

Hip and pelvis region MRI reference image atlas for scoring inflammation in peripheral joints and entheses according to the OMERACT-MRI WIPE scoring system in patients with spondyloarthritis

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ABSTRACT

Objective: To develop a reference image atlas for scoring the hip/pelvis region according to the OMERACT whole-body MRI scoring system for inflammation in peripheral joints and entheses (MRI-WIPE).

Methods: We collected image examples of each pathology, location and grade, discussed them at web-based, interactive meetings and, finally, selected reference images by consensus.

Results: Reference images for each grade and location of osteitis, synovitis and soft tissue inflammation are provided, as are definitions, reader rules and recommended MRI-sequences.

Conclusion: A reference image atlas was created to guide scoring whole-body MRIs for arthritis and enthesitis in the hip/pelvis region in spondyloarthritis/psoriatic arthritis clinical trials and cohorts.

Introduction

The hip and pelvis region is frequently involved in spondyloarthritis

(SpA) including psoriatic arthritis (PsA), often causing considerable pain and reduced function [1,2]. Inflammation in joints and entheses in the region can be captured by magnetic resonance imaging (MRI) [3]. Since

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SpA and PsA generally involve several anatomical locations, assessing the entheses and joints of the entire body in one examination would be desirable in clinical practice and particularly in clinical trials and cohorts. Whole-body MRI (WBMRI) allows this, and therefore the OMERACT MRI in Arthritis Working Group developed and validated the OMERACT MRI Whole-body scoring system for Inflammation in Peripheral joints and Entheses (OMERACT MRI-WIPE) [4,5]. The reliability for the hip and pelvis region was subsequently documented [6]. However, identifying the exact area to be assessed and ascertaining the differences between the individual grades of the scoring system may be challenging, particularly for new readers. This can be facilitated by the development of effective knowledge transfer tools. The application and reproducibility of scoring systems has been shown to improve by providing standard reference images for comparison [7–10].

Therefore, our aim was to develop a set of standard reference images, a “reference image atlas”, for the hip and pelvis region to use as a guide for scoring arthritis and enthesitis in the hip/pelvis region based on the OMERACT MRI-WIPE method.

Methods

Image selection

Images representing each MRI feature, location and grade, as per MRI-WIPE definitions [5], were collected internationally from working group members and collaborators, and preliminary selections of potential examples of each grade were selected by three group members and presented for general discussion at web-based, interactive meetings between the members (rheumatologists and radiologists) of the OMERACT MRI in Arthritis Working Group. At these web-based meetings, example images of each grade of each MRI feature were discussed, taking into consideration detailed definitions and reader rules. Subsequently, consensus on the image selection was reached. Images were thereafter cropped and mounted, and subsequently all participating group members approved the final set of reference images.

MRI-WIPE scoring methodology

Using OMERACT MRI-WIPE, osteitis is assessed in the bone from the articular surface/enthesal insertion to a depth of 1 cm on all available

images (Fig. 1).

The osteitis (bone marrow edema) grading scale is 0–3 based on the proportion of bone with oedema, compared to the “assessed bone volume”, judged on all available images: 0: normal; 1: mild (1–33 % of bone edematous); 2: moderate (34–66 % of bone edematous); 3: severe (67–100 % of bone edematous).

Soft tissue inflammation is assessed inside the ligament/tendon and its immediate surroundings up to 1 cm from the enthesal insertion (grades 0–3): 0: normal; 1: mild; 2: moderate; 3: severe – by thirds of the maximum potential volume of inflammatory tissue.

Synovitis is assessed in the entire synovial compartment on all available images (grades 0–3): 0: normal; 1: mild; 2: moderate; 3: severe – by thirds of the maximum potential volume of enhancing tissue in the synovial compartment.

