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Distribution of spinal damage in patients with axial spondyloarthritis as assessed by MRI: a prospective and blinded study

Andreas Haidmayer[1†], Gabriel Adelsmayr[2†], Christopher Spreizer[3], Eva Valentina Klocker[4], Franz Quehenberger[5], Michael Fuchsjaeger[1], Jens Thiel[1] and Josef Hermann[1*]

Abstract

Background Axial spondyloarthritis (SpA) leads to structural bone lesions in every part of the vertebral column. These lesions are only partially visualized on conventional radiographs, omitting posterior parts of the vertebral column and the thoracic spine, that may nevertheless contribute to impaired spinal mobility and function in patients with axial SpA.

Methods In this prospective and blinded investigation, we assessed the distribution of structural spinal lesions using magnetic resonance imaging (MRI) of the whole spine in 55 patients with axial SpA classified according to the Assessment in Spondyloarthritis International Society (ASAS) criteria. After assessment of spinal mobility and function two blinded radiologists independently evaluated MRIs of 23 vertebral units in every patient. Non-parametric statistical methods, Spearman's correlation and linear regression models were used to analyze structural lesion distribution and the relationship with clinical spinal mobility and function parameters.

Results In 55 patients with axial SpA (13 females, average disease duration 14.9 years) 657 ventral and 139 dorsal vertebral body structural bone lesions and, notably, 534 facet joint lesions could be visualized. The median number of lesions per patient was higher in the thoracic (8.5, range 1.0–41.0) than in the lumbar (7.5, range 0.0-27.5) and the cervical spine (3.5, range 0.0-24.5). A negative correlation was noted between the number of osteoproliferative structural bone lesions and impairment of spinal mobility and function in univariate, but not in multivariate analyses.

Conclusion MRI of the whole spine revealed a high prevalence of lesions in dorsal parts of the vertebral column and in the thoracic spine in patients with axial SpA that may not be adequately visualized on conventional radiographs. These findings could further contribute to a better understanding of reduced mobility of the spine typically associated with axial SpA and assist diagnostics.

Keywords Axial spondyloarthritis, Magnetic resonance imaging (MRI), Vertebral column, Syndesmophytes, Ankylosis, Facet joints

[†]Andreas Haidmayer and Gabriel Adelsmayr contributed equally to this work.

*Correspondence:
Josef Hermann
josef.hermann@medunigraz.at
Full list of author information is available at the end of the article

Background

Spondyloarthritides (SpAs) are a group of immune-mediated inflammatory diseases affecting predominantly either the axial skeleton (axial SpA) or the extremities (peripheral SpA) and extra-musculoskeletal organs such as the skin or the eye [1]. Axial SpA is characterized by ongoing inflammation of entheses that lead to structural lesions of sacroiliac joints and the spine including bone erosions followed by new bone formation with the development of sclerosis, syndesmophytes and ankylosis [2, 3]. Entheses are distributed across the vertebral column, hence structural bone lesions may be present in the ventral and dorsal parts of the spine [4].

For both clinical trials and for routine work-up plain x-rays are performed to quantify structural bone lesions using the modified Stoke Ankylosing Spondylitis Spine Score (mSASSS), but neither the thoracic spine nor the posterior parts of the vertebral column, including the facet joints and the spinous processes, are adequately mapped with this method [5].

Computer tomography (CT) remains the gold standard for depiction of osseous structures and structural lesions in particular of facet joints and of the thoracic spine of patients with axial SpA can be visualized [6]. However, as patients with axial SpA are comparatively young, the indication for examinations involving radiation exposure is particularly stringently established. Moreover, active inflammatory disease cannot be detected with standard CT [7].

Magnetic resonance imaging (MRI) has become an important tool to visualize active inflammation in axial SpA and is also able to detect sacroiliac joint (SIJ) erosions with higher sensitivity than conventional radiography [8]. MRI has also demonstrated capability to visualize structural lesions at the spinal level, thereby providing comprehensive imaging of axial SpA without radiation exposure [9].

