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Magnetic resonance imaging assessment in patients with axial spondyloarthritis: development of checklists for use in clinical practice

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Abstract

The objective of our study was to standardize magnetic resonance imaging (MRI) assessment of spine and sacroiliac joints in patients with axial spondyloarthritis (axSpA) and/or inflammatory spinal pain, by creating checklists and templates based on the opinions of rheumatologists and radiologists. A scientific committee developed a series of questionnaires with multiple items regarding MRI in patients with axial inflammatory pain and/or axSpA. Then an expert panel of rheumatologists and radiologists rated all items in a 9-point Likert scale. Finally, the scientific committee and the expert panel met to create the definitive documents. Several definitive checklists and templates were generated for rheumatologist-requested MRI and for radiologist-requested MRI reports of sacroiliac joint and spinal examinations. A technical requirement protocol was also agreed on. Our results could be useful in increasing understanding between rheumatologists and radiologists regarding MRI in axSpA diagnosis and follow-up.

Keywords Ankylosing spondylitis · Magnetic resonance imaging · Rheumatologists · Radiologists · Surveys and questionnaires

Introduction

Axial spondyloarthritis (axSpA) is a systemic, chronic, inflammatory disease that affects the sacroiliac joints (SIJ) and spine. It affects patients' personal and work life [1] and impairs their health-related quality of life (HRQoL) [2]. It also represents a substantial burden on the health system [1]. Therefore, early diagnosis of axSpA is of paramount importance [1]. In 2009, the Assessment of SpondyloArthritis international Society (ASAS) included active inflammation of sacroiliac joints on MRI within the diagnostic algorithm for axSpA [3], and subsequent recommendations have supported the role of MRI in this disease [4]. MRI is increasingly used in axSpA diagnosis, although currently it is not the first choice of imaging examination [5]. However, according to the Guidelines of the European League Against Rheumatism (EULAR), 'in certain cases, such as young patients and those with short symptom duration, MRI of the SI joints is an alternative first imaging method' and 'if the diagnosis of axial SpA cannot be established based on clinical features and conventional radiography, and axial SpA is still suspected, MRI of the SI joints is recommended' [6]. Furthermore, these guidelines consider MRI to be useful as an additional imaging method for monitoring disease activity and structural changes, as well as for predicting the outcome, severity, and effect of treatment [6]. Similarly, the 2016 ASAS-EULAR management recommendations state that MRI can be used to study inflammation and, in some cases, it may help to decide whether a particular drug should be continued [7]. MRI allows early recognition of axSpA and is better than other techniques such as conventional radiography at detecting structural changes. Therefore, in certain

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cases MRI could eventually replace conventional radiography of SIJ for axSpA diagnosis [8].

The Spondyloarthritis Study Group of the Spanish Rheumatology Society (GRESSER) and the Spanish Society of Musculoskeletal Radiology (SERME) promote the PROGRESSES project, an education program on MRI in axSpA. Its main objectives are to improve knowledge of axSpA and use of MRI, and to encourage cooperation between rheumatologists and radiologists. As part of the project, more than 20 annual workshops were held across Spain for three consecutive years. Afterward, 147 workshop participants (96 rheumatologists and 51 radiologists) completed a survey whose results showed that there was a need for a better implementation of MRI protocols and for standardized MRI requests and reports in axSpA. Only around 50% of the specialists surveyed had at their disposal standardized reports that allowed rheumatologists to correctly interpret MRI results. Besides, technical requirement protocols for MRI were available for only 65.5% of rheumatologists and 55.2% of radiologists. These protocols already existed before the workshops in more than 50% of centers for rheumatologists and in more than 70% of centers for radiologists [9]. Consequently, workshop teachers considered that there was a need to standardize rheumatologists' and radiologists' MRI assessment of patients with axSpA and/or inflammatory spinal pain. Use of checklists would improve early diagnosis of axSpA and would also prevent improper diagnoses by differential diagnosis with other causes of inflammatory spinal pain. Workshop teachers also felt it was essential that radiologists received appropriate information for the correct interpretation of MRI images. Finally, they considered it useful to define a technical requirement protocol for MRI examinations of suspected axSpA.

Therefore, the objective of our study was to standardize MRI assessment in patients with axSpA and/or inflammatory spinal pain by creating checklists and templates based on the opinions of rheumatologists and radiologists.