Additional reader rules are as follows: 1) Positive vs. negative score: A positive score of 1 should only be made when the reader is confident that there is an abnormality. All synovial joints contain normal joint fluid; this should not be scored. The scoring system aims at scoring inflammation. If the reader is hesitating whether to score a possible lesion 1 (mild) or 0 (none), the recommendation is to score it as 0 (none). 2) Lesion judged borderline between two scores: If the lesion is judged borderline grades 1 vs. 2 or 2 vs. 3, the signal intensity (brightness) of the lesion may be considered. For instance, if a lesion is borderline between grades 1 (mild) and 2 (moderate), it may be scored 1 (mild) if not judged intense. Similarly, for instance, if a lesion is borderline between grades 2 (moderate) and 3 (severe), it may be scored 3 (severe) if judged intense. When there is an increased amount of synovial tissue, not just effusion, and the lesion is judged to be borderline between two scores, the higher score may be assigned.

Preferentially, synovitis and soft tissue inflammation are assessed on T1-post-Gd images and osteitis on Short Tau Inversion Recovery (STIR)/T2-Weighted Fat Saturated (T2FS) images, but if only STIR/T2FS is available, synovitis and soft tissue inflammation can be assessed based on this. The current atlas focuses on STIR/T2FS images.

Results

A graphical display of locations of the individual MRI features in the hip and pelvis region that should be scored in WIPE is provided in Fig. 1, together with the scoring ranges for the region. The areas assessed for

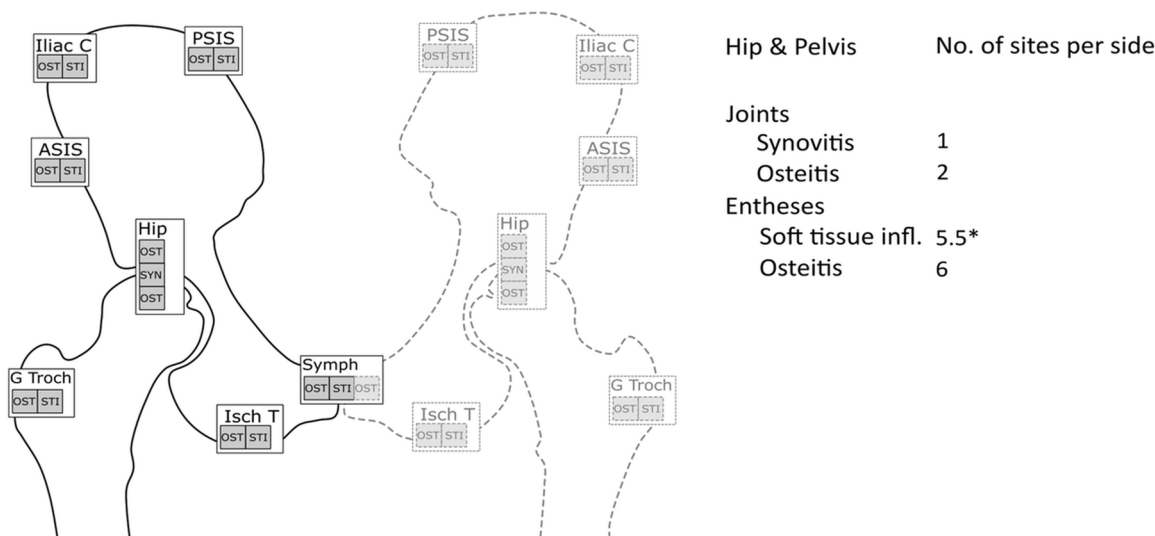


Fig. 1. OMERACT MRI-WIPE schematic and scoring range for the hip and pelvis region. Abbreviations: SYN, synovitis; STI, Soft tissue inflammation, OST, Osteitis (bone marrow edema); ASIS: anterior superior iliac spine; G Troch, greater trochanter; Hip, hip joint; Iliac C, iliac crest; Isch T, ischial tuberosity; PSIS, posterior superior iliac spine, Symph, Pubic symphysis. *STI at pubic symphysis is only scored once per pelvis; thus it only counts as a ½ on each side. In the entire pelvis, joint synovitis is scored at 2 sites, joint osteitis at 4 sites, enthesal soft tissue inflammation at 11 sites and enthesal osteitis at 12 sites; all sites are scored 0–3 per site, giving a max total score of 87 (joints: 18; entheses 69).

