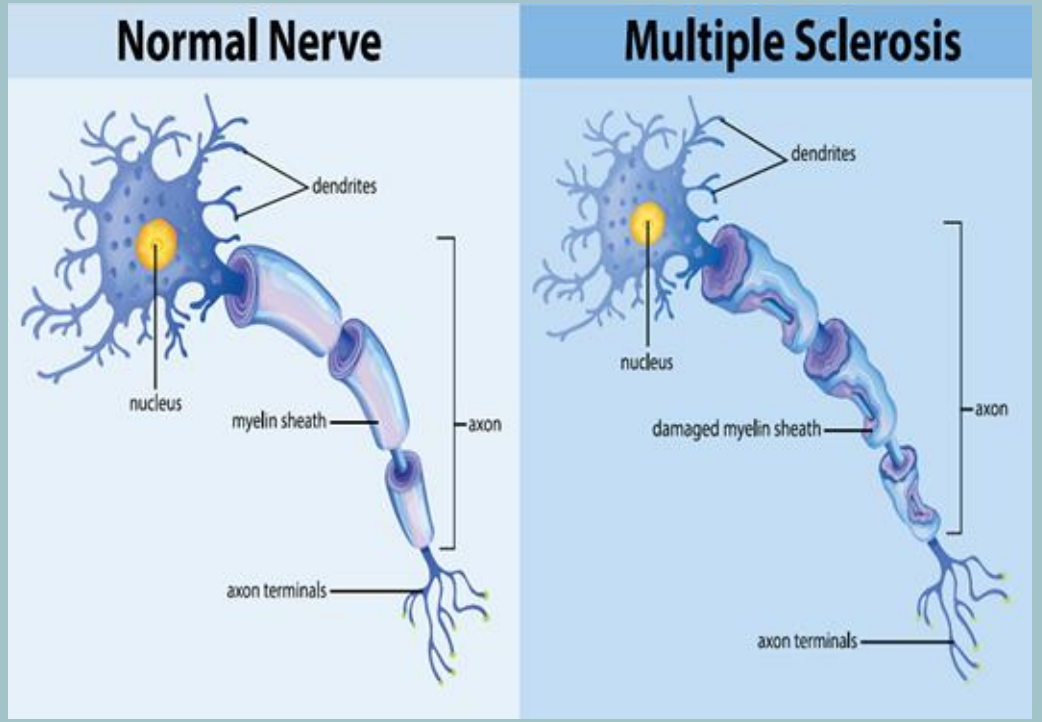
What is Multiple Sclerosis or MS

- Is a disease that attacks the myelin sheath in the brain, the spinal cord or both
    - The myelin sheath is a protective covering over the nerve fibers
- When the myelin sheaths are damaged, it causes an impairment of the transmission of nerve signals



Empowering people affected by MS to live their best lives. National Multiple Sclerosis Society. (n.d.-b). https://www.nationalmssociety.org/managing-ms/treating-ms/disease-modifying-therapies