The extent of radiographic damage as assessed by plain x-ray only partially correlates with measures of spinal mobility and function parameters [10–12]. Extended radiographic damage located in the posterior parts of the vertebral column, which is not included into the mSASSS may explain this observation [13].

Therefore, the aim of this prospective study was to evaluate the distribution of structural bone lesions throughout the vertebral column in axial SpA with MRI. Our hypothesis was that (a) damage can be assessed with MRI also in dorsal parts of the vertebral column and particularly the thoracic spine which is difficult to evaluate when using x-ray because of superimpositions; (b) these MRI findings correlate with function and mobility of the spine.

Methods

Patients

For this study axial SpA patients 18 years of age or older, fulfilling the ASAS classification criteria for axial SpA [14] with a minimum symptom duration of five years attending the outpatient clinic of the Division of Rheumatology and Immunology were recruited. The study was conducted in accordance with the Declaration of Helsinki and was approved by the local ethics committee of the Medical University of Graz (EC-number 28–542 ex 15/16). Informed consent was obtained from all subjects prior to enrollment into the study. Patients were excluded from the study in case of contraindications to MRI examination, when presenting with a Cobb angle > 20° [15], in the case of pregnancy, or without written informed consent.

Patients' characteristics included duration of symptoms and time since diagnosis, clinical and laboratory parameters of disease activity including the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) and Ankylosing Spondylitis Disease Activity Score (ASDAS) and are presented in Table 1. In addition, functional impairment and spinal mobility was assessed using the Bath Ankylosing Spondylitis Functional Index (BASFI) and the Bath Ankylosing Spondylitis Metrology Index (BASMI) [16].

Table 1 Demographics and clinical characteristics of patients with axial SpA

	Axial SpA patients
Sex (n, f/m)	13/42
Age, median (range) years	50.4 (21.7–66.0)
HLA-B27 positive (n, %)	47 (85.5)
Duration of symptoms, median (range) years	20.0 (3.6–49.0)
Time since diagnosis, mean (S.D.) years	14.9 (10.2)
BASDAI, median (range)	2.5 (0.0–6.5)
BASFI, mean (S.D.)	2.4 (1.6)
BASMI, median (range)	2.6 (0.3–6.4)
ASDAS-CRP, mean (S.D.)	1.8 (0.7)
CRP, mean (S.D.) mg/l*	4.0 (5.0)
Patients on TNF-inhibitors n (%)	33 (60.0)
Patients on IL-17-inhibitors n (%)	3 (5.5)
Patients on JAK-inhibitors n (%)	1 (0.2)
Patients on continuous NSAID-therapy n (%)	8 (14.6)

Values are presented in mean ± standard deviation (SD) or median (range).

* Normal range 0–5 mg/l.

TNF = Tumour necrosis factor.

IL-17 = Interleukin-17.

JAK = Januskinase.

NSAID = nonsteroidal anti-inflammatory drug.

Magnetic resonance imaging of the spine

MRI of the cervical, thoracic and lumbar spine was performed on the day of clinical assessment, using a 3 Tesla scanner (Skyra, Siemens Healthcare, Erlangen, Germany). We selected MRI to visualize structural lesions of the spine as it has already been shown that MRI cannot only detect inflammatory but also structural bone lesions in patients with axial SpA without exposing this study population to radiation [9]. The whole spine was scanned with T1-weighted and Turbo-Inversion Recovery Magnitude (TIRM) sequences in sagittal planes to assess structural changes [17]. Cervical, thoracic and lumbar spine MRI images were analyzed independently by two radiologists (GA and CS) with a years-long experience in musculoskeletal imaging and blinded for the clinical data of the study participants. Twenty-three vertebral units of the vertebral column (6 cervical, 12 thoracic and 5 lumbar) were analyzed, amounting to a total of 1265 vertebral units (330 cervical, 660 thoracic and 275 lumbar vertebral units). Each vertebral unit was divided into four quadrants covering the ventral and dorsal half of the lower and upper half of two adjacent vertebral bodies. In addition to the ventral and dorsal half of the vertebral body, we analyzed the posterior elements of the vertebral unit covering 2530 facet joints and the spinous process of each vertebral body. Structural changes including erosions, syndesmophytes, ankylosis of vertebral bodies and partial or complete ankylosis of facet joints as well as osteoproliferative changes (fibro-osteoses) or osseous fusion of spinous processes were counted for further analysis. If both readers agreed on a certain lesion at a vertebral unit, it was counted as "1". If both readers agreed on the absence of a certain lesion, it was counted as "0" and if readers contradicted each other about a certain lesion, a consensus was sought by the two readers.