each hip joint are 2 locations of subchondral bone marrow edema/osteitis (acetabulum and femoral head), as well as hip joint synovitis. Furthermore, osteitis and soft tissue inflammation are assessed separately at the symphysis (osteitis separately in left and right pubic bone + soft tissue inflammation), as well as at 5 different entheses per side, 10 in total (greater trochanter, ischial tuberosity, anterior superior iliac spine, iliac crest, posterior superior iliac spine). In total, synovitis and osteitis are scored at 2 and 4 joint locations, respectively, while soft tissue inflammation and osteitis are scored at 11 respectively 12 enthesal locations, respectively, i.e. in total 29 individual scores are assigned.

Representative examples of the different grades for each of the MRI features to be assessed are presented in Figs. 2-4. Line drawings, depicting the area of focus while scoring each MRI feature according to WIPE, are included. Images of some grades of pathologies at certain locations were not available.

Discussion

In this MRI reference image atlas, we have depicted different grades of each MRI pathology in the hip and pelvis region to be scored using the OMERACT whole-body MRI scoring system for inflammation in peripheral joints and entheses in patients with SpA or PsA in clinical trials and cohorts.

OMERACT is a global, volunteer-driven, not-for-profit organisation committed to improving outcomes for patients with autoimmune and musculoskeletal diseases by advancing the design and quality of clinical studies. It has developed outcome measurement instruments, including imaging tools, for use in clinical trials [11–13]. An OMERACT whole-body MRI scoring system was published in 2019 [5]. Other WBMRI assessment systems have been reported, differing from the MRI-WIPE in being less validated and by focusing on the lower

