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Spinal Lesions in Axial Psoriatic Disease: How Should They Be Identified and Quantified by Magnetic Resonance Imaging?

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ABSTRACT. Proper assessment of patients with psoriatic arthritis (PsA) requires assessment of all disease domains, including axial disease. Magnetic resonance imaging (MRI) is the method of choice for evaluating axial involvement in PsA. When assessing patients with PsA for spinal involvement, it is important to assess both vertebral body lesions and posterolateral lesions, such as inflammation in facet joints and costovertebral joints, and enthesitis at spinous and transverse processes. The Canada-Denmark (CanDen) assessment system for spine MRIs is the preferred method for detailed evaluation of inflammation and structural damage at various anatomical locations in the spine, and it is reproducible and sensitive to change. The Assessment of Spondyloarthritis international Society (ASAS) has recently published MRI definitions of inflammatory and structural lesions in the spine, incorporating the CanDen definitions of spinal lesions on MRI. Applying the ASAS definitions and the CanDen assessment system in clinical practice and trials is recommended. Ongoing research/studies, not least the Axial Involvement in Psoriatic Arthritis (AXIS) study, may provide a data-driven definition of axial involvement in PsA. Ongoing research is expected to further improve and validate assessment tools for axial PsA and to provide a much-needed data-driven consensus-based definition of axial involvement in PsA.

Key Indexing Terms: GRAPPA, magnetic resonance imaging, psoriasis, psoriatic arthritis, spine, spondyloarthritis

Introduction

Psoriatic arthritis (PsA) and other diseases within the spondyloarthritis disease spectrum are characterized by various patterns of inflammation in peripheral and axial joints and entheses. The various manifestations all contribute to the considerable pain, fatigue, and functional disability experienced by patients.[1,2]

Axial disease is one of the domains in the Group for Research and Assessment of Psoriasis and Psoriatic Arthritis (GRAPPA) treatment recommendations for PsA.[3] These recommendations specifically state that appropriate assessment of patients with PsA requires consideration of all disease domains so that treatment targets all the domains involved in individual patient disease.[3] Thus, the ability to assess the axial manifestations of PsA in clinical practice is crucial. Further, there may be a difference in response to certain treatments between axial vs peripheral symptoms in PsA and/or between patients with axial manifestations due to axial spondyloarthritis (axSpA) vs due to PsA with axial involvement (axPsA).[4,5] Consequently, there is also a large need for sensitive detection and monitoring of axial inflammation in order to identify the most effective therapies for axial inflammation in PsA in future clinical trials.

No generally accepted definition of axial involvement in PsA yet exists. Clinical examination does not allow assessment of axial inflammation (ie, disease activity). Serum C-reactive protein and responses to questionnaires such as the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) may be heavily influenced by peripheral manifestations,[3] which are very common in PsA. In contrast, imaging provides direct visualization of axial manifestations and is therefore considered a promising assessment tool by GRAPPA members.[6] Different imaging modalities have different strengths and weaknesses.[7,8] Conventional radiography (radiography) and computed tomography (CT) do not allow assessment of current inflammation and the axial joints are not accessible to ultrasonography (US); in contrast, inflammation in the sacroiliac joints and the spine in PsA can be visualized by magnetic resonance imaging (MRI; see the Table for details).[7,8] The current article focuses on MRI assess-

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Table. Ability of different imaging modalities to visualize sacroiliac and spine pathologies.

	Radiography	US	MRI	CT
Sacroiliac joints				
Inflammation				
Bone marrow edema	–	–	+++	(+)[a]
Capsulitis, enthesitis, etc.	–	(+)[b]	+++	–
Structural damage				
Bone erosion	+	–	+++	+++
Fat lesion	–	–	+++	–
New bone formation/ankylosis	+	–	++	+++
Spine				
Inflammation				
Bone marrow edema	–	–	+++	(+)[a]
Soft tissue inflammation[c]	–	(+)[b]	+++	–
Structural damage				
Bone erosion	+	–	++	+++
Fat lesion	–	–	+++	–
New bone formation/ankylosis	++[d]	–	+[e]	+++
Disc degeneration/herniation	+	–	+++	+