Additionally, the Ankylosing Spondylitis Spine Magnetic Resonance Imaging chronicity score (ASspiMRI-c) composite score that includes structural lesions of the vertebral body and excludes structural lesions of the posterior elements was calculated [18]. The ASspiMRI-c score is a semiquantitative measure to evaluate structural changes of vertebral units including sclerosis, erosions, syndesmophytes, vertebral bridging and vertebral fusion ranging from 0 to 6. A vertebral unit is defined as the region between the middle of two adjacent vertebral bodies including the vertebral disc.

Statistical analysis

We analyzed our data using R 3.6.3 (www.r-project.org). Continuous variables are presented as mean (S.D.) or median (range) values depending on the results of the Shapiro-Wilk test. Counts of lesions were compared using Wilcoxon's signed ranks test. When comparing counts between three segments of the vertebral columns, differences were considered statistically significant only if the Friedman test for equality of more than two paired samples was significant. This procedure accounts for multiple testing by the closed testing principle.

Spearman's correlation coefficient was used to test the relationship between variables of function and spinal mobility and the number and distribution of different lesions. Univariate and multivariate linear regression analyses were applied to investigate these relations in more detail. Inter-reader agreement was calculated using kappa-statistics with equations from Fleiss. *P*-values < 0.05 were considered to be statistically significant.

Results

Baseline characteristics

A total of 57 patients were recruited for this study. In one patient clinical data were missing and in one patient MRI could not be evaluated because of multiple artefacts. Therefore 55 patients were analyzed. Out of these, ten patients presented with non-radiographic and 45 patients with radiographic axial SpA. Further patient's demographics and clinical characteristics are presented in Table 1.

Frequency of structural spinal lesions visualized by MRI

Kappa between MRI-readers for syndesmophytes and ankyloses of vertebral segments was 0.84 (95% CI: 0.79–0.89) and 0.86 (95% CI: 0.82–0.90), respectively, between MRI-readers for facet joint partial ankylosis or fusion 0.77 (95% CI: 0.71–0.84) and between MRI-readers for erosions 0.67 (95% CI: 0.53–0.82), indicating substantial inter-reader agreement. All patients in our cohort with axial SpA showed structural lesions. Partial or complete ankylosis of facet joints was the most common structural lesion in the vertebral column. Facet joint partial ankylosis or fusion was detected in 534 (21.1%) joints in 54 (98.1%) out of 55 patients with axial SpA. Syndesmophytes were the second most frequent structural lesions in the vertebral column with 431 syndesmophytes seen in 1265 vertebral units in 45 out of 55 (81.8%) patients with axial SpA. Erosions were less frequently visible on MRI than syndesmophytes and facet joint ankylosis with 180 erosions visualized in 1265 vertebral units in 32 (58.2%) out of 55 axial SpA patients.