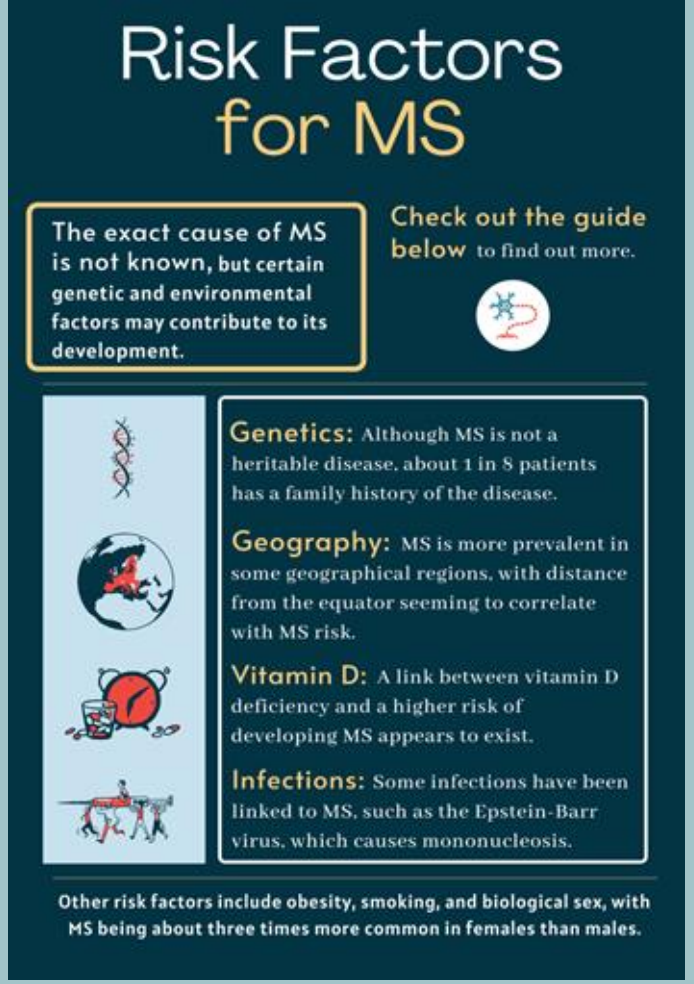
Symptoms

- Can include but not limited to
  - Fatigue
  - Muscle weakness
  - Vision problems
  - Balance and coordination

"Department of Neurology." *Symptoms of MS | USF Health*, health.usf.edu/medicine/neurology/multiple-sclerosis/symptoms-ms. Accessed 22 Jan. 2026.

What Causes MS

- There is no definitive answer but research has shown that there could be multiple factors on why people develop this disease such as vitamin D deficiency, genetics, geographic (People living in Colder areas) and ethnic factors.
- The biggest factor though is the immune system.
- MS is Known as an “immune Mediated” disease
    - The body mistakenly attacks itself



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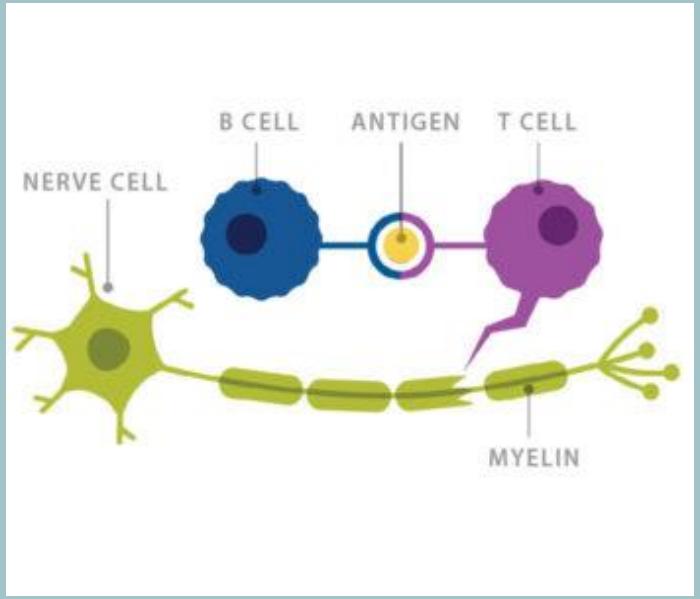
What Causes MS

- **B and T cells play a big role**
  - **B cells**
    - Mistakenly tell the T cells that the myelin sheath is a foreign invader
  - **T cells or "Killer T Cells"**
    - Release chemicals that start the demyelination process by attacking the myelin and starts inflammation due to the B cells mistake



