



ORIGINAL ARTICLE

Recommendations for the coordination of Neurology and Neuroradiology Departments in the management of patients with multiple sclerosis[☆]



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KEYWORDS

Multiple sclerosis;
Good practice
guidelines;
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Radiology;

Abstract

Introduction: Magnetic resonance imaging (MRI) is widely used for the diagnosis and follow-up of patients with multiple sclerosis (MS). Coordination between neurology and neuroradiology departments is crucial for performing and interpreting radiological studies as efficiently and as accurately as possible. However, improvements can be made in the communication between these departments in many Spanish hospitals.

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Neuroradiology;
Magnetic resonance
imaging

Methods: A panel of 17 neurologists and neuroradiologists from 8 Spanish hospitals held in-person and online meetings to draft a series of good practice guidelines for the coordinated management of MS. The drafting process included 4 phases: 1) establishing the scope of the guidelines and the methodology of the study; 2) literature review on good practices or recommendations on the use of MRI in MS; 3) discussion and consensus between experts; and 4) validation of the contents.

Results: The expert panel agreed a total of 9 recommendations for improving coordination between neurology and neuroradiology departments. The recommendations revolve around 4 main pillars: 1) standardising the process for requesting and scheduling MRI studies and reports; 2) designing common protocols for MRI studies; 3) establishing multidisciplinary committees and coordination meetings; and 4) creating formal communication channels between both departments.

Conclusions: These consensus recommendations are intended to optimise coordination between neurologists and neuroradiologists, with the ultimate goal of improving the diagnosis and follow-up of patients with MS.

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PALABRAS CLAVE

Esclerosis múltiple;
Guía de buenas
prácticas;
Neurología;
Radiología;
Neurorradiología;
Resonancia
magnética

Recomendaciones para la coordinación de los servicios de Neurología y Neurorradiología en la atención a pacientes con esclerosis múltiple

Resumen

Introducción: El uso de la resonancia magnética (RM) está ampliamente extendido en el diagnóstico y seguimiento de los pacientes con esclerosis múltiple (EM). La coordinación entre los Servicios de Neurología y Neurorradiología es clave para la realización e interpretación de estudios radiológicos de la manera más eficaz posible. Sin embargo, esta coordinación es susceptible de mejoras en una gran parte de los hospitales nacionales.

Métodos: Un panel de 17 neurólogos y neurorradiólogos de 8 hospitales españoles, presencialmente y a través de comunicación *online*, consensuaron una Guía de Buenas Prácticas en la Coordinación en EM. La guía se estableció en cuatro fases: 1) definición del alcance de la guía y metodología del estudio; 2) revisión bibliográfica sobre buenas prácticas o recomendaciones en el uso de la RM en EM; 3) discusión y búsqueda de consenso entre los expertos; 4) formalización y validación de los contenidos para elaborar el documento de consenso.

Resultados: Se consensuaron un total de 9 recomendaciones dirigidas a la mejora de la coordinación entre los Servicios de Neurología y Neurorradiología, que se pueden resumir en: I) estandarizar las solicitudes de RM, informes y planificación, II) crear protocolos compartidos para los estudios de RM, III) establecer comités multidisciplinares y sesiones de coordinación, y IV) generar canales de comunicación formales entre los profesionales de ambos departamentos.

Conclusiones: Se espera que las recomendaciones consensuadas sirvan de guía para optimizar la coordinación entre neurólogos y neurorradiólogos y que repercutan en la mejora del diagnóstico y seguimiento de los pacientes con EM.

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Introduction

Multiple sclerosis (MS) is an inflammatory demyelinating neurodegenerative disease of the central nervous system. It constitutes the leading cause of non-traumatic disability in young adults.¹ Its prevalence has increased considerably in recent decades,² with the disease affecting approximately 2.3 million people worldwide.^{2,3} In Spain, the prevalence of MS is classed as medium-to-high, with 80–180 cases per 100 000 population.⁴ The mean age at diagnosis is 32 years.⁵ The symptoms of MS negatively impact patients' daily liv-

ing activities, ability to work, and quality of life.⁶ The high level of associated disability also results in a considerable economic burden; Spain is one of the European countries with the highest cost per patient.⁵

From a pathological viewpoint, MS is characterised by the formation of demyelinating plaques^{7,8} in the central nervous system (CNS), including the brain, spinal cord, and optic nerve,^{9–11} and the development of brain and spinal cord atrophy.^{12,13} Magnetic resonance imaging (MRI) is considered the most reliable and precise paraclinical method for diagnosing and evaluating disease activity,^{14,15} as it identifies the presence and stage of MS lesions with different

sequences.¹⁶ Some of the most frequently used sequences are T2-weighted, T2-FLAIR, and T1-weighted sequences. Gadolinium-enhanced T1-weighted sequences can also be used to identify lesions with acute inflammatory activity.