Sagittal distribution of structural spinal lesions visualized by MRI

In our cohort of 55 SpA-patients we detected 657 structural lesions (i.e., erosions, syndesmophytes, bridging) in the ventral quadrants and 139 structural lesions in the dorsal quadrants of vertebral bodies as

well as 534 structural lesions of facet joints (i.e., partial and complete ankylosis) and 54 lesions of spinous processes (Fig. 1). The median number (range) of structural lesions per patient seen in the ventral quadrants of the vertebral body was significantly higher than in the dorsal quadrants of the vertebral body (8.5 (2.0–37.0) vs. 0.0 (0.0–12.0); $p < 0.0001$)). The median number of structural lesions per patient visualized in facet joints and spinous processes was significantly higher compared to the number of structural lesions in the dorsal quadrants (12.0 (0.0–35.5); $p < 0.001$)) and numerically

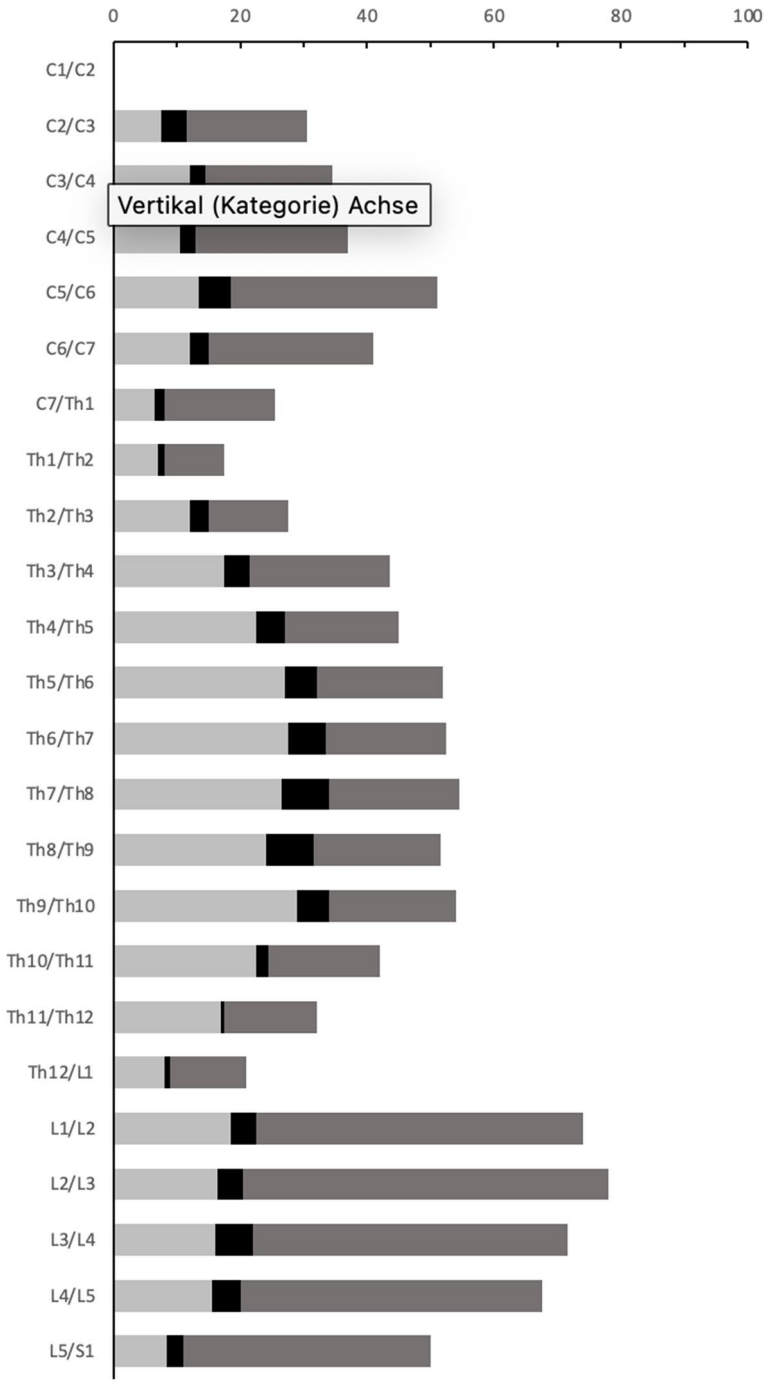

Fig. 1 Image of frequency of structural lesions at the ventral and dorsal quadrants and of the posterior elements of the vertebral columns in 55 patients with axial SpA visualised by MRI

higher compared to the number of structural lesions in the ventral quadrants of vertebral bodies ($p = 0.150$).