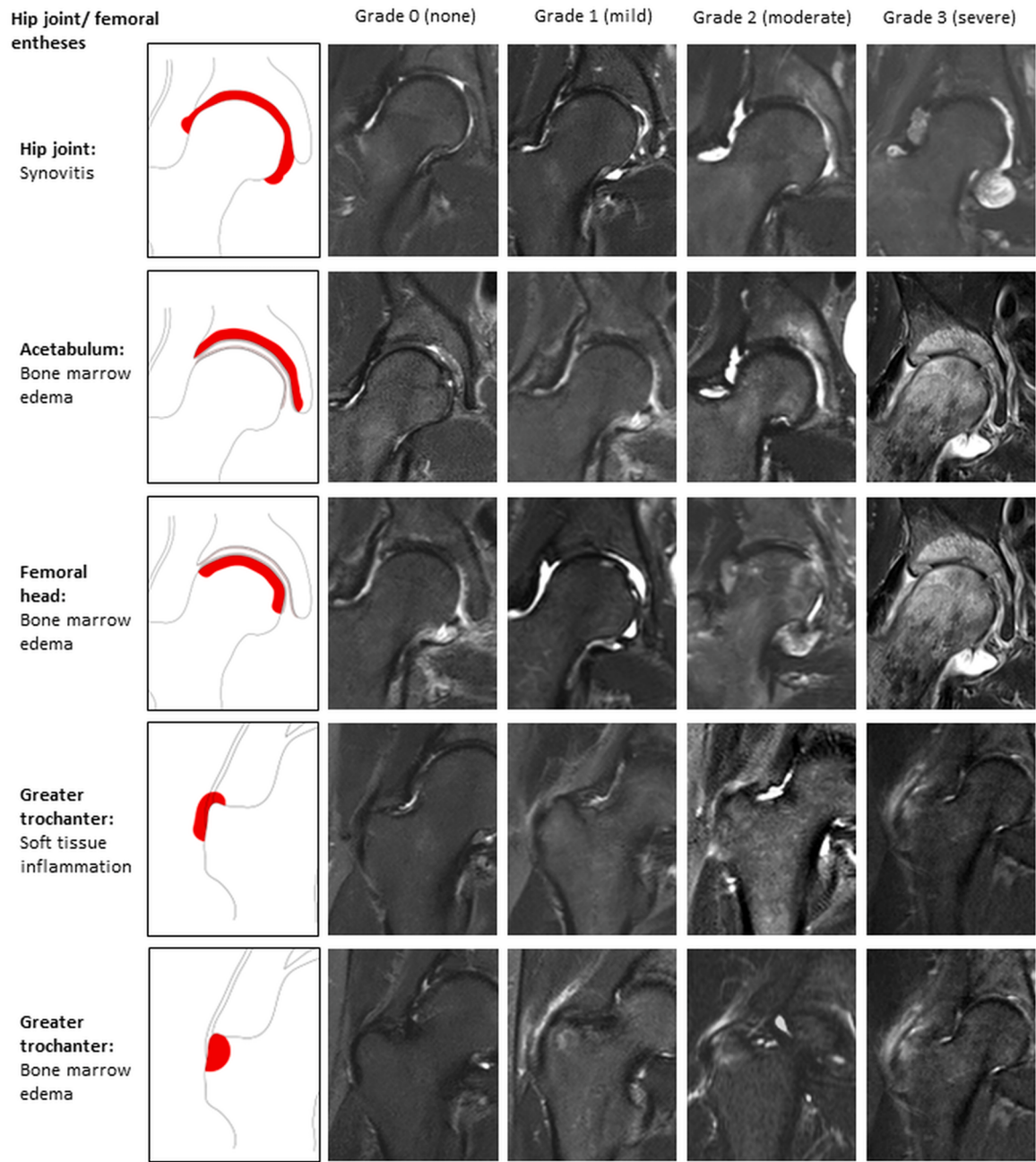


Fig. 2. MRI-WIPE scoring system grades for inflammatory pathologies at hip joint and femoral entheses. A line drawing (left) depicts the area to assess. Images are coronal short tau inversion recovery or T2-weighted fat saturated MR images.