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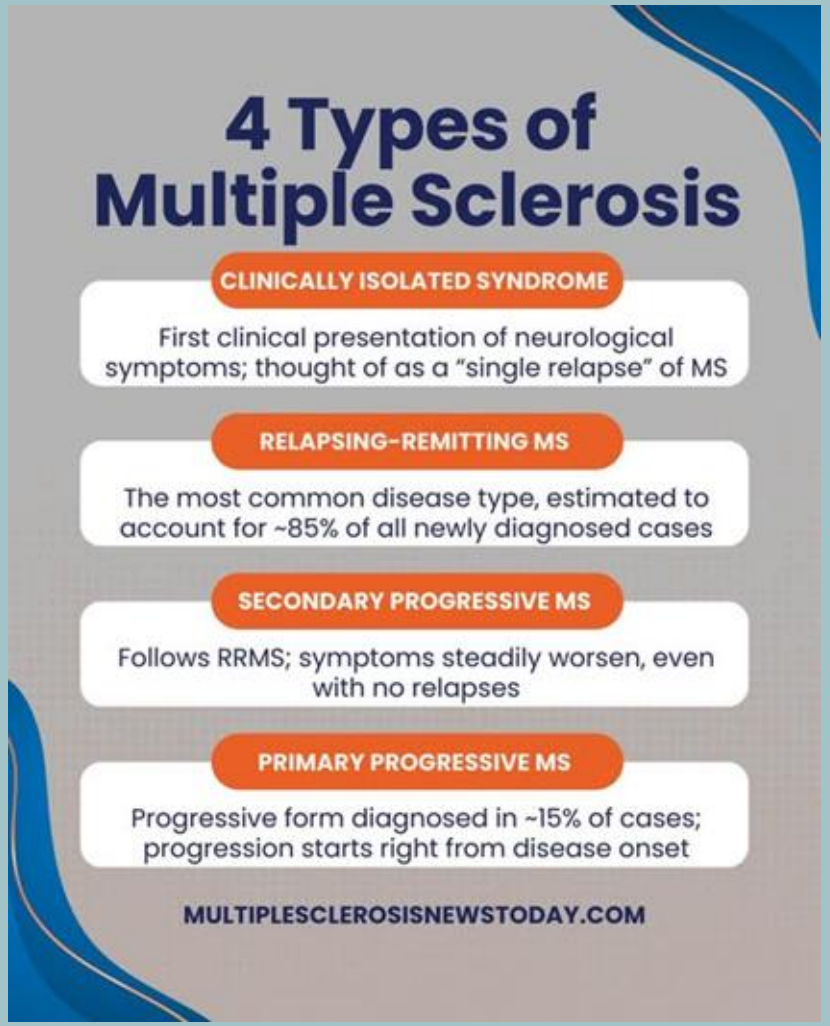
Different Types

- Many people do not have the same signs and symptoms
    - Some people can even go asymptomatic for months to years
- Studies have also shown that women are four times more likely to get Multiple Sclerosis than men. Since the actual cause of Multiple Sclerosis has not been identified, it does make it harder for researchers to be able to figure out why women are more likely than men to be diagnosed with this disease.



HISTORY

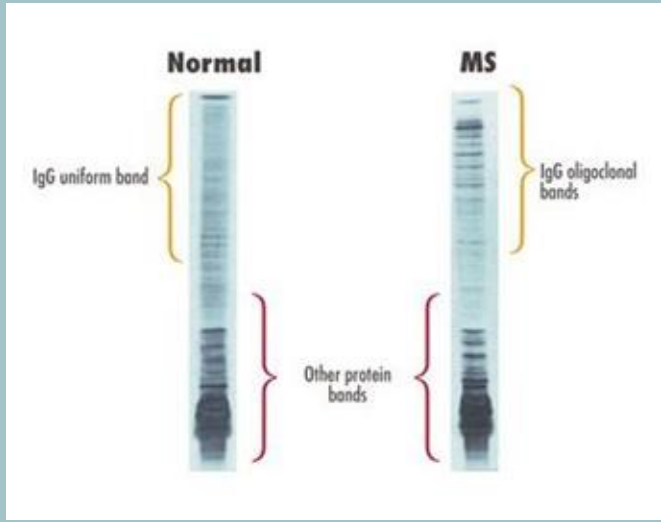
- Multiple Sclerosis diagnosis date back to 1868 when French physician Jean-Martin Charcot is credited with the discovery of Multiple Sclerosis.
- Charcot performed autopsies where he found sclerotic plaques on the brain and spine of patients that showed symptoms of intention tremors, nystagmus (uncontrollable movement of the eyes) and scanning speech.
- These three traits of MS became known as Charcot's triad.
- While this did lead to some true diagnosis of MS, it more frequently led to misdiagnosis where the patient could have had Parkinson's or Lyme disease.