Erosions and syndesmophytes were both significantly more frequently seen in ventral compared to dorsal quadrants of the vertebral bodies investigated ($p < 0.001$).

Vertical distribution of structural spinal lesions visualized by MRI

The number of structural lesions was unevenly distributed between the cervical, thoracic and lumbar spine (Fig. 1). The median (range) number of all structural lesions including erosions, syndesmophytes, bridging and partial or complete ankylosis of facet joints in different parts of the vertebral column visualized per patient was significantly higher in the thoracic spine (8.5 (1.0–41.0)) compared to the lumbar spine (7.5 (0.0–27.5)) and the cervical spine (3.5 (0.0–24.5)) ($p < 0.005$ for all comparisons). In addition, the number of structural lesions of the ventral and dorsal quadrants of the vertebral body including erosions, syndesmophytes and bridging was significantly higher in the thoracic spine compared to the cervical and the lumbar spine, whereas partial and complete ankylosis of facet joints was predominantly seen in the lumbar spine and less frequently in the thoracic and the cervical spine (Table 2).

The mean number of erosions per patient was not statistically significantly different between the cervical, thoracic and lumbar spine ($p = 0.360$). Syndesmophytes could be visualized significantly more frequently in the thoracic spine (5.0 (0.0–21.5) (median (range)) per patient compared to the cervical (1.0 (0.0–8.5); $p < 0.001$) and lumbar spine (0.5 (0.0–4.5); $p < 0.001$), whereas partial or complete ankylosis of facet joints per patient was significantly more frequently seen at the lumbar spine (5.0 (0.0–12.0); median (range)) compared to the cervical (2.0 (0.0–11.0), $p < 0.001$) and thoracic spine (1.0 (0.0–22.0), $p < 0.05$).

Scoring of the ASspiMRI-c in 55 patients with axial SpA

The ASspiMRI-c score is a grading system for structural spinal lesions such as sclerosis, erosions, syndesmophytes and bridging visualized with T1 MRI-sequences in patients with axial SpA (18). The median (range) ASspiMRI-c score per segment was significantly higher in the thoracic spine (1.5 (0–5.5)) compared to the cervical (0.75 (0–3.5)) and lumbar spine (0.75 (0–5.5)) ($p < 0.001$).

Impact of vertebral structural lesions on spinal mobility and function

When analyzing the number of all structural lesions in the spine seen on MRI, we found a statistically significant correlation with spinal mobility measured by the BASMI ($r = 0.65$, 95% CI 0.46–0.78, $p < 0.001$) and with physical function measured by the BASFI ($r = 0.37$, 95% CI 0.11–0.58, $p < 0.01$). In addition, we detected a significant relationship between the amount of osteoproliferative lesions including the formation of syndesmophytes, bridging and partial or complete ankylosis of facet joints and spinous processes and the BASMI (Table 3; Supplementary table S1). Furthermore, the number of osteoproliferative lesions in the lumbar spine correlated negatively with the mobility of the lumbar spine measured by the Schober's test ($r = -0.36$, $p < 0.01$) and the average lateral flexion ($r = -0.58$, $p < 0.001$) (Fig. 2a and b).

Table 2 Distribution of different structural lesions at the vertebral column in 55 patients with axial SpA

	Cervical spine	Thoracic spine	Lumbar spine
Erosions, n (%*)	38.5 (11.7)	76.0 (11.5)	60.0 (21.8)
Syndesmophytes, n (%*)	55.0 (16.7)	288.5 (43.7)†	62.5 (22.7)
Bridging, n (%*)	2.0 (0.6)	46.5 (7.1)§	8 (2.9)
Facet joint ankylosis < 50%, n (%**)	140.5 (21.3)	181.0 (13.7)	223.5 (40.6)§
Facet joint ankylosis > 50%, n (%**)	17.5 (2.7)	35.5 (2.7)	59.0 (10.7)§
Facet joint fusion‡, n (%**)	2.5 (0.4)	10.5 (0.8)§	2.5 (0.5)
Fibrostosis¶ and fusion of PE#, n (%*)	1.0 (0.3)	10.5 (1.6)	2.5 (0.9)