Materials and methods

In February 2018, the study coordinators (two rheumatologists and one radiologist) developed a checklist and a request template regarding the information rheumatologists should provide to radiologists, and checklists and report templates for SIJ and spinal MRI examinations. A technical requirement protocol was also developed. All documents were based on the best evidence available, because they were developed after a literature review (PubMed as well as national and international guidelines and consensus) for all the socio-demographic, clinical, and therapeutical variables related to assessment of patients with AxSpA. All documents were intended to be adapted to clinical practice, and all the checklist items were selected according to their clinical relevance, validity and feasibility. Each item and the proposed templates were rated on a 9-point Likert scale from 1 (totally disagree) to 9 (totally agree): 1–3, disagree; 4–6, neither agree nor disagree; 7–9, agree. Afterward, the documents were presented to an expert panel.

In March 2018, the questionnaires were sent by post to the expert panel, composed of 18 workshop teachers and selected to achieve geographical representation. Participants also had to return the completed questionnaires by post.

Finally, the scientific committee and the expert panel met to discuss the potential inclusions in the checklists and templates of those items scoring < 7 points and ≥ 4 points. Here, we present the definitive documents.

Statistical analysis

Scores for each item, as well as scores for the templates, were analyzed using Stata 15.0 software (StataCorp. 2017) to obtain the respective means, medians, and mean confidence intervals.

Results

Seventeen experts (10 rheumatologists and 7 radiologists) completed the survey. After the scientific committee and expert panel meeting, definitive checklists, report templates, and technical requirements were agreed on.

MRI-request checklist for rheumatologists

Rheumatologists should include a series of items in their MRI requests to appropriately inform radiologists. These items are related to clinical information (age, gender, personal history, family history, reason for request, suspected diagnosis and differential diagnosis, and other clinical information), and whether follow-up MRI is needed (Table 1). Items included had a mean ≥ 7 or were added because they were considered relevant by the scientific committee and expert panel (Online resource 1).

Some proposed items did not reach the minimum score (7 points) and/or were discarded by the scientific committee because of their irrelevance to the MRI request: some comorbidities (blood hypertension, smoking, diabetes, dyslipidemia, cardiovascular events, and renal failure), physical examination, Bath Ankylosing Spondylitis Activity Index (BASDAI) and Bath Ankylosing Spondylitis Functional Index (BASFI) scores, and disease-modifying antirheumatic drug (DMARDs) treatment.

Table 1 Checklist for MRI request by rheumatologists

Demographic data	Age
	Gender
Personal history	Allergies to drugs and/or contrast media
	Comorbidities (morbid obesity, active infection, neoplasia, osteoporosis, and others [specify])
	Prior diagnosis of spondyloarthritis (yes/no) and spinal ankylosis (yes/no)
	Surgery (yes/no)
Family history	Spondyloarthritis, psoriasis, reactive arthritis, uveitis, IBD, others
Reason for request	Back pain characteristics (inflammatory/mechanical/mixed; neurogenic claudication)
	Back pain site (cervical/dorsal/lumbar; alternating buttock pain)
	Duration of symptoms
	Neurologic symptoms (paresthesia, loss of strength, osteotendinous reflex abolition)
	Traumas (yes/no)
	Other joint symptoms (peripheral arthritis, dactylitis, enthesitis)
	Extra-articular manifestations (IBD, psoriasis, urethritis/cervicitis, uveitis, fever, others)
Suspected diagnosis and differential diagnosis	axSpA
	Degenerative disc disease; spinal stenosis; spondylolysis; rupture of annulus fibrosus; SIJ arthrosis; osteitis condensans; DISH; fractures; infections; tumors; microcrystal-induced arthritis; ochronosis; anatomic variants
Follow-up/evolution MRI	Yes/no
Previous additional tests	APR (ESR and/or CRP) increase; creatinine/urea/GFR; HLA B27; spine and pelvis Rx; MRI of spine and/or SIJ, hips; others (CT, scintigraphy)
Clinical control	ASDAS
Current therapies	NSAIDs, corticosteroids, biological therapies, and others
Safety information	Allergy to contrast media/gadolinium
	Renal function
	Pregnancy (first trimester)
	Claustrophobia
	Use of metal-containing devices (pacemakers, prosthesis, iron-containing tattoos, and piercings)

IBD inflammatory bowel disease, *axSpA* axial spondyloarthritis, *SIJ* sacroiliac joint, *DISH* diffuse idiopathic skeletal hyperostosis, *APR* acute phase reactants, *ESR* erythrocyte sedimentation rate, *CRP* C-reactive protein, *GFR* glomerular filtration rate, *Rx* plain X-rays, *CT* computed tomography, *ASDAS* Ankylosing Spondylitis Disease Activity Score, *NSAID* nonsteroidal anti-inflammatory drug

The MRI request should also include safety information (Table 1). All proposed items were accepted (Online resource 1) except for the use of an intrauterine device.