Explanation of ability levels: +: yes, some ability; ++: yes, good ability; +++: yes, very good ability; –: no ability; (x): in certain areas/under certain conditions. [a] With dual-energy CT. [b] In areas accessible to US. [c] Eg, at entheses. [d] ++ In lumbar and cervical spine; not accessible in thoracic spine due to superimposition of thoracic cage. [e] + with conventional MRI. Newer techniques will probably improve this (see Willesen et al[29]). CT: computed tomography; MRI: magnetic resonance imaging; US: ultrasonography.

ment of the spine in PsA. This topic was presented and discussed within a workshop at the GRAPPA 2023 annual meeting.

Assessment of the spine using MRI

Patients with axSpA and axPsA demonstrate inflammation and damage at different anatomical locations in the spine on MRI, including the vertebral bodies and the posterolateral elements of the vertebrae (ie, the costotransverse joints, costovertebral joints, facet joints, spinous/transverse processes, and the surrounding soft tissues).[9,10] Several well-established methods exist for assessing inflammation in the spine in patients with axSpA. The Spondyloarthritis Research Consortium of Canada (SPARCC) MRI Spine Index and the Berlin modification of the Ankylosing Spondylitis spine MRI-activity (ASspiMRI-a) methods are the most frequently used in clinical trials.[11,12] These methods are based on assessment of the vertebral bodies of each discovertebral unit. They do not record where in the vertebral bodies the inflammation is located (ie, whether inflammation is present as anterior or posterior corner lesions [reflecting enthesitis at the anterior or posterior longitudinal ligaments], as noncorner lesions [reflecting spondylodiscitis], or as lateral lesions) and they do not assess inflammation in the posterolateral elements of the spine. In contrast to these well-established MRI scoring systems, the Canada-Denmark (CanDen) MRI scoring method for assessment of spinal inflammatory and structural lesions in patients with axSpA was developed to allow detailed anatomical evaluation of the vertebral bodies as well as the posterolateral elements (Figure).[13,14] The CanDen definitions have recently been adopted by the Assessment of Spondyloarthritis international Society (ASAS), as described in a recent paper reporting definitions for spinal lesions on MRI in axSpA (Box).[15] Inflammation at each vertebral level can be assessed separately in relation to discrete lesions at each vertebral endplate and vertebral corner, in synovial joints such as facet joints, in costovertebral and costotransversal joints, and at posterior entheses at the spinous processes and transverse processes.[13,16] Similarly, assessment of structural lesions, such as fat metaplasia, bone erosion, and, with lower sensitivity, new bone formation (Box), is possible at each individual location.[14,16] It is highly relevant to be able to assess not only the vertebral bodies as a whole, but also individual locations, not least in the posterolateral elements, both for diagnosis and monitoring, since findings there are part of the disease and contribute to the symptoms of the patients and to diagnostic certainty (some lesions are more specific to axSpA than others). Further, the disease at the different locations may not respond identically to various therapies, as described below.[10,17-19]

The CanDen MRI scoring system of spinal inflammatory lesions is highly sensitive to change, as reported in several drug trials of patients with axSpA. The method has allowed documentation of statistically significant efficacy of several drugs, including tumor necrosis factor and Janus kinase inhibitors.[10,17-19] In several of these studies, the CanDen method also showed differing efficacy per location. In particular, axSpA-specific inflammatory lesions at facet and costovertebral joints improved significantly during active therapy, whereas others, such as noncorner inflammatory lesions (also known as vertebral endplate inflammatory lesions), showed less improvement.[10,18] This is consistent with the fact that the bone marrow edema of noncorner inflammation is located along the disc at the vertebral endplate, which is also seen very frequently in degenerative disc disease.[20,21] Some of these lesions may therefore have a degenerative origin and, consequently, this lesion type may, on average, be expected to improve less with treatment. Including lesions at this location in