* Percent of vertebral units investigated

** Percent of vertebral joints investigated

† $p < 0.001$ compared to the number of syndesmophytes at the cervical or lumbar spine

§ $p < 0.05$ compared to intervertebral joint ankylosis < 50% at the cervical spine

‡ It means complete ankylosis of a facet joint

¶ It means osteoproliferative changes of the spinous process

Posterior elements

Table 3 Spearman's correlation of structural changes of the vertebral column on spinal mobility and function in 55 patients with axial SpA

	BASMI	BASFI
Syndesmophytes[a], r (95%CI)	0.30* (0.04–0.53)	0.26 (−0.05-0.50)
Bridging[b], r (95%CI)	0.43# (0.18–0.62)	0.22 (−0.06-0.46)
Partial ankylosis/fusion (facet joints), r (95%CI)	0.58# 0.37–0.74)	0.30* (−0.30-0.52)

[a] Syndesmophytes at the ventral and dorsal quadrants of vertebral bodies of the spine; r = Spearman correlation coefficient; [b]ankylosis at the ventral and dorsal quadrants of vertebral bodies of the spine

* $p < 0.05$

# $p < 0.01$

When analyzing the number of osteoproliferative lesions in the spine adjusting for age, we found a statistically significant relationship with the BASMI (b = 0.036, 95% CI 0.004–0.068, $p < 0.05$) but not with the BASFI (b = 0.014, 95% CI −0.020-0.049) (Supplementary table S1). After adjusting for age, gender and disease activity measured by the BASDAI, ASDAS-CRP and CRP we did not find a significant relationship between the number of osteoproliferative lesions in the spine and the BASMI and BASFI (Supplementary table S1).

Investigation of the effect of osteoproliferative lesions of the cervical, thoracic and lumbar spine on the corresponding single items of the BASMI adjusted for age revealed a statistically significant negative association between lumbar osteoproliferative lesions and Schober's test (b= −0.150, 95% CI −0.029- −0.006; $p < 0.05$) and lumbar lateral flexion (b= −0.440, 95% CI −0.830- −0.044; $p < 0.05$) and a statistically significant positive association of cervical osteoproliferative lesions and the occiput to wall distance (b = 0.400, 95% CI 0.110–0.690; $p = 0.01$) (Supplementary table S1). After adjusting for age, gender, BASDAI, ASDAS-CRP and CRP in a multivariate analysis a positive relationship could only be detected between cervical osteoproliferative lesions and the tragus to wall distance (b = 0.390, 95% CI 0.154–0.620; $p < 0.005$) (Supplementary table S1).

In contrast, we did not find a statistically significant correlation between the ASspiMRI-c of the lumbar spine with the Schober's test result ($r = -0.10$) or the lumbar lateral flexion ($r = -0.16$).

Discussion

This study evaluated the distribution of spinal structural bone lesions in patients with axial SpA as detected by high resolution MRI in a reasonably large and well characterized cohort. We could detect structural lesions not only in the vertebral bodies as already demonstrated in a prior study [18] but also in facet joints and posterior elements of the vertebral column. Only one group analyzed inflammatory and structural lesions including erosions and new bone formation throughout the vertebral column in axial SpA using MRI [19]. In accordance with results of our study the authors reported structural lesions more frequently in facet joints than in vertebral bodies supporting the fact that plain x-ray of the vertebral column seems to underestimate bone formation in axial SpA. In contrast to results of our study, they found signs of bone formation such as syndesmophytes and facet joint ankylosis in only up to 12% of the patients. Older age and a longer symptom duration may have contributed to the much higher number of structural lesions observed in our study cohort.