According to the 2017 McDonald diagnostic criteria,¹⁷ MRI is a useful complementary tool in determining dissemination in space (demyelinating lesions in at least 2 distinct anatomical locations) or time (detection of at least 2 demyelinating lesions at different time points) in patients presenting a single episode (clinically isolated syndrome [CIS]). MRI facilitates the early diagnosis of MS,¹⁸ enabling treatment in the initial stages of the disease. Furthermore, this imaging technique is highly valuable in establishing prognosis, in patient follow-up, and in evaluating and predicting the effect of disease-modifying therapies (DMT).^{19–21}

Despite its usefulness and dissemination in clinical practice, and the important advances made in recent years, the use of MRI in the diagnosis and follow-up of patients with MS also has some limitations. Firstly, variability in acquisition protocols, MRI machines, and assessment criteria hinders the comparison of results.^{22,23} In addition, MRI findings are frequently assessed by neuroradiologists, who may lack the necessary clinical data or sufficient experience in interpreting MRI findings, or are unaware of the diagnostic criteria for MS.²⁴

Although several publications have issued recommendations on the use of MRI in patients with MS,^{14,25–29} these do not focus on cooperation between neurologists and neuroradiologists, despite the great importance of this factor.²⁶ There is a need for guidelines on the most effective use of MRI in the diagnosis and follow-up of patients with MS through improved coordination between the healthcare professionals involved. This article presents the recommendations made by a panel of experts on the coordination between neurology and neuroradiology departments to improve the use of MRI in the management of patients with MS in Spain.

Methods

The study was conducted in 4 stages. In the first stage, a panel of expert neurologists and neuroradiologists from Spanish hospitals met in Barcelona in December 2018 to establish the scope and methodology of the study. The panel was formed by an assessment committee, responsible for developing and validating the contents, and a technical team (2 experts), who were part of the assessment committee and were also responsible for directing and supervising the process. The assessment committee included 17 neurologists and neuroradiologists (15 experts plus the 2 members of the technical team) from 8 Spanish hospitals: 3 in Catalonia (Hospital Clínic de Barcelona, Hospital Universitario Vall d'Hebron, and Hospital Moisès Broggi de Sant Joan Despí), 2 in Madrid (Hospital Universitario Ramón y Cajal and Hospital Universitario 12 de Octubre), one in Valencia (Hospital Universitario Dr Peset), one in Andalusia (Hospital Universitario

Reina Sofía), and one in Murcia (Hospital Clínico Universitario Virgen de la Arrixaca). The technical team included a neurologist from Hospital Clínic de Barcelona and a neuroradiologist from Hospital Universitario Vall d'Hebron.

During the second stage, the participants developed the contents of the study based on the available evidence on good practices and recommendations on the use of MRI in MS; this stage was conducted online. In the third stage, a workshop was held in March 2019 in Madrid to share and establish the contents of the study by consensus between the participants. During this session, each participant presented a proposal, and all proposals were reviewed and discussed until consensus was reached. During the fourth stage, the draft of the recommendations was formalised and validated online by all participants. The recommendations were validated first by the technical team and subsequently by the assessment committee; the final version is presented in this article.

Results

The assessment committee established a total of 9 recommendations, based on the available literature and the experience of the participants, which aim to improve coordination between the neurology and neuroradiology departments in the management of patients with MS in Spain.

Implementation of shared protocols

Several recommendations have been issued regarding the development and implementation of MRI acquisition protocols (request, performance, and image acquisition) and MRI reports, both for patients with suspected MS and for those with an established diagnosis.^{14–16,27–29} These protocols establish a common language to facilitate communication between the professionals involved in the diagnosis and follow-up of these patients,²⁶ assisting in their work and minimising the risk of incoherences, errors, or loss of information. Correct interpretation and implementation of protocols requires that the neurologists and neuroradiologists using them participate actively in their development.

Such aspects as the type of sequence or technical parameters of the study may vary according to the available equipment and the experience of the professionals at each centre. However, it is essential that the information included in the MRI request protocol and in radiology reports be approved and validated by a multidisciplinary team, based on the available scientific evidence and expert guidelines.^{14–16,27–30} To improve the design, implementation, and assessment of these shared protocols, it is essential to establish bilateral communication processes and schedule periodic team meetings. Furthermore, protocols should ideally be available in writing, to ensure that they are readily accessible by all the healthcare professionals involved.