Jean-Martin Charcot

Mental disorder - Dissociation, Amnesia, Identity | Britannica

HISTORY

- Early in the twentieth century, Merritt and Fremont-Smith started using lumbar puncture to diagnose, which were done under fluoroscopy.
- They found that patients with Multiple Sclerosis have the detection of oligoclonal bands in the cerebral spinal fluid.
- This is an indication of inflammation in the Central Nervous System.
- If two or more unique oligoclonal bonds are found in the cerebral spinal fluid, one of the diagnostic criteria for Multiple Sclerosis has been met.
- Oligoclonal bands are found in over ninety percent of Multiple Sclerosis patients at some point in their illness



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MRI and the McDonald Criteria

- In the 1980s, Magnetic Resonance Imaging became a significant factor in diagnosis of Multiple Sclerosis.
    - Which lead to the McDonald criteria in 2001 and has been revised multiple times latest being in 2024
- McDonald Criteria includes evidence of at least one relapse, evidence of dissemination in space (DIS), dissemination in time (DIT), a spinal tap, and other blood work.

The McDonald Criteria

Developed by and named for neurologist W. Ian McDonald in 2001, these guidelines were revised in 2010 and again in 2017 to give us what's now the state of the art in diagnosis.

Clinical Attacks	Number of lesions with objective clinical evidence	Additional Data Needed for MS Diagnosis
Two or more	Two or more	None
Two or more	One with clear historical evidence of a previous attack	None
Two or more	One	Dissemination in Space (additional attack indicating effects on a different area of the Central Nervous System, ***OR*** lesions in different areas shown by MRI)
One	Two or more	Dissemination in Time (additional clinical attack, ***OR*** lesions detected by MRI, ***OR*** oligoclonal bands detected in spinal fluid)
One	One	Dissemination in Space (additional attack indicating effects on a different area of the Central Nervous System, ***OR*** lesions in different areas shown by MRI); ***AND*** Dissemination in Time (additional clinical attack, ***OR*** lesions detected by MRI, ***OR*** oligoclonal bands detected in spinal fluid)

Peter BroderickPete Broderick is the Marketing and Communications Manager at the Rocky Mountain MS Center. He is also the editor and one of the primary writers for InforMS Magazine. (2024, May 30). *Diagnosing multiple sclerosis*. Rocky Mountain MS Center. https://mscenter.org/article/diagnosing-multiple-sclerosis/

MRI and the McDonald Criteria

- Dissemination in space : is looking at the nerve damage in at least two out of five specific central nervous system areas. They include, periventricular, juxtacortical/cortical, infratentorial, spinal cord and the optic nerve.
- DIT has more to do with follow up MRIs to show damage to the central nervous system at different points in time.