The mSASSS is a widely used validated radiographic measure to quantify structural lesions at the spine of axial SpA-patients, but only lesions at the ventral quadrants of the vertebral unit of the cervical and lumbar spine are

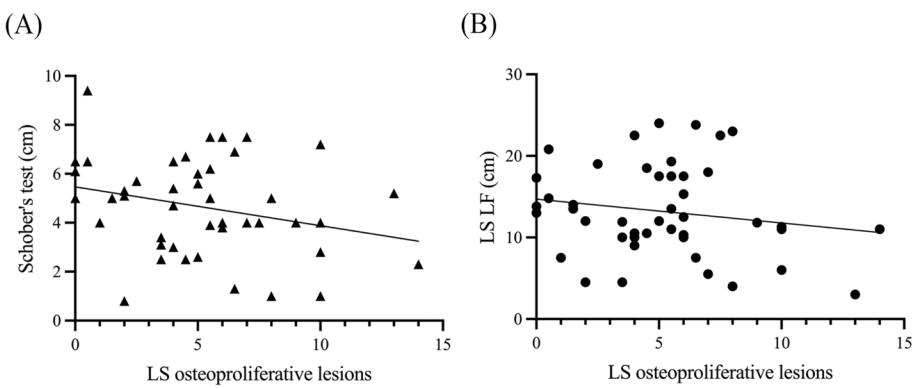

Fig. 2 Correlation of lumbar spine osteoproliferative lesions with lumbar spine mobility. Part A: inverse correlation of the amount of osteoproliferative lesions present at the lumbar spine with the Schober's test. Part B: inverse correlation of the amount of osteoproliferative lesions present at the lumbar spine with lumbar spine lateral flexion (LSLF)

assessed by this method [5]. In contrast, we were able to visualize a high number of structural lesions in the thoracic spine and in facet joints of the vertebral column. A weak relationship of the mSASSS with findings on MRI has already been demonstrated by Braun et al. [18]. They found a good association of the ASspiMRI-c score, a sum score for morphological changes on MRI, with the Bath Ankylosing Spondylitis Radiology Index but not with the mSASSS. Relying on the mSASSS may therefore underestimate the extension of structural lesions present in patients with axial SpA.

A CT scan is generally regarded as the method of choice to detect structural bone lesions in sacroiliac joints [20]. de Koning et al., using a new scoring system, performed low dose CT scan of the vertebral column and analyzed the distribution and progression of syndesmophytes over two years [6]. Syndesmophytes were present most frequently in the thoracic spine, that is in accordance with our study's findings. Our results are also supported by work from the USA using CT scan that showed that syndesmophytes are most frequently seen in the lower part of the thoracic spine, predominantly at the posterolateral vertebral rim [21]. Posterolateral location of syndesmophytes could have led to the reporting of low numbers of syndesmophytes in dorsal quadrants of the vertebral body in our cohort as sagittal slices produced with MRI may have missed these structural lesions. More recently, a Dutch group used low-dose CT scan to detect ankylosis of facet joints and progression of syndesmophytes in patients with radiographic axial SpA [22]. This group reported ankylosis of facet joints most frequently in the thoracic spine, indicating that this region is predominantly affected in axial SpA which can be visualized reasonably well only with MRI or CT scan, but not with conventional radiography. Despite the introduction of low-dose CT for visualizing structural bone lesions of the spine, it still involves radiation exposure of the patients. In order to avoid radiation exposure in our study population, we opted to use MRI exclusively to assess spinal structural lesions. As a result, our study does not allow a direct comparison of the diagnostic performance of MRI and CT for detecting spinal structural lesions, which remains a limitation of our study and a potential topic for future research.

Axial SpA frequently leads to restricted spinal mobility and impaired function [12, 23]. Reduced spinal mobility has been associated with radiographic damage and spinal inflammation before [12, 24]. In the study from Leiden spinal mobility correlated fairly well with the mSASSS but only weakly with the ASspiMRI-a, a score to measure inflammatory changes in the spