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Guidelines

Guidelines of the Polish Medical Society of radiology for the routinely used MRI protocol in patients with multiple sclerosis

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ABSTRACT

Magnetic resonance imaging is widely used in diagnosing multiple sclerosis as a basic method for detecting and monitoring the disease.

Introduction: Polish Medical Society of Radiology presents the second version of the recommendations for the routinely conducted MRI in multiple sclerosis, which include new data and practical remarks for radiographers and radiologists. The recommended protocol aims to improve the imaging procedure and, most importantly, to standardize conducting MRI scans in all MRI departments. This is crucial for monitoring the patients with MS, which directly contributes to essential clinical decisions.

Aim of the guidelines: Multiple sclerosis (MS) is a chronic inflammatory demyelinating and degenerative disease of the central nervous system (CNS) with its etiology still unknown. The fundamental requirement of the disease is the CNS destruction process disseminated in time (DIT) and space (DIS). MR imaging detects focal lesions in white and gray matter with high sensitivity and is the best way to assess brain atrophy in MS patients. It is unquestionably the best diagnostic tool to follow-up the clinical course of the disease and treatment of MS patients. However, to achieve a diagnosis based on MRI scans, and follow-up MS patients according to the latest standards, an MRI scan has to meet certain quality criteria that are the subject of this work.

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1. Guidelines for conducting MRI in MS patients with 1.5 Tesla MRI scanners

1.1. *General remarks*

When performing an MRI scan of MS patients, it is necessary to administer an intravenous paramagnetic contrast agent (gadolinium) to make a preliminary diagnosis, monitor disease progression and treatment response. In view of the high frequency of contrast-enhanced MRI scans in MS patients, administration of linear gadolinium-based contrast agents (GBCAs) to MS patients is not recommended.

For the time being, there is no evidence that gadolinium deposition in the brain has caused any harm to patients. However, EMA has recommended restrictions and suspensions for some intravenous linear agents to prevent any risks that might potentially be associated with gadolinium brain deposition. Therefore, performing contrast-enhanced MRI scans is not recommended unless – according to the referring neurologist – there are absolute indications for administering an intravenous contrast agent.

In line with the recommendations of medical professionals and medical literature, we argue that there is no need to administer a contrast agent (gadolinium) in clinically stable patients that have been given immunomodulatory treatment for a long period of time. However, the current regulations of the Polish National Health Fund drug program impose the obligation of performing a contrast-enhanced MRI scan in MS patients every 12 months [9].

Procedures performed in patients with Clinically Isolated Syndrome (CIS) or in patients with suspected MS [1–4]:

- MRI scan of the head with the IV contrast agent (Table 1)
- It is recommended to scan the cervical and/or thoracic spinal cord (according to the neurologist referral/recommendation) with the IV contrast (Table 2). An MRI examination of the spinal cord is especially important for diagnosing primary progressive MS in accordance with the existing diagnostic criteria (Appendix)
- In patients with multifocal nervous system damage that entails the symptomatology associated with the brain and spinal cord damage, it is possible – depending on the recommendations of the referring neurologist – to perform an MRI scan of the head and the chosen part of the spinal cord at the same time and using one MRI protocol in order to shorten the time of diagnostic evaluation (Table 3).

Recommendations for monitoring the clinical course of the disease based on MR imaging [4–8]:

- MR imaging of the head with IV contrast to image new active lesions (Table 1)
- It is recommended to scan the cervical and/or thoracic spinal cord (according to the neurologist referral/recommendation) with the IV contrast agent, especially in primary progressive MS (Table 2).

1.2. *MR brain imaging protocol for patients with multiple sclerosis*

To achieve the same scanning planes, it is recommended to obtain the true midline plane at follow-up visits.

Table 1 – MRI scan protocol of the head.

Parameters	Description
Electromagnetic field	Images should be in high quality, with appropriate SNR value and resolution (≤1 × 1 mm)
Reference line	While planning the scan plane use the line parallel to the inferior edge of the rostrum and the splenium of the corpus callosum to obtain the same angle of the planned planes as in the previously obtained planes.
Scanned area	Scan of the whole brain
Slice thickness and gaps	≤3 mm, without the gaps (in 2D and 3D acquisition)
Basic sequences	1. Isotropic 3D T1-weighted axial 2. T2-weighted axial 3. diffusion-weighted (DWI) axial CONTRAST administration:[a] T1-weighted sequence within minimum 5, maximum 10 min after administration 4. FLAIR CE sagittal 5. FLAIR CE axial 6. isotropic 3D T1-weighted CE axial[b]
	[a]*The recommended dose of the contrast agent is 0.1 mmol/kg body weight (not linear – see: General remarks)* [b]*It is recommended to obtain and save the sagittal planes on a CD and, if possible, in the PACS system as an integral part of the procedure.*
Optional sequences	1. Proton density weighted (PD) axial 2. Susceptibility weighted (SW, for identification of the large veins in T2-weighted lesions and microbleeds) 3. Double inversion recovery (DIR) – to asses cortical and subcortical lesions