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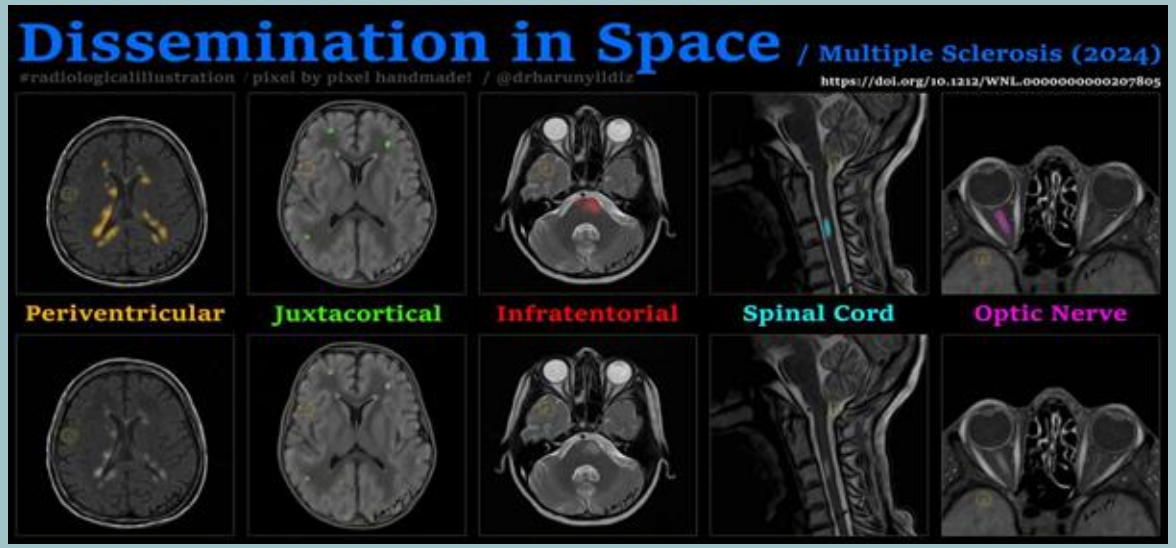
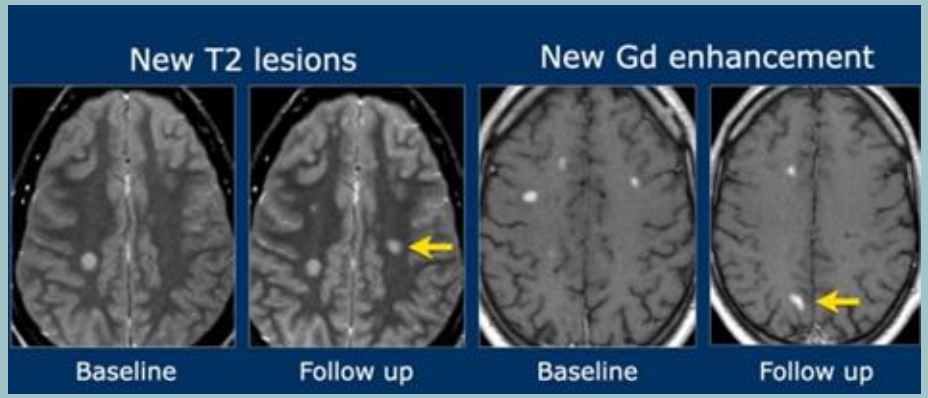


MRI (DIT) and the McDonald Criteria continued

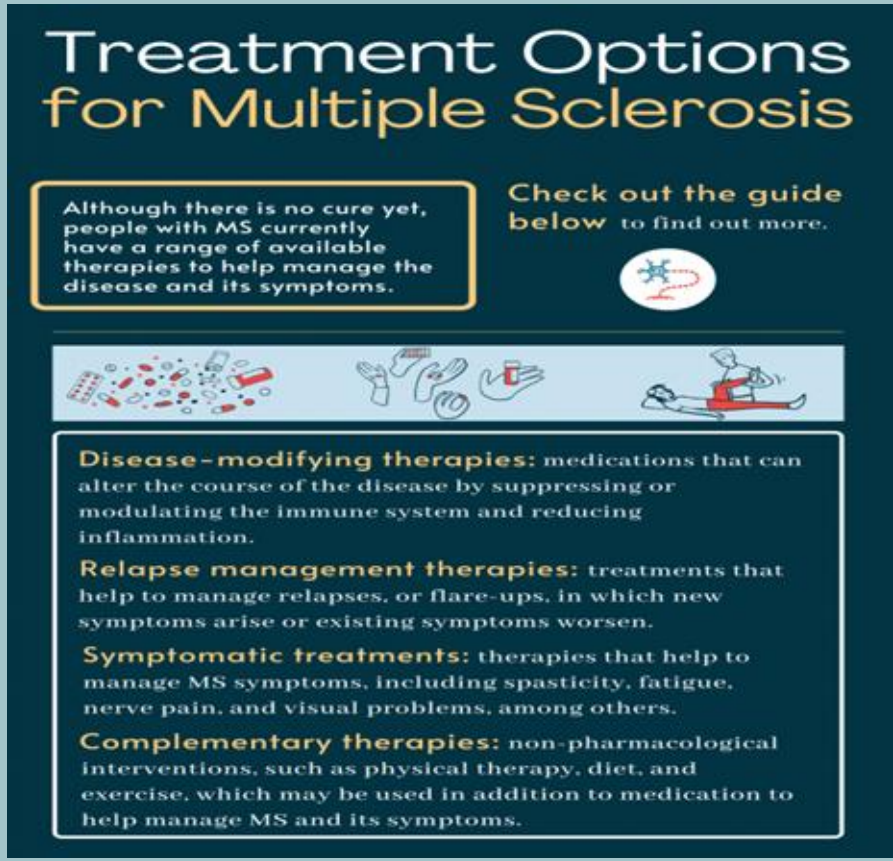
- This step helps doctors confirm that the disease is ongoing rather than a single event. DIT can be shown when new lesions appear on a follow-up MRI scan compared to a previous one, or when both active (enhancing) and older (non-enhancing) lesions are seen at the same time.
- These findings indicate that inflammation has occurred more than once, which supports a diagnosis of MS.
- Before the McDonald criteria, “the average time to get an MS
  - diagnosis was 4 years. Over time, this has dropped by 75% — to an average of 1 year” (National MS Society, 2025).



Treatments

- Since there is no cure for this chronic disease, the only thing that physicians are able to do is treat the symptoms that patients are having and to try and slow the progression of this disease. There are different treatments for the different types of Multiple Sclerosis that have multi-layered approaches for treatment.

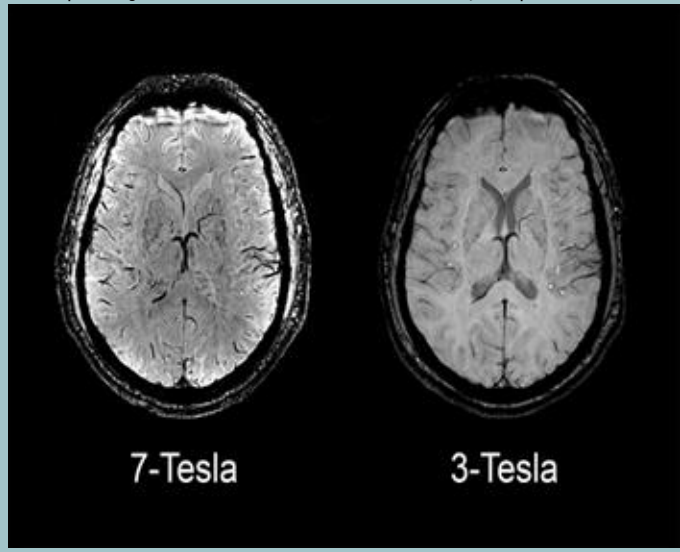
Marisa Wexler, M. (2025a, December 23). *Multiple sclerosis treatment options*. Multiple Sclerosis News Today. https://multiplesclerosisnewstoday.com/multiple-sclerosis-treatment/



Treatments

- One of the first things patients can do, if possible, is to keep their body temperature normal and not overwork themselves. When a patient becomes overheated it even further disrupts the central nervous system and can take up to 24 hrs or more for the patient to get back to
  baseline
- Many patients in the beginning of this disease are put on high doses of corticosteroids such as methylprednisolone. Corticosteroids work by suppressing the immune system's activity, which reduces swelling and inflammation around damaged nerves in the brain and spinal cord
- Another option is DTM or in other words disease modifying therapies. They can reduce the attacks on the central nervous system and inflammation in newer areas They include oral (at home), injectable (at home or medical facility) or infused therapies (medical facility). DTM are used in moderate to severe forms of this disease. They effectively target the underlying immune dysfunction, reduce relapses, and slow disease progression, and aid in long term efficacy of slowing down relapses ultimately improving the quality of life for those affected by MS.
- PT and OT are also used to help weakness, and balance issues

New technology: 7-Tesla MRI scanner



"Arizona's First 7-Tesla MRI Offers Clarity and Hope for Ms Patients." *PHOENIX Magazine*, 24 Dec. 2024, www.phoenixmag.com/2024/12/24/arizonas-first-7-tesla-mri-offers-clarity-and-hope/.

- In 2017, the 7-tesla MRI with MR spectroscopic imaging (MRSI) was approved to be used in a clinical setting. A 7T MRI has a better signal-to- noise ratio which allows for extremely fine detail compared to a 1.5 or 3 Tesla
- A 7T is primarily used in brain and musculoskeletal system exams It is able to separate the biochemical changes in a brain that would look normal on a regular MRI.
- One drawback of the 7T is that it has a greater sensitivity to motion, which can show up as an artifact.
- Earlier and more detailed imaging means doctors can detect MS and monitor its progression more precisely, potentially acting sooner or tailoring therapies better.

New technology: Quantitative Susceptibility Mapping

- It is an MRI technique that “uses phase images to create a quantitative map of a tissue's magnetic susceptibility, which can then be used to identify and quantify materials like iron and calcium” (Okada, T., Fujimoto, 2022) during the post processing.
- It is used for Multiple Sclerosis to be able to measure the amount of myelin left.

New technology: Diffusion Basis Spectrum Imaging (DBSI)

- Is another technique using standard MRIs.
- It is most commonly used in monitoring of the disease and aimed for newer therapies that are aimed at repairing/protecting the myelin sheath.
- It has the ability to quantify inflammation and axonal (slender projection of nerve cell) loss independently, which enables clinicians to assess disease activity more precisely, identify areas of active immune response, and evaluate the extent of irreversible damage.

New Technology : Kappa free light chains (KFLC)

- This is one option that does not require ionizing or non-ionizing radiation.
- It is a blood test that looks at the cerebrospinal fluid. It looks at the kappa free light chains instead of looking at the oligoclonal bands.
- Kappa free light chains (KFLC) are produced in excess by plasma cells, which signifies abnormal plasma cell activity. At elevated levels, they indicate a plasma cell disorder.
- This is still a very new kind of testing that is still being researched but it is used in the diagnosis of lymph cell disorders and different kinds of cancers.

Ahlstrom, Jennifer. "Kappa and Lambda Light Chains." *HealthTree for Multiple Myeloma*, HealthTree for Multiple Myeloma, 12 July 2024, healthtree.org/myeloma/community/articles/kappa-lambda-light-chain.

New Technology: Artificial Intelligence

- Can now also be used in MS imaging by identifying lesion segmentation.
- AI systems can quickly outline and measure the size and number of lesions across multiple MRI sequences.
- This automation reduces variability between radiologists and provides more standardized measurements.
- AI is also used to predict disease progression by analyzing large sets of MRI and clinical data to forecast future relapses or disability worsening.

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New Technology: Artificial Intelligence

- AI tools help monitor treatment response by tracking changes in lesion volume or brain tissue integrity over time, supporting more personalized therapy decisions.
- AI can also be used with MRI scanners to help reveal patterns of the disease, along with being used to help figure out the best course of treatment that is tailored to the patient.

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Conclusion

- All in all, the ability to diagnose, monitor, and understand multiple sclerosis using modern imaging methods, such as Diffusion Basis Spectrum Imaging (DBSI), Magnetization Transfer Imaging (MTI), provide deeper insight into the structural and functional changes occurring in the central nervous system than just autopsies and blood tests.
- These innovations go beyond simply detecting lesions; it can now detect inflammation and irreversible damage done by the destruction of the myelin sheath.
- Additionally, Artificial Intelligence (AI) are being integrated into radiology to more efficiently analyze MRI scans, predict relapse risk, and detect subtle changes in brain tissue that may be invisible to the human eye.
- Every year there is newer advancement in technology and treatments for this disease and hopefully one day researchers will find ways to cure and even prevent Multiple Sclerosis.

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