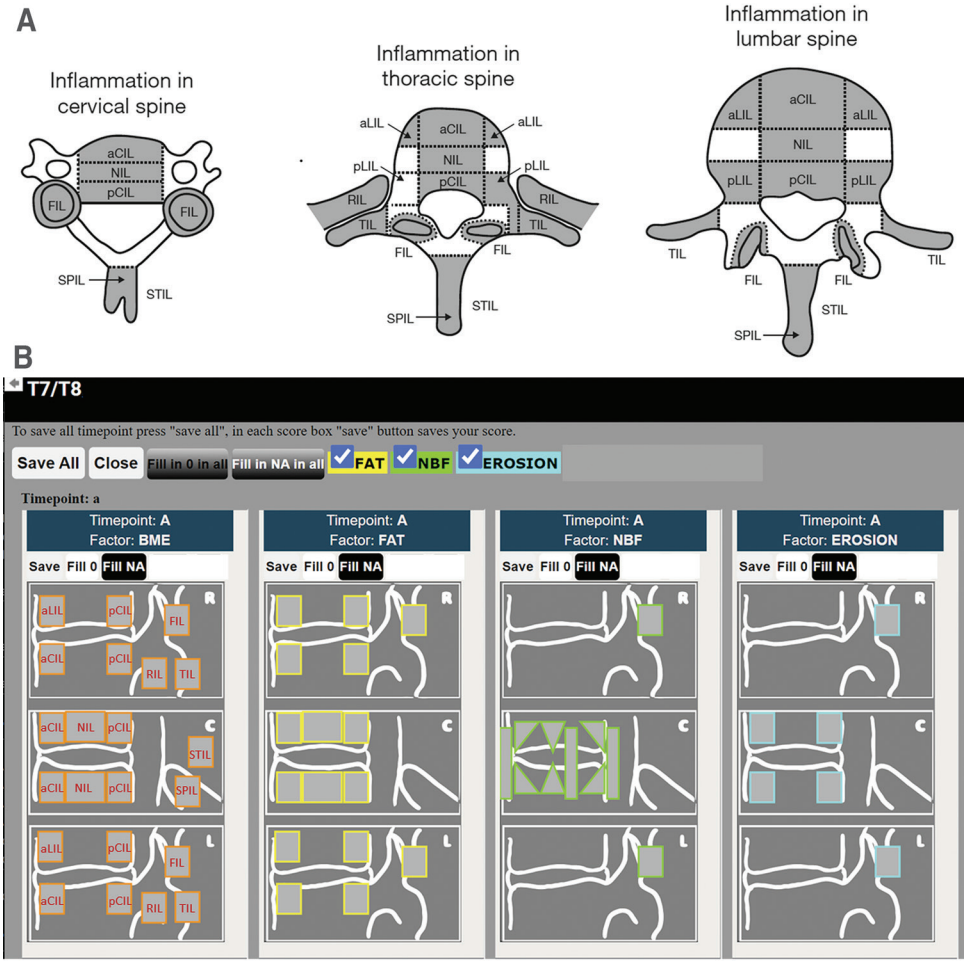

Figure. (A) Anatomical location of lesions assessed by the CanDen method. The following inflammatory lesions are assessed when using the CanDen method: aCIL, aLIL, FIL, NIL, pCIL, pLIL (also known as costovertebral inflammatory lesion in the thoracic region), RIL, SPIL, STIL, TIL. Line drawing reproduced from Østergaard et al.[19] To view a copy of the license to reproduce this open access figure, visit http://creativecommons.org/licenses/by-nc/4.0/. (B) Illustration of an online interface for scoring inflammation (BME), fat, NBF, and erosion in a thoracic discovertebral unit, according to the CanDen method. The boxes represent the locations of the pathologies on sagittal images, with the middle row being the central sagittal slices (abbreviated C), and the upper and lower row of drawings being the right (R) and left (L) lateral sagittal slices, respectively. Each box is clicked in case a lesion is present at that location. In the part on inflammation, the letters explain the location, as seen in (A). The schematic is from https://samri3.zitelab.eu/ (with permission), developed by COPECARE and Zitelab. aCIL: anterior corner inflammatory lesion; aLIL: anterior lateral inflammatory lesion; BME: bone marrow edema; C: central sagittal slice; CanDen: Canada-Denmark; COPECARE: Copenhagen Center for Arthritis Research; FIL: facet joint inflammatory lesion; L: left; NA: not applicable; NBF: new bone formation; NIL: noncorner inflammatory lesion; pCIL: posterior corner inflammatory lesion; pLIL: posterior lateral inflammatory lesion (in the thoracic region also known as costovertebral inflammatory lesion); R: right; RIL: rib inflammatory lesion; SPIL: spinous process inflammatory lesion; STIL: soft tissue inflammatory lesion; TIL: transverse process inflammatory lesion.