Table 2 – MRI scan protocol of the spinal cord.

Parameters	Description
Electromagnetic field	Images should be of high quality, with appropriate SNR value and resolution (≤1 × 1 mm)
Scanned area	Scan of the cervical spinal cord
Slice thickness and gaps	Sagittal: ≤3 mm, without the gaps (in 2D and 3D acquisition) Axial: 3 mm, without the gaps
Basic sequences	1. T2-weighted sagittal 2. T1-weighted sagittal Contrast administration:[a] T1-weighted sequence within minimum 5, maximum 10 min after administration 3. T2-weighted, fat saturation (STIR) sagittal 4. T2-weighted axial on the level of lesions visible in SAG sequences 5. T1-weighted sagittal 6. T1-weighted axial [a]*The recommended dose of the contrast agent is 0.1 mmol/kg body weight (not linear – see: General remarks)*
Optional sequences	1. T2-weighted coronal on the level of lesions visible in STIR SAG 2. 3D T1-weighted sagittal (for atrophy assessment)

Therefore, having obtained three localization slices, five T2-weighted sagittal 3 mm thick slices should be planned as thoroughly as possible. The slices should be planned exactly parallel to the longitudinal fissure of the brain, using localization slices in transverse and coronal planes. Out of the five slices, the third one should pass through the medial fissure of the brain as precisely as possible.

On the base of the obtained median slice, transverse slices should be planned parallel to the inferior edge of the rostrum (anterior commissure, AC) and the splenium of the corpus callosum (posterior commissure, AP), along the AC-PC line (Fig. 1).

ATTENTION: At follow-up visits, while planning the scan plane based on the position of corpus callosum, it is necessary to compare the slice angle of the planned slices to the angle of the previously obtained slices.

In some scanners it is impossible to save a particular slice, which is the best for such comparison. In cases like that the slice should be carefully planned as shown in the figure below.

2. Important remarks

1. While scanning axial planes, it is crucial to scan in the direction from bottom to top, whereas while scanning in sagittal planes the direction is from right to left (also while scanning the cervical spine).
2. The gap between the slices should be as small as possible (suggested 0.3 mm, i.e. 10% of the slice thickness).
3. 3D T1-weighted sequence is recommended as the first sequence to avoid MRI motion artifacts over time. This sequence is crucial for precise volumetric assessment of the brain.
4. Both FLAIR sequences have to be post-contrast sequences to delay the beginning of T1-weighted CE acquisition (within 5–10 min after contrast administration) to obtain better contrast enhancement. The contrast agent does not affect the quality of FLAIR images, while the time the patient spends in the scanner is optimized.

Table 3 – Joined MRI scan protocol of the head and the spinal cord.

Parameters	Description
Electromagnetic field	Images should be in high quality, with appropriate SNR value and resolution (≤1 × 1 mm)
Scanned area	Scan of the brain and cervical spinal cord
Slice thickness and gaps	Head and spinal cord (sag): ≤3 mm, without the gaps (in 2D and 3D acquisition) Spinal cord axial: 3 mm, without the gaps
Basic sequences	1. Use the protocol before contrast agent administration for the head and spinal cord Contrast administration:[a] sequence T1-weighted within minimum 5, maximum 10 min after administration 2. FLAIR CE sagittal (head) 3. STIR CE sagittal (spinal cord) 4. T2-weighted CE axial on the level of lesions visible in SAG sequences (spinal cord) 5. FLAIR CE axial (head) 6. Isotropic 3D T1-weighted CE axial (head)[b] 7. T1-weighted CE sagittal (spinal cord) 8. T1-weighted CE axial (spinal cord) [a]*The recommended dose of the contrast agent is 0.1 mmol/kg body weight (not linear – see: General remarks)* [b]It is recommended to obtain and save the sagittal planes on a CD and, if possible, in the PACS system as an integral part of the procedure.
Optional sequences	*The same as in the protocols for the head and the spinal cord

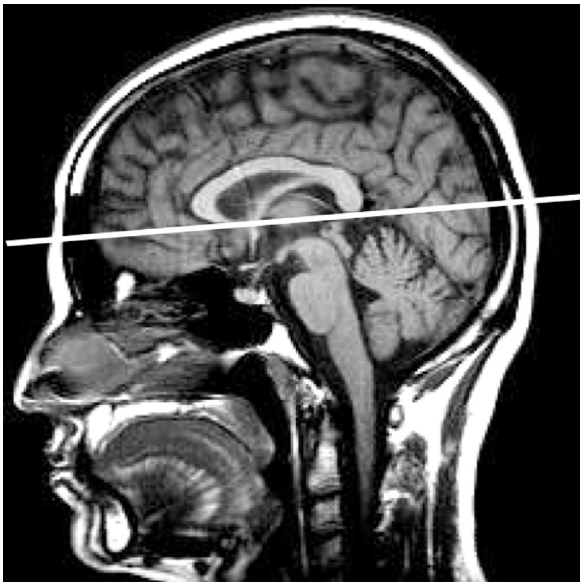

Fig. 1 – Reference line positioned parallelly to the corpus callosum.

Table 4 – Multifocal central nervous system damage developed over time according to the 2017 McDonald criteria.

Multifocal CNS damage disseminated in space (DIS)	CNS damage disseminated in time (DIT)
At least 1 lesion on T2-weighted scans in two anatomical locations: 1. Juxtacortical/cortical 2. Periventricular 3. Infratentorial 4. In the spinal cord	New lesions on T2-weighted scans and/or enhancing lesions on follow-up MRI, with reference to a baseline scan, irrespective of the timing of the baseline MRI or Simultaneous presence of enhancing and non-enhancing lesions after contrast agent administration, irrespective of the timing of either the MRI or neurological symptoms occurrence (also primary scan)

5. If 3D T2-weighted and 3D FLAIR sequences are possible, they should be used with the secondary transverse 3 mm thick slices reconstruction on the plane planned to the inferior edge of the corpus callosum.
6. If possible, please use the software that automatically plans the angle and the scanned area based on the previous scans.

The radiology report should contain the standard terminology for assessing the brain.

Focal lesions assessment:

1. Anatomical location (supratentorial: cortical, juxtacortical, central white matter, periventricular, infratentorial, the area of corpus callosum, brainstem, spinal cord)
2. Size – if many lesions are visible, please include the longest dimension from-to
3. Number of demyelinating lesions – it should be indicated in the following format: 1, 2, 3–8, ≥9
4. Character of the lesion, i.e., specify whether the image is typical for MS demyelination or differential diagnosis is required, e.g. ischemic focus
5. Are the lesions disseminated in space (DIS) and meet the 2017 McDonald criteria (Appendix)
6. Comparison to previous scans, i.e., presence of new lesions and if they meet the dissemination in time (DIT) criteria, according to the 2017 McDonald criteria (Appendix)
7. Comparison to previous scan with regard to the size of the demyelinating lesions
8. Activity assessment, i.e., number of contrast enhancing lesions on a current scan and the number of new lesions with reference to a previous scan – indicated in the following format: 1, 2, 3–8, ≥9
9. Brain atrophy assessment

Conflict of interest

None declared.

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Appendix A. Appendix A

McDonald diagnostic criteria for multiple sclerosis 2017.

At least two clinical attacks, 2 lesions with objective clinical evidence	Not required
At least two clinical attacks, 1 lesion with objective clinical evidence	Multifocal CNS on MRI scan (Table 4) or another clinical attack in a distinct clinical location
One clinical attack, clinical evidence of ≥2 lesions	CNS damage developed over time on MRI scan (Table 4) or presence of CSF-specific oligoclonal bands or another clinical attack
1 clinical attack, clinical evidence of 1 lesion (*clinically isolated syndrome*)	Multifocal CNS damage developed over time on MRI scan or presence of CSF-specific oligoclonal bands
Primary progressive multiple sclerosis	1 year of disability progression (retrospectively or prospectively determined) and two of the following: 1. Multifocal lesions on MRI scan 2. Multifocal lesions on MRI scan of the spinal cord (≥2 lesions) 3. Cerebrospinal fluid analysis showing presence of oligoclonal bands and/or elevated immunoglobulin levels

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