Standardisation of MRI requests

Requests for diagnostic or follow-up MRI studies should include relevant clinical information, given that the results of these studies determine diagnostic and therapeutic decision-making. In clinical practice, MRI request forms submitted by the neurology department do not always include the information required by neuroradiologists (justification for the study,²⁸ missing clinical information, or omission of questions to be addressed). The lack of clinical information negatively impacts the technical planning of the test and the subsequent radiology report²⁹; therefore, the neurologist is responsible for providing the necessary data as completely, as clearly, and as accurately as possible.

To this end, we recommend standardising the minimum information to be included in MRI requests in cases of suspected and established MS (Table 1). This will not only provide the neuroradiologist with the information needed to prioritise and plan the MRI study, but also inform about the reasons for requesting the study and summarise the patient's clinical status, which will inform the study report.³²

Standardisation of radiology reports

Radiology reports vary greatly in terms of structure and the type of information provided by the neuroradiologist. On occasion, reports provide a brief summary of findings that confirm diagnosis or merely inform about an increase in lesion number; this information is insufficient for treatment decision-making. A structured radiology report makes it easier for the neuroradiologist to include information relevant to the neurologist, simplifies reporting of findings for the neuroradiologist, improves communication between both parties, and enables the inclusion of information in a common database for subsequent analysis. There is growing evidence that structured radiology reports provide a greater number of relevant findings in MS, improve comprehension of the data by the neurologist,^{33,34} and improve the consistency of reports.³⁵ In the light of these benefits, several international expert groups have recommended the implementation of structured radiology reports.^{14,27,36}

Based on the available evidence,^{14,25,27,36,38} the assessment committee recommends that MRI reports include the minimum radiological information needed to establish a diagnosis of MS (according to the 2017 revised McDonald criteria¹⁷) and to plan patient management.^{14,26,27,32,37} Therefore, reports should include the following: 1) an initial description of radiological findings; 2) parts of the CNS that were examined; 3) type and dose of contrast medium administered; 4) number, size, and location of demyelinating lesions (with and without contrast uptake); 5) description and interpretation of relevant incidental findings; 6) whether findings meet the radiological McDonald criteria for dissemination in time and space; and 7) interpretation of differential radiological and diagnostic findings.

Reports of studies requested for patient follow-up must also include an assessment of any relevant changes with respect to the previous study.

Table 2 presents our proposal for diagnostic and follow-up structured radiology reports.

Standardised quantification of demyelinating lesions

The quantification of lesion load plays a pivotal role in assessing a patient's status. On the one hand, the number, size, and location of lesions, together with the number of relapses, demonstrating dissemination in time and space, determines the diagnosis of MS.¹⁷ On the other hand, quantification of the number of active lesions (new or growing on T2-weighted images, or displaying contrast uptake) is increasingly important in the follow-up of patients with MS due to the increasing availability of DMTs. The presence of active lesions, a well-known marker of disease progression, is one of the parameters used to determine the presence or absence of disease activity (NEDA, or no evidence of disease activity)³⁸ in patients receiving DMTs. The most frequently used MRI sequences in MS are T2-weighted and T2-FLAIR sequences in studies of the brain, and T2-weighted and STIR sequences for the spinal cord. These sequences are sometimes complemented by gadolinium-enhanced T1-weighted sequences.³⁹ The number or volume of T2 lesions and the number of gadolinium-enhancing lesions predict the progression of disability^{40,41} and increases in the relapse rate.⁴²

There are inherent difficulties in quantifying the total number of lesions or the number of new or growing T2 lesions, especially when these are small or in patients with a high lesion load. Although automated techniques have been developed to count MS lesions in recent years,⁴³ the most widely used technique in clinical practice is visual analysis, which is subject to great variability.²² Another added difficulty is the lack of a standardised criterion for reporting lesion number, which results in great variability between neuroradiology reports. Some national⁴⁴ and international guidelines²⁵ propose classifying the number of lesions using ranges.

Table 3 presents our proposal for quantifying the number of brain and spinal T2 lesions in radiology reports. For counts of up to 20 brain lesions or 10 spinal cord lesions, these will be identified visually one by one; for greater numbers, the count will be approximate and expressed as a range. If brain lesions cannot be counted or are confluent with other lesions, or if spinal cord lesions present a diffuse pattern, this information should be indicated in the report.