MRI-request template for rheumatologists

Rheumatologists should carefully prepare MRI requests. Table 2 includes a template for a spinal and/or sacroiliac joint MRI request in a patient with axial inflammatory pain and/or axial spondyloarthritis. There was a mean consensus of 7.79 for this template.

Furthermore, the suspected diagnosis is essential. It is important to provide information relating to previous studies, response to treatment, renal function, history of trauma, family history, and extra-articular manifestations or symptoms that will not be assessed by MRI.

Checklist for MRI of sacroiliac joints

Table 3 shows the checklist for MRI of SIJs designed to provide radiologists with necessary information about patients with axSpA. Items to be assessed are related to technique, potential anatomic variants, special findings

Table 2 Model of template for MRI request of spine and/or sacroiliac joint in a patient with axial inflammatory pain and/or axial spondyloarthritis

Man/women of __ years, with **family history** of (_____), relevant **personal clinical and safety history** of (_____), **diagnosed with** HLA-B27 positive spondyloarthritis, **stage** (or others: spondylosis, others…) treated with (_____). He/she has pain (**location, type and duration**). He/she also has (**extra-joint and/or joint symptoms**). Additional tests showed (**laboratory tests, imaging tests**). Please assess (**suspected diagnosis and differential diagnosis**)

Table 3 Checklist for MRI report of sacroiliac joint

Technique	Slices and sequences, gadolinium, signal/noise ratio (or image quality), artifacts
Anatomic variant	Lumbosacral transition anomaly, (posterior) accessory joint, bilateral bipartite iliac bone plates
SIJ	Space: normal, increased or reduced; synovitis/effusion (yes/no); interline calcification (yes/no)
	Subchondral cortical: absence or presence of osteophytes, geodes, erosions, backfill lesion, bony bridges, and ankylosis Subchondral bone marrow: edema, fat, sclerosis
	Bone marrow adjacent to capsule insertion (edema/capsulitis)
Other entheses	Signal (normal, increased)
Visualized lumbosacral union	L5–S1 disc: normal, degenerative disc disease (Modic) vs. inflammatory disc disease
	Interapophyseal joints: normal, degenerative changes vs. inflammatory pathology
Other findings	Increase of perijoint soft tissue (for example, infectious sacroiliitis)
	Radicular tumor (for example, schwannoma)
	Bone injury (hidden fracture, failure or stress fracture, tumor, tumoral diffuse infiltration, and others)
	Intrapelvic injury
	Hips (if included in para-axial slice): absence or presence of bone edema, joint pinching, erosions, geodes, osteophytes, synovitis–effusion

including bone marrow edema, other entheses, visualized lumbosacral union, and other findings. Radiologists should assess all items in patients with suspected or confirmed axSpA and/or inflammatory spinal pain. All proposed items were included in the final checklist except some technical parameters [slice thickness (ST), field of view (FOV), and matrix] (Online resource 2).

Template for MRI report of sacroiliac joints

There was consensus for the template for SIJ MRI report with a mean of 7.94 (Table 4). Radiologists should quantify the number and size of inflammatory lesions (bone marrow edema, BME) and specify the number of consecutive slices where they are visualized. A recent Rx study is essential; anteroposterior and lateral Rx of lumbar spine that include SIJs are adequate. These should be compared with prior studies, if available. Radiologists should also indicate whether hip morphology is normal or dysplastic.

Checklist for MRI of spine

Table 5 contains the checklist for items that radiologists should assess in MRI of spine in patients with suspected axial spondyloarthritis and/or inflammatory pain. Items are classified as related to technique, intervertebral disc unit (disc, vertebral endplate, vertebral bone marrow, and posterior elements), and other findings. There was consensus on all the proposed items with the exception of the aforementioned technical parameters (ST, FOV, and matrix) (Online resource 3).

Template for MRI report of spine

There was also consensus on the proposed template for spine MRI report by radiologists (mean 7.88) (Table 6). Radiologists should describe lesions (specifying their inflammatory or degenerative origin and using Romanus and Andersson terms), and quantify the number and location of inflammatory lesions. It is important to compare these with prior studies, if available.

Table 4 Template for normal MRI report of sacroiliac joint in patients with suspected axial spondyloarthritis and/or inflammatory pain

- The MRI study has been performed with SIJ sagittal and coronal slices, both T1- and STIR-weighted.
- No anatomical variant or lumbosacral transition disorders including L4–S1 interapophyseal joints, has been identified.
- SIJs with preserved joint space, without evidence of erosions or osteophytes (pay attention to small (< 1 cm) marginal foci of osteophyte-associated edema).
- No alterations in subchondral bone marrow signal and visualized enthesis have been identified.
- No increase of perijoint soft tissue has been identified.
- Mention hip joints (if included in para-axial slice) only in case of alteration.
- Bone marrow edema: quantitative assessment (classify as mild, moderate, or severe if no further information is available).
- If prior studies are available, assess image evolution.
- Conclusion: No morphological or inflammatory sacroiliitic lesions were identified.