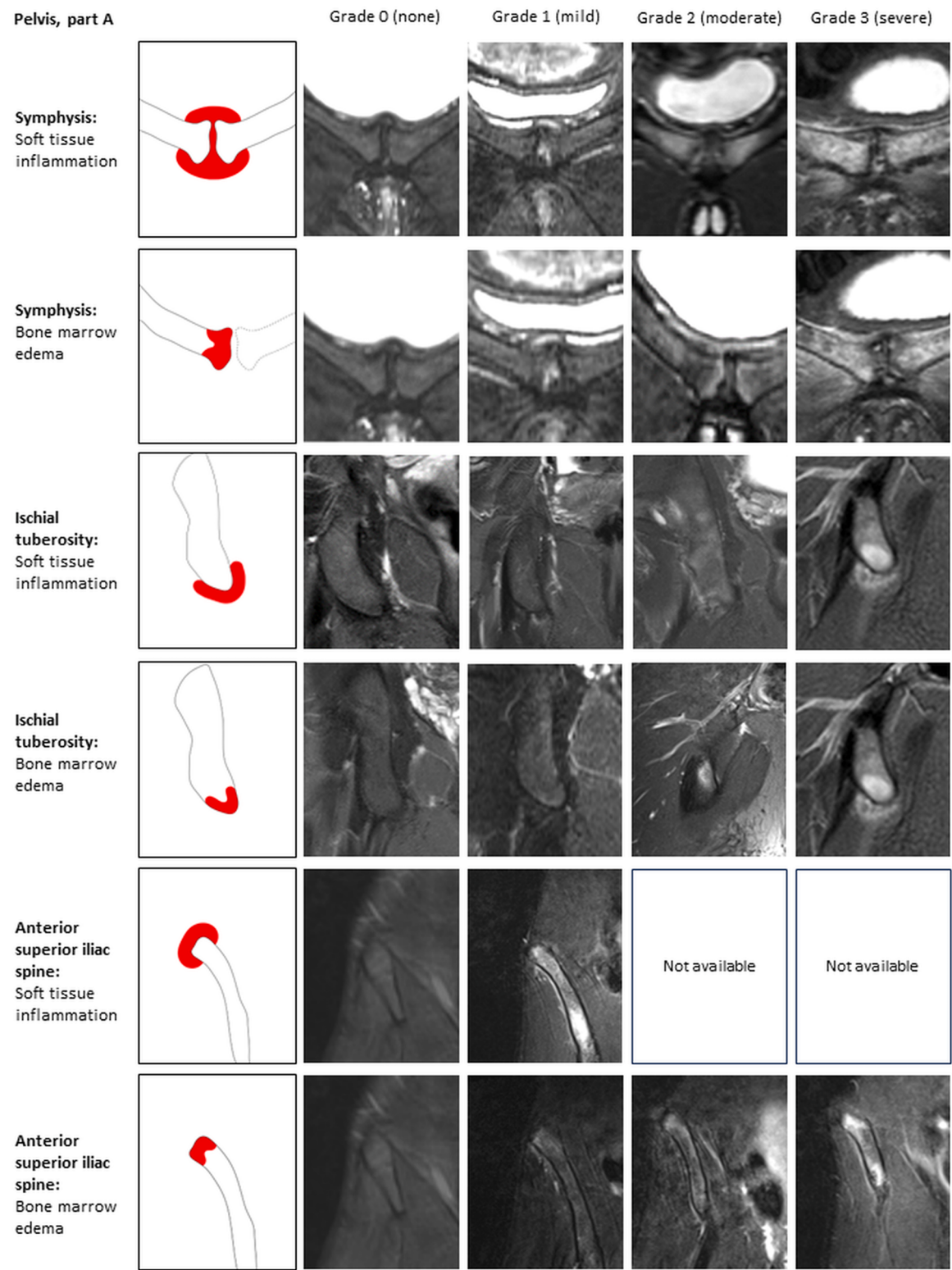


Fig. 3. MRI-WIPE scoring system grades for enthesitis in the pelvis region (Part A). A line drawing (left) depicts the area to assess. Images are coronal short tau inversion recovery or T2-weighted fat saturated MR images.

extremities [3,14], adding or deleting a few enthesitis locations compared to MRI-WIPE and/or using binary or 0–2 scoring systems [2, 14–17]. These studies consistently provide evidence in support of the sensitivity of WBMRI in detecting and detecting change in inflammation in joints and entheses. The current atlas will complement existing MRI-WIPE publications by easing conceptualization of relevant

inflammatory pathologies and their individual grades. It is important that readers are sufficiently aware of the relevant anatomy, the MRI appearance of the region, pathologies of interest in SpA, and common pitfalls in their assessment. It is highly recommended that a reader trains and calibrates with a trained WIPE reader, since training and calibration are known to increase reproducibility [7,9,10]. For evaluation we