the MRI outcome may therefore not give a true representation of the effect of a drug on axSpA or axPsA. This example illustrates the additional value provided by the anatomy-based evaluation using the CanDen method.

Next steps

Next steps include the development of an internationally agreed definition for axPsA. This requires more methodological research, clinical studies, and international collaboration. GRAPPA and ASAS have agreed to develop data-driven classification criteria for axPsA to be used for research purposes.[22] The Axial Involvement in Psoriatic Arthritis (AXIS) study was established to systematically evaluate clinical and imaging manifestations indicative of axPsA, to develop classification criteria, and to create a unified nomenclature for axPsA that allows characterization of a homogeneous subgroup of patients for research.[22] In the AXIS study, spine images are evaluated according to the CanDen method, and several ongoing international clinical trials and initiatives addressing axPsA also apply the CanDen methodology.[23-26] These studies will provide additional informa-

Box. ASAS MRI working group consensus definitions for MRI lesions in the spine of patients with axial SpA (adapted from Baraliakos et al[15]).

A. Overarching principles

1. All definitions of inflammatory lesions relate to their appearance on the water-sensitive sagittal T2FS or STIR images. In both, an increased water content is seen as an increased signal intensity.
2. All definitions of structural lesions relate to their appearance on the fat-sensitive sagittal T1W MR images in the sagittal orientation.
3. The appearance of all lesions must be highly suggestive of SpA.
4. The term "increased signal in bone marrow" refers to a signal intensity higher than the "normal bone marrow signal." The bone marrow signal in the center of the vertebra, if normal, constitutes the reference for designation of a normal signal or, alternatively, in the center of the closest available normal vertebra.
5. Based on anatomical location, the images of the thoracic and lumbar spine on a sagittal MRI scan may be divided into "central" and "lateral" slices, which are defined as follows:
   a. Central sagittal slices: The sagittal slices that include the spinal canal. The pedicle may be partially seen but is not continuous between the vertebral body and posterior elements.
   b. Lateral sagittal slices: The sagittal slices that are located lateral to the spinal canal. These slices do not include the spinal canal, and either the pedicle must be continuous between vertebral body and posterior elements, or the slice is lateral to the pedicle.
6. The maximum sagittal slice thickness is 4 mm.

B. MRI spine lesions indicating activity ("inflammatory lesions")

These observations are made on MRI sequences that are sensitive for the detection of disease activity such as T2-weighted sequences with fat suppression that are sensitive for free water, such as STIR or T2FS or T1W sequences with fat suppression that are sensitive for contrast enhancement such as T1FS post-Gd.

These can be divided into:

1. Vertebral body inflammatory lesion:
   a. Vertebral corner inflammatory lesion (also known as anterior/posterior spondylitis): Increased signal in bone marrow in a water-sensitive sequence at the vertebral corner in at least 2 continuous sagittal slices. These can be subdivided into anterior and posterior vertebral corner lesions. There are 2 types:
      a1. Regular corner lesion or type A: Increased signal extends to the corners.
      a2. Irregular corner lesion or type B: Increased signal does not cover the whole corner but extends to both the endplate and the anterior/posterior border of the vertebra.
      Notes: In the corner itself, often an erosion, sclerosis, or a fat lesion is present. If inflammation (bone marrow edema) is only visible on 1 slice, a type B lesion may be scored on that single slice provided the structural component of the lesion is visible in at least 2 slices. In all other circumstances, the appearance of the type B lesion must be present on 2 or more slices.
   b. Vertebral endplate inflammatory lesion including the intervertebral disc (also known as noncorner inflammatory lesion or aseptic spondylodiscitis): Increased signal in bone marrow in a water-sensitive sequence adjacent to the vertebral endplate that involves the vertebral endplate but not the vertebral corner.
   c. Thoracic lateral inflammatory lesion (a lateral inflammatory lesion located in the posterior part of the slice is also known as arthritis of the costovertebral joints/costovertebral; applies to thoracic spine only): Increased signal in bone marrow on STIR/T2FS sequence adjacent to the endplate in at least 1 lateral sagittal slice.
2. Vertebral inflammatory lesions not involving the vertebral body:
   a. Facet joint inflammatory lesion (also known as facet joint arthritis): Increased signal in bone marrow in at least 1 sagittal slice in a water-sensitive sequence in at least 1 facet of a facet joint.
   b. Posterior element inflammatory lesion (including enthesitis of spinal ligaments and costotransverse joint inflammation): Increased signal in bone marrow in at least 1 sagittal slice in a water-sensitive sequence in 1 of the other posterior elements at which there are ligamentous or muscular attachments, or at the costotransverse joint (the pedicle, facet processes, and pars interarticularis are excluded).

C. MRI spine lesions indicating structural change

These observations are made on MRI sequences that are sensitive for the detection of structural change. Most of the observations can only be seen clearly on sequences sensitive for fat signal, specifically T1W spin echo without fat suppression.

1. Bone erosion: Full-thickness loss of the dark appearance of cortical bone and loss of normal bright appearance of adjacent bone marrow on T1W images in at least 1 sagittal slice. Only erosions involving the vertebral corners are assessed. Erosions can be subdivided into anterior and posterior corner erosions.
2. Focal fat lesion: Focal increased signal in bone marrow on T1W images in at least 2 sagittal slices. Only fat lesions involving the vertebral corners are assessed. Fat lesions can be subdivided into anterior and posterior corner fat lesions.
3. Bone spur in the direction of the anterior or posterior longitudinal ligament (also known as syndesmophytes): Bright signal on T1W images extending vertically from the vertebral corner toward the adjacent vertebral corner, seen in at least 1 sagittal slice. Bone spurs do not reach the adjacent vertebra and can be subdivided into anterior and posterior corner bone spurs (located in anterior and posterior corners, respectively).
   Notes: Bone spurs should not be scored as related to SpA (ie, syndesmophytes) in the presence of disc degeneration.
4. Ankylosis: Bright signal on T1W images extending from a vertebra and being continuous with the adjacent vertebra. This can be divided as follows:
   a. Vertebral corner ankylosis: Ankylosis involving the vertebral corner in at least 1 sagittal slice. This can be subdivided into anterior and posterior corner ankylosis (located in anterior and posterior corners, respectively).
   b. Vertebral endplate ankylosis: Ankylosis involving the endplate but neither the anterior nor the posterior lateral corner.
   c. Facet joint ankylosis: Ankylosis of a facet joint.

ASAS: Assessment of Spondyloarthritis international Society; MRI: magnetic resonance imaging; post-Gd: after gadolinium contrast; SpA: spondyloarthritis; STIR: sagittal short tau inversion recovery; T1-weighted fat-suppressed; T1W: T1-weighted; T2FS: T2-weighted fat-suppressed.

tion on the utility of this method. Further research activities will aim to improve this methodology; for example, by developing and validating knowledge transfer tools aimed at enhancing training and calibration of readers in clinical trials and practice. Future research will also explore novel methods for improving the assessment of spine inflammation and damage, which may include the application of artificial intelligence.[27-32]

Conclusion

MRI is the method of choice for evaluating axial involvement in PsA. It is important to assess both vertebral body lesions and lesions in the posterolateral elements of the spine. The CanDen assessment system for spine MRIs is a reproducible and responsive method for detailed evaluation of inflammation and structural damage at various anatomical locations in the spine. ASAS has recently published MRI definitions of inflammatory and structural lesions in the spine, incorporating the CanDen definitions. While awaiting consensus definitions and data-driven classification criteria for axPsA, it is recommended to use the ASAS definitions and the CanDen assessment system for assessing spinal involvement in PsA, with the aim of increasing reproducibility, international standardization of evaluation, and comparability between data from different studies and cohorts.

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