Table 5 Checklist for MRI of spine

Technique	Slices and sequences, gadolinium, signal/noise ratio (or image quality), artifacts
Anatomic variant	Lumbosacral transition anomaly, limbus vertebra, vertebral segmentation anomalies (vertebral body, posterior arch), spina bifida, others
Intervertebral disc unit	Disc
	Height (normal, decreased); signal (normal, increased, decreased); annulus fibrosus (bulging, herniation, protrusion, rupture); calcification (absent, present)
	Vertebral endplate
	Absence or presence of Schmorl's nodes, erosions, osteophytes, syndesmophytes (location, number), bony bridges (location, number), calcification of the anterior longitudinal ligament, and gadolinium enhancement
	Vertebral bone marrow
	Edema
	Romanus: location of segment and vertebra; location in vertebral body (anterior, posterior, massive); number
	Andersson lesions: spinal location (cervical, dorsal, lumbar); extent (mild, moderate, severe)
	Modic I: location of segment and vertebra; number
	Fat
	Inactive Romanus: location of segment and vertebra; location in vertebral body (anterior, posterior, massive); number
	Modic II: location of segment and vertebra; number
	Sclerosis (absent, present)
	Posterior elements
	Interapophyseal joints, spinous process, spine ligaments, costovertebral joint, costotransverse joint, and facet joints; edema (subchondral and/or enthesis); increased soft tissue; erosion, sclerosis, fat lesion, ankylosis
	Spinal canal
	Lumen (normal, increased, stenosis)
	Arachnoiditis
Other findings	Spine fracture/wedging (with or without bone edema, number, location); increase of perivertebral soft tissue (infectious spondylodiscitis or other causes); spine tumor (osteoid osteoma, hemangioma or others); myeloma; Scheuermann's disease; ochronosis; DISH; others

DISH diffuse idiopathic skeletal hyperostosis

Table 6 Template for normal MRI report of spine in patients with suspected axial spondyloarthritis and/or inflammatory pain

- The MRI study was performed with T1- and T2 -weighted sagittal and axial slices. STIR-weighted sagittal slices.
- No anatomical variants have been identified. Normal lumbosacral transition. Normal structure of posterior arches.
- Alignment, morphology and height of vertebral bodies without significant alterations.
- No marginal osteophytes or syndesmophytes have been identified. Normal bone marrow signal without evidence of edema foci (increased STIR signal) or by fat infiltration (increased T1 signal). (Description and assessment if the origin is inflammatory, degenerative, etc. Optional use of term Romanus and Andersson) (Quantitative assessment of number of edematous or fat lesions).
- Intervertebral discs of normal height and signal with preserved annulus fibrosus. Interapophyseal joints of normal morphology and without edematous changes (hyperintense in STIR) in bone marrow and perijoint soft tissue. No alterations in signal of bone marrow and soft tissues adjacent to visualised costovertebral and costotransverse joints. Enthesis unchanged.
- Wide spinal canal, with normal lateral recesses and intervertebral foramina; no radicular compromise has been identified.
- No alteration in conus medullaris or cauda equina.
- Compare with prior studies if available.
- Conclusion: No significant alterations. No spondylolysis, radicular compromise, or inflammatory signs have been identified.

MRI protocols

There was consensus on MRI protocol for SIJ using axial and coronal planes regarding SIJs in T1 and STIR sequences whereby:

- in axial planes, FOV must include hips (at least 35 cm);
- slice thickness ≤ 3 mm and gap ≤ 0.6;
- matrix should not be too small (not < 320);
- if a diffusion sequence is performed, use $b = 800$.

For spinal MRI, there was agreement in performing sagittal plane scans with SE T1, FSE T2, and STIR sequences, and axial planes with T1 and T2 sequences (with possible fat suppression) whereby:

- FOV is adjusted to the studied segment;
- slice thickness ≤ 3 mm and gap ≤ 0.6;
- slices in sagittal planes of dorsal segment must include costotransverse joints;
- matrix should not be too small (not < 280).

For more detailed parameters, the scientific committee and the expert panel recommended those of the consensus of the Arthritis Subcommittee of the European Society of Skeletal Radiology (ESSR) [10, 11].

Discussion

Collaboration and communication between rheumatologists and radiologists are essential for MRI use and interpretation in rheumatic diseases [12] such as axSpA [13], rheumatoid arthritis (RA) [14, 15] and juvenile idiopathic arthritis [16]. Regarding axSpA, cooperation between both types of specialists has to be improved to assure better diagnosis and treatment of the disease [13].

Combined efforts of rheumatologists and radiologists have produced recommendations for MRI use in rheumatic diseases [17], including axSpA [6]. However, a joint consensus statement on MRI use in axSpA [13] is still needed, as well as an increased standardization of MRI procedures in axSpA [18]. The PROGRESSES project also detected this need for standardization in MRI requests, reports, and protocols in axSpA [9]. We present a series of checklists and templates that could improve the relationship between rheumatologists and radiologists providing standardized models for MRI requests and reports. The proposed checklists and templates are potentially useful in clinical practice, particularly in improving axSpA diagnosis and its differential diagnosis.

Currently, axSpA remains underdiagnosed [19, 20], especially in patients without 'typical' features [21], and diagnosis can be delayed up to 8 years [22, 23]. Delayed diagnosis has been related to worse outcomes and unsatisfactory response to therapy in patients with axSpA [24]. Disease burden is higher than in patients with RA [25], with back pain as the most frequent complaint [19], as well as depression and physical limitations [26]. The consequences of physical limitations imply direct and indirect costs to health systems, patients, and society. MRI is not only useful in diagnosing axSpA, but also for differential diagnosis [27]. MRI can distinguish vertebral fractures, neoplasias or degenerative lesions from axSpA lesions. It is important to remember that there is an increased risk of vertebral fractures in axSpA. Therefore, patients should be assessed even after minimal trauma. MRI can show occult fractures that can be unseen in plain radiography and even in computed tomography scans [28, 29].

Accurate diagnosis of axSpA allows therapeutic measures to be initiated as required. In addition, it could prevent iatrogenic damage by inappropriate therapy and be cost saving. Furthermore, MRI standardization could improve axSpA diagnosis and patient management [8]. However, costs associated with MRI can restrict its use in developing countries [30], where repeated MRI may be not feasible for patients' follow-up.

MRI has a role in axSpA management. If disease activity is seen in MRI in spite of treatment with nonsteroidal anti-inflammatory drugs (NSAIDs), biological therapy is recommended [31]. However, spine MRI could be of limited value to decide treatment changes. According to ASAS classification criteria, positive spine MRI includes active Romanus lesions (three or more lesions) and inactive fat lesions (five or more lesions) [3]. However, these images can be seen in healthy people. Therefore, axSpA therapy cannot be changed only by these findings, and clinical, analytical, and other imaging findings have to be considered [6]. By contrast, other MRI findings are more specific: Andersson lesions or posterior element lesions suggest disease activity and are useful to guide therapy. Moreover, MRI can identify patients with high risk of progression: fat lesions, extensive bone marrow edema, and/or syndesmophytes. Finally, MRI helps to predict response to axSpA: high inflammatory activity (bone marrow lesions) in MRI is a predictor of good response to anti-TNF agents. Thus, MRI can be used to initiate anti-TNF therapy [6]. Moreover, the 2019 update of the American College of Rheumatology on the treatment of axSpA highlights the role of MRI for the management and follow-up of axSpA [31]. In this context, we hope that our checklists and templates contribute to a better and more extensive use of MRI in axSpA.

One potential limitation of our study was that we did not use a Delphi approach, as this was not appropriate for such a small number of participants. Furthermore, the multiple items in the questionnaires would have implied an excessive number of questions and been too time-consuming. Therefore, we used a Likert scale and performed only a descriptive statistical analysis of the data.

With regard to items where no consensus was reached, we are planning a new study with a larger expert panel. This way, we hope to be able to develop even more accurate checklists and templates for rheumatologists and radiologists. These future documents could include items related to other potential alterations such as anterior chest wall inflammation, a not uncommon finding in axSpA [32]. In addition, the scientific committee and the expert panel discarded some items related to personal or family history which were awarded mid-range scores (neither agree nor disagree) because they are not needed for a correct MRI report. We did not include the 'ST/FOV/matrix' item in the final checklists because radiologists always assess this item,

and we did not consider these technical details (included in the image-acquisition protocol) to be significant in the MRI report. Moreover, we did not include technical details or specify sequences and planes in the MRI-request template, as information provided by rheumatologists should be enough for radiologists to choose the most appropriate approach.

In conclusion, we consider that our results could be useful for increasing understanding between rheumatologists and radiologists about MRI for axSpA diagnosis and follow-up. Extensive and detailed MRI requests and reports could result in a better knowledge of axSpA, as well as in better patient care.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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