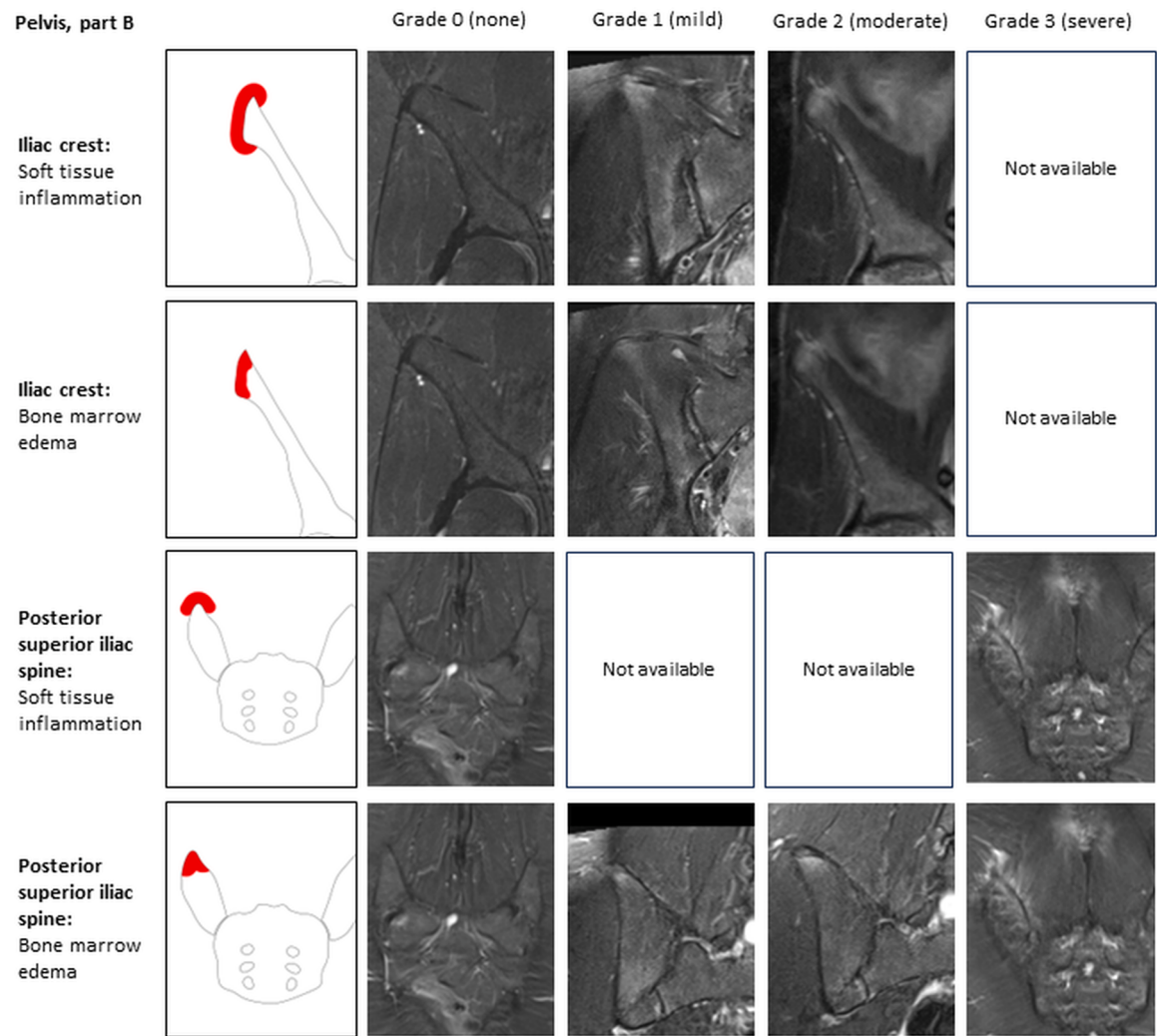


Fig. 4. MRI-WIPE scoring system grades for enthesitis in the pelvis region (Part B). A line drawing (left) depicts the area to assess. Images are coronal short tau inversion recovery or T2-weighted fat saturated MR images.

recommend a monitor size of at least 24 inches with a resolution of at least 2 megapixels.

The current atlas presents short-tau inversion recovery (STIR) and T2-weighted fat saturated MR images, which are well-suited for assessing inflammation without the use of intravenous contrast [18]. The MRI-WIPE definitions of the grades of the individual pathologies should always be kept in mind, but the atlas is considered the best reference to keep scoring consistent between readers. MRI-WIPE scores can be entered in dedicated online modules located at <https://samri3.zitelab.eu> and <https://www.carearthrititis.com>. It would have been optimal to display the entire volume of the entheses and not only a selected slice. However, this was not technically feasible. The above-mentioned images do not allow proper assessment of structural changes, but for the purpose of scoring disease activity in a clinical trial this is not essential. For use in clinical practice, the goal of the MRI examination may be different, e.g., diagnosis, requiring additional MRI sequences, e.g., T1-weighted images. Optimal assessment of synovitis requires T1-weighted images before and after administration of gadolinium contrast [19,20], which can depict the inflamed synovium distinct from joint fluid. To save time and to allow the entire body to be scanned, such sequences are often omitted in WBMRI as is imaging in more than only one plane per individual region. Assessment of structural changes, such as bone erosions, would also require other sequences than STIR/T2FS images, e.g. T1-weighted images. Furthermore, higher image

resolution would be needed, particularly in the smaller joints. This would increase acquisition time, which is already long. Assessment of bone erosion in smaller joints is, therefore, not currently feasible in WBMRI protocols, but may soon be, due to rapid technical developments.

As the most important locations of inflammatory pathologies in the hip and pelvis region (such as hip joint, greater trochanter, and the pubic symphysis) are well depicted in coronal images, this plane is recommended if time only allows one imaging plane. Consequently, the reference images in the current atlas are in the coronal plane (Figs. 2-4). Using only this plane hinders evaluation of certain parts of the enthesal attachments on the ilium and sacrum. In clinical practice, other planes may therefore be added.

In conclusion, we have provided a set of standard reference images depicting inflammation of joints and entheses in the hip and pelvis region to enhance calibration between readers in clinical trials and cohorts. The reference image set may also be useful for new readers interested in MRI assessment of the hip/pelvis region in patients with SpA and PsA.

CRedit authorship contribution statement

Mikkel Østergaard: Conceptualization, Methodology, Software, Validation, Investigation, Data curation, Writing – original draft,

Visualization, Supervision, Project administration. **Robert GW Lambert:** Conceptualization, Methodology, Validation, Resources, Writing – review & editing. **Anna EF Hadsbjerg:** Methodology, Software, Validation, Writing – review & editing, Visualization. **Iris Eshed:** Validation, Resources, Writing – review & editing. **Walter P Maksymowych:** Conceptualization, Validation, Writing – review & editing. **Ashish J Mathew:** Validation, Writing – review & editing. **Lennart Jans:** Validation, Resources, Writing – review & editing. **Susanne J Pedersen:** Validation, Writing – review & editing. **Philippe Carron:** Resources, Writing – review & editing. **Yasser Emad:** Validation, Resources, Writing – review & editing. **Gabriele De Marco:** Resources, Writing – review & editing. **Paul Bird:** Validation, Writing – review & editing. **Maria S Stoenoiu:** Validation, Writing – review & editing. **Violaine Foltz:** Validation, Writing – review & editing. **Joel Paschke:** Validation, Writing – review & editing. **Helena Marzo-Ortega:** Resources, Writing – review & editing. **Signe Møller-Bisgaard:** Validation, Writing – review & editing. **Philip G Conaghan:** Conceptualization, Validation, Writing – review & editing. **Marie Wetterslev:** Conceptualization, Methodology, Validation, Investigation, Data curation, Writing – review & editing, Visualization, Supervision, Project administration.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests

Mikkel Østergaard has received research grants from Abbvie, BMS, Merck, Novartis and UCB, consultancy fees from Abbvie, BMS, Celgene, Eli-Lilly, Galapagos, Gilead, Janssen, MEDAC, Merck, Novartis, Pfizer, Sandoz, and UCB Abbvie, BMS, Celgene, Eli-Lilly, Galapagos, Gilead, Janssen, MEDAC, Merck, Novartis, Pfizer, Sandoz, and UCB and speaker fees from Abbvie, BMS, Celgene, Eli-Lilly, Galapagos, Gilead, Janssen, MEDAC, Merck, Novartis, Pfizer, Sandoz, and UCB. Robert GW Lambert has received research grants from Calyx and Care Arthritis, and consultancy fees from Image Analysis Group, Calyx and Care Arthritis. Walter P Maksymowych is Chief Medical Officer at CARE Arthritis Limited. Helena Marzo-Ortega has received research grants from Janssen, Novartis, Pfizer and UCB, and speaker fees from AbbVie, Amgen, Biogen, Eli Lilly, Janssen, Novartis, Pfizer, Takeda, UCB. Philip G Conaghan has received consultancy fees from AbbVie, BMS, Eli Lilly, Galapagos, GSK, Janssen, Novartis and Takeda and speaker fees from AbbVie, Eli Lilly and Novartis. The remaining authors declare no financial interests/personal relationships.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.semarthrit.2024.152383](https://doi.org/10.1016/j.semarthrit.2024.152383).

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