Standardised scheduling of MRI scans

Radiology departments offer numerous types of MRI studies; the criteria for scheduling one study or another must therefore be unified. The factors affecting MRI scheduling include the time needed to complete the study, the specific

Table 1 Minimum information to be included in MRI requests.

Diagnosis	Follow-up
Date of CIS	Clinical status: symptoms, stability
Symptoms and progression	Diagnosis: MS phenotype
Suspected diagnosis	Reason for requesting an MRI study: suspected relapse, change in treatment, follow-up study in a stable patient, risk or suspicion of progressive multifocal leukoencephalopathy
Treatment with corticosteroids (start and end dates)	Clinical signs of disease activity and/or progression
Parts of CNS to be examined (and clinical justification)	Level of disability
Relevant comorbidities	Current treatment and start date (corticosteroids, DMTs)
Presence of severe kidney failure	Parts of CNS to be examined (and clinical justification)
Known allergy to contrast media	Relevant comorbidities
Special needs (level of independence, claustrophobia, pregnancy or breastfeeding, medical devices, etc)	Presence of severe kidney failure
Priority level	Known allergy to contrast media
	Special needs (level of independence, claustrophobia, pregnancy or breastfeeding, medical devices, etc)
	Priority level

Four levels of clinical priority may be established: emergency (same day), very urgent (within 72 h), urgent (within 15 days), and standard (before next appointment with neurology department).
CIS: clinically isolated syndrome; CNS: central nervous system; DMT: disease-modifying therapy; MS: multiple sclerosis.
Source: Spanish Official State Gazette.³¹

MRI protocol, equipment availability, and even the patient's level of independence. This results in high variability in the time elapsed between the MRI request and performance of the study. We present some recommendations for improving the scheduling of MRI studies.

Scheduling according to the appropriate time for each patient and type of study

The use of standard times (typically 20-40 minutes) for all MRI studies is a common practice; however, studies should be scheduled according to the time needed for each patient or type of study. Based on the times proposed by experts from other countries⁴⁵ and the experience of the members of the assessment committee, we propose estimated minimum times for diagnostic and follow-up MRI studies (Table 4).

Reducing unscheduled studies

To minimise delays caused by the performance of unscheduled (emergency) studies, we propose allocating a pre-established number of appointments for emergency studies based on historical data on the department's activity. This would enable emergency MRI studies to be performed without delaying previously scheduled appointments.

Prioritising emergency or priority studies

Effective scheduling must be sufficiently flexible to accommodate unscheduled emergency or priority studies. For

example, in patients with typical CIS, a diagnostic MRI study should be performed within a week. To meet this objective, specific time slots should be allocated for these emergency studies.

Sending reminders for outpatient appointments

To optimise the use of the available resources, last-minute changes and cancellations by the patient should be minimised. To this end, a telephone call should be made 24 to 48 hours before the appointment, or an automated appointment reminder system should be implemented.

Identification of reference neuroradiologists for MS

The same MRI machine and acquisition protocol or the same neuroradiology team should ideally be used to minimise variability between studies and radiology reports.¹⁴ Radiologists should also have a high level of experience with and knowledge about MRI, as MRI reports made by radiologists without specific expertise in neuroradiology have shown lower sensitivity and a higher false-negative rate in the detection of new MS lesions than those performed by experienced neuroradiologists.²⁴ This suggests that a neuroradiology team with experience in performing and interpreting MRI studies in patients with MS improves clinical outcomes.

The assessment committee recommends that working teams be stable and in close communication. The activity of neuroradiologists should be organised by neurology subspecialty; this promotes specialisation and participation in research projects. To improve communication between neu-

Table 2 Proposed information for inclusion in radiology reports for diagnosis and follow-up.

Diagnosis	Follow-up
Technique: Brain and/or spinal MRI (sequence) with/without gadolinium (dose)	Technique: Brain and/or spinal MRI (sequence) with/without gadolinium (dose)
Date of last study for comparison (if applicable)	Comparative analysis with previous studies
Comparative study with previous MRI to indicate the number of new/growing T2 lesions	<i>Date of previous study</i>
Detailed description of findings	<i>Indicate whether comparative analysis is technically viable</i>
<i>Global assessment of number of T2 and T2-FLAIR lesions (lesion load: minimal, low, moderate, high, very high)</i>	<i>Number of T2 lesions</i>
<i>Presence of lesions</i>	<i>Number and location of new or growing T2 lesions</i>
Periventricular: yes/no	<i>Number and location of gadolinium-enhancing lesions</i>
Juxtacortical: yes/no	<i>Presence of leptomeningeal gadolinium enhancement (T2-FLAIR)</i>
Brainstem: yes/no	<i>Detection of focal lesions with severe tissue damage (hypointense on T1-SE or T2-FLAIR). Increase in number and size</i>
Cerebellum: yes/no	<i>Presence and progression of brain atrophy</i>
Corpus callosum: yes/no	<i>Relevant incidental findings</i>
Spinal cord: yes/no	
<i>Description of lesion size and shape</i>	
<i>Number and location of gadolinium-enhancing lesions</i>	
<i>Presence of leptomeningeal uptake (T2-FLAIR)</i>	
<i>Detection of focal lesions with severe tissue damage (hypointense on T1-SE or T2-FLAIR)</i>	
<i>Brain atrophy: absent, mild, moderate, severe</i>	
<i>Relevant incidental findings</i>	
<i>Meeting radiological McDonald criteria</i>	
Dissemination in time: yes/no	
Dissemination in space: yes/no	
<i>Interpretation of findings and differential diagnosis</i>	

Table 3 Recommended ranges for quantification of lesions.

Number of lesions	
Brain MRI	Spinal cord MRI
0-20 (specify exact number)	< 10 (specify exact number)
20-50	> 10
50-100	Diffuse pattern
> 100	
Cannot be counted/confluent with other lesions	
MRI: magnetic resonance imaging.	

rologists and neuroradiologists, we recommend appointing “consultant” neuroradiologists based on their experience; these neuroradiologists will answer any questions posed by other specialists. This should be a rotating position, and the appointed neuroradiologists should be readily available through pre-established communication protocols.

Implementation of multidisciplinary committees for demyelinating diseases

As MS is a multidimensional disease, patients require multidisciplinary management. Coordination between all the

specialists involved is essential to ensuring appropriate management.^{26,46,47} The existence of a multidisciplinary committee would ensure that the diagnosis, treatment, and follow-up of these patients meets the required standards. [Table 5](#) includes our recommendations on the functions, responsibilities, and composition of the multidisciplinary team. Together with the specialists included in the support team ([Table 5](#)), multidisciplinary teams may include other specialists, according to the patient’s needs.

Implementation of liaison sessions between neurologists and neuroradiologists

To contribute to the continuous improvement of the care provided to patients with MS, a management structure should be created to coordinate the neurology and neuro-radiology departments. However, this practice is not sufficiently widespread among healthcare centres treating these patients. Establishing liaison sessions between neurologists and neuroradiologists, on the one hand, and the organisation and management team, on the other, may bring numerous improvements, such as sharing relevant information, developing shared protocols, analysing results using indicators, monitoring compliance with quality standards, and scheduling appointments. [Table 6](#) presents the recommendations for liaison sessions established by the assessment committee.

Table 4 Recommended minimum times allocated for MRI studies.

Description	Time
Diagnostic brain MRI	40 min
Follow-up brain MRI	30 min
Diagnostic brain MRI + spinal MRI (partial)	40 min + 15 min
Follow-up brain MRI + spinal MRI (partial)	30 min + 15 min
Diagnostic brain MRI + spinal MRI (complete)	40 min + 20 min
Follow-up brain MRI + spinal MRI (complete)	30 min + 20 min

These combinations of intervals aim to optimise scheduling of MRI studies, as they combine brain and spinal MRI scans in a single study, preventing them from being performed at different appointments. The duration of the appointments scheduled must take into account the patient's level of independence, the time needed to operate the MRI machine, and the changeover time between patients. To facilitate comparison of MRI studies, the machine and technique used should be the same as in previous scans performed with the same patient.

MRI: magnetic resonance imaging.

Development of formal communication mechanisms

One of the most frequent organisational problems in the hospital setting is the use of informal channels of communication. The use of informal mechanisms not only results in additional time costs for the professionals involved, but also has a detrimental effect on cases in which immediate action is needed.

Establishing formal channels of communication would result in faster, more efficient coordination between professionals. Communication should be automated whenever possible, adapting to each centre's possibilities. To standardise communication channels, such mechanisms as alert systems, telephone calls, and mobile instant messaging applications may be implemented. Communication should be bilateral, with the receiver sending confirmation of receipt.

Conclusions

The use of MRI in the diagnosis and follow-up of patients with MS is increasingly widespread due to its high sensitivity for detecting pathological events associated with the disease. Due to its key role and the anticipated increase in its usage in the coming years, several aspects should be optimised. More specifically, neurologists and neuroradiologists should combine their efforts to improve coordination between their departments. The assessment committee, made up of distinguished experts from both specialties, agreed on a series of recommendations aimed at standardising the information provided by each department and improving communication between them. These recommendations are based on the available scientific evidence, international good practice guidelines, and the experience of the expert panel.

The assessment committee recognises that the implementation of these recommendations largely depends on the resources, volume of clinical activity, and size of the hospital, but invites neurologists and neuroradiologists to incorporate them in their centres whenever possible. Implementing these recommendations, even partially, may

Table 5 Recommendations regarding the multidisciplinary committee.

Composition

Stable team: neurologist, neuroradiologist, nurse

Support team: neurophysiatrist, speech therapist, neurophysiologist, urologist, neuro-ophthalmologist, psychologist, psychiatrist, and pharmacist

Functions and responsibilities

Identification of complex cases

Presentation of cases

Discussion about diagnosis

Discussion about therapeutic management

Risk minimisation

Discussion about patient involvement and shared decisions

Aspects to be established once the multidisciplinary committee is created

Areas of competence, adapted to the needs of each centre

Composition and roles of committee members

Coordination of meetings (should be managed by reference neurologists and neuroradiologists)

Implementation of decisions by creating official clinical committees

Holding meetings at pre-established intervals (at least monthly). The contents of the meeting will vary depending on the clinical workload. Meetings may be cancelled if deemed unnecessary.

Table 6 Recommendations for liaison sessions between the neurology and neuroradiology departments.

At least 2 meetings per year
Topic should be outlined beforehand to encourage reflection prior to the session.
Sessions should be formalised through drafting and signing of the minutes of the meeting.
Hospital management should be informed of any decisions involving significant changes.
Attendees: neuroradiologists, neurologists, and nurses specialising in neurology. Radiology technicians and other specialists should also attend, depending on the contents of the sessions.

significantly improve the efficiency and functioning of the departments involved in the diagnosis, treatment, and follow-up of patients with MS.

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Conflicts of interest

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References

1. Thompson AJ, Baranzini SE, Geurts J, Hemmer B, Ciccarelli O. Multiple sclerosis. *Lancet*. 2018;391:1622–36.
2. Wallin MT, Culpepper WJ, Nichols E, Bhutta ZA, Gebrehiwot TT, Hay SI, et al. Global, regional, and national burden of multiple sclerosis 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. *Lancet Neurol*. 2019;18:269–85.
3. Browne P, Chandraratna D, Angood C, Tremlett H, Baker C, Taylor BV, et al. Atlas of Multiple Sclerosis 2013: a growing global problem with widespread inequity. *Neurology*. 2014;83:1022–4.
4. Perez-Carmona N, Fernandez-Jover E, Sempere AP. [Epidemiology of multiple sclerosis in Spain]. *Rev Neurol*. 2019;69:32–8.
5. Kobelt G, Thompson A, Berg J, Gannedahl M, Eriksson J. New insights into the burden and costs of multiple sclerosis in Europe. *Mult Scler*. 2017;23:1123–36.
6. Isaksson A-K, Ahlström G, Gunnarsson L-G. Quality of life and impairment in patients with multiple sclerosis. *J Neurol Neurosurg Psychiatry*. 2005;76:64–9.
7. Charil A, Filippi M. Inflammatory demyelination and neurodegeneration in early multiple sclerosis. *J Neurol Sci*. 2007;259:7–15.
8. Bevan RJ, Evans R, Griffiths L, Watkins LM, Rees MI, Magliozzi R, et al. Meningeal inflammation and cortical demyelination in acute multiple sclerosis. *Ann Neurol*. 2018;84:829–42.
9. Gilmore CP, Donaldson I, Bo L, Owens T, Lowe J, Evangelou N. Regional variations in the extent and pattern of grey matter demyelination in multiple sclerosis: a comparison between the cerebral cortex, cerebellar cortex, deep grey matter nuclei and the spinal cord. *J Neurol Neurosurg Psychiatry*. 2009;80:182–7.
10. Green AJ, McQuaid S, Hauser SL, Allen IV, Lyness R. Ocular pathology in multiple sclerosis: retinal atrophy and inflammation irrespective of disease duration. *Brain*. 2010;133:1591–601.
11. Petrova N, Carassiti D, Altmann DR, Baker D, Schmierer K. Axonal loss in the multiple sclerosis spinal cord revisited. *Brain Pathol*. 2018;28:334–48.
12. De Stefano N, Matthews PM, Filippi M, Agosta F, De Luca M, Bartolozzi ML, et al. Evidence of early cortical atrophy in MS: relevance to white matter changes and disability. *Neurology*. 2003;60:1157–62.

13. Casserly C, Seyman EE, Alcaide-Leon P, Guenette M, Lyons C, Sankar S, et al. Spinal cord atrophy in multiple sclerosis: a systematic review and meta-analysis. *J Neuroimaging*. 2018;28:556–86.
14. Rovira A, Wattjes MP, Tintoré M, Tur C, Yousry TA, Sormani MP, et al. MAGNIMS consensus guidelines on the use of MRI in multiple sclerosis—clinical implementation in the diagnostic process. *Nat Rev Neurol*. 2015;11:471–82.
15. Wattjes MP, Rovira A, Miller D, Yousry TA, Sormani MP, de Stefano MP, et al. Evidence-based guidelines: MAGNIMS consensus guidelines on the use of MRI in multiple sclerosis—establishing disease prognosis and monitoring patients. *Nat Rev Neurol*. 2015;11:597–606.
16. Rovira A, Tintoré M, Álvarez-Cermeño JC, Izquierdo G, Prieto JM. Recomendaciones para la utilización e interpretación de los estudios de resonancia magnética en la esclerosis múltiple. *Neurología*. 2010;25:248–65.
17. Thompson AJ, Banwell BL, Barkhof F, Carroll WM, Coetzee T, Comi G, et al. Diagnosis of multiple sclerosis: 2017 revisions of the McDonald criteria. *Lancet Neurol*. 2018;17:162–73.
18. Mantero V, Abate L, Balgera R, La Mantia L, Salmaggi A. Clinical application of 2017 McDonald diagnostic criteria for multiple sclerosis. *J Clin Neurol (Seoul, Korea)*. 2018;14:387–92.
19. Louapre C, Bodini B, Lubetzki C, Freeman L, Stankoff B. Imaging markers of multiple sclerosis prognosis. *Curr Opin Neurol*. 2017;30:231–6.
20. Kaunzner UW, Gauthier SA. MRI in the assessment and monitoring of multiple sclerosis: an update on best practice. *Ther Adv Neurol Disord*. 2017;10:247–61.
21. Sormani MP, Bruzzi P. MRI lesions as a surrogate for relapses in multiple sclerosis: a meta-analysis of randomised trials. *Lancet Neurol*. 2013;12:669–76.
22. Erbayat Altay E, Fisher E, Jones SE, Hara-Cleaver C, Lee JC, Rudick RA. Reliability of classifying multiple sclerosis disease activity using magnetic resonance imaging in a multiple sclerosis clinic. *JAMA Neurol*. 2013;70:338–44.
23. Shinohara R, Calabresi PA, Davatzikos C, Doshi J, Henry RG, Kim G, et al. Inter-scanner MRI variability of multiple sclerosis lesion and tissue volumes in the NAIMS cooperative. London: Congress of the ECTRIMS; 2016.
24. Wang W, van Heerden J, Tacey MA, Gaillard F. Neuroradiologists compared with non-neuroradiologists in the detection of new multiple sclerosis plaques. *AJNR Am J Neuroradiol*. 2017;38:1323–7.
25. Vagberg M, Axelsson M, Birgander R, Burman J, Cananau C, Forslin Y, et al. Guidelines for the use of magnetic resonance imaging in diagnosing and monitoring the treatment of multiple sclerosis: recommendations of the Swedish Multiple Sclerosis Association and the Swedish Neuroradiological Society. *Acta Neurol Scand*. 2017;135:17–24.
26. Soelberg Sorensen P, Giovannoni G, Montalban X, Thalheim C, Zaratin P, Comi G. The multiple sclerosis care unit. *Mult Scler*. 2019;25:627–36.
27. The Consortium of Multiple Sclerosis Centers. 2018 Revised Guidelines of the Consortium of MS Centers MRI Protocol for the Diagnosis and Follow-up of MS. Available from: https://www.msccare.org/page/MRI_protocol.
28. Bouëtté A, Karoussou-Schreiner A, Ducou Le Pointe H, Grieten M, de Kerviler E, Rausin L, et al. National audit on the appropriateness of CT and MRI examinations in Luxembourg. *Insights Imaging*. 2019;10:54.
29. Leslie A, Jones AJ, Goddard PR. The influence of clinical information on the reporting of CT by radiologists. *Br J Radiol*. 2000;73:1052–5.
30. Arevalo O, Riascos R, Rabiei P, Kamali A, Nelson F. Standardizing magnetic resonance imaging protocols, requisitions, and reports in multiple sclerosis: an update for radiologist based on 2017 magnetic resonance imaging in multiple sclerosis and 2018 Consortium of Multiple Sclerosis Centers Consensus Guidelines. *J Comput Assist Tomogr*. 2019;43:1–12.
31. BOE. Real Decreto 605/2003, de 23 de mayo, por el que se establecen medidas para el tratamiento homogéneo de la información sobre las listas de espera en el Sistema Nacional de Salud.
32. European Society of Radiology. Good practice for radiological reporting. Guidelines from the European Society of Radiology (ESR). *Insights Imaging*. 2011;2:93–6.
33. Alessandrino F, Pichiecchio A, Mallucci G, Ghione E, Romani A, Bergamaschi R, et al. Do MRI Structured reports for multiple sclerosis contain adequate information for clinical decision making? *AJR Am J Roentgenol*. 2018;210:24–9.
34. Dickerson E, Davenport MS, Syed F, Stuve O, Cohen JA, Rinker JR, et al. Effect of template reporting of brain MRIs for multiple sclerosis on report thoroughness and neurologist-rated quality: results of a prospective quality improvement project. *J Am Coll Radiol*. 2017;14:371–9.
35. Larson DB, Towbin AJ, Pryor RM, Donnelly LF. Improving consistency in radiology reporting through the use of department-wide standardized structured reporting. *Radiology*. 2013;267:240–50.
36. Charles E, Kahn J, Langlotz CP, Burnside ES, Carrino JA, Channin DS, et al. Toward best practices in radiology reporting. *Radiology*. 2009;252:852–6.
37. Traboulsee A, Letourneau-Guillon L, Freedman MS, O'Connor PW, Bharatha A, Chakraborty S, et al. Canadian expert panel recommendations for MRI use in MS diagnosis and monitoring. *Can J Neurol Sci*. 2015;42:159–67.
38. Giovannoni G, Bermel R, Phillips T, Rudick R. A brief history of NEDA. *Mult Scler Relat Dis*. 2018;20:228–30.
39. Filippi M, Preziosa P, Banwell BL, Barkhof F, Ciccarelli O, De Stefano N, et al. Assessment of lesions on magnetic resonance imaging in multiple sclerosis: practical guidelines. *Brain*. 2019;142:1858–75.
40. Brex PA, Ciccarelli O, O'Riordan JI, Sailer M, Thompson AJ, Miller DH. A longitudinal study of abnormalities on MRI and disability from multiple sclerosis. *N Engl J Med*. 2002;346:158–64.
41. Brownlee WJ, Altmann DR, Prados F, Miszkil KA, Eshaghi A, Gandini Wheeler-Kingshott CAM, et al. Early imaging predictors of long-term outcomes in relapse-onset multiple sclerosis. *Brain*. 2019;142:2276–87.
42. Kappos L, Moeri D, Radue EW, Schoetzau A, Schweikert K, Barkhof F, et al. Gadolinium MRI Meta-analysis Group. Predictive value of gadolinium-enhanced magnetic resonance imaging for relapse rate and changes in disability or impairment in multiple sclerosis: a meta-analysis. *Lancet*. 1999;353:964–9.
43. Dworkin JD, Linn KA, Oguz I, Fleishman GM, Bakshi R, Nair G, et al. An automated statistical technique for counting distinct multiple sclerosis lesions. *Am J Neuroradiol*. 2018;39:626–33.
44. Gobierno de Canarias, Consejería de Sanidad. Guía de actuación en pacientes con esclerosis múltiple. 2016.
45. Ontario. Ministry of Health and Long-Term Care. Ontario Best Practice Guidelines for Managing the Flow of Patients Requiring

- an MRI or CT Examination, effective as of May 28, 2009. Toronto (ON): Ministry of Health and Long-Term Care (ON); 2009. 43p.
46. National Institute for Health and Care Excellence. Multiple sclerosis in adults: management. 2014; Available from: <https://www.nice.org.uk/guidance/cg186>.
47. Gallien P, Gich J, Sanchez-Dalmau BF, Feneberg W. Multi-disciplinary management of multiple sclerosis symptoms. *Eur Neurol*. 2014;1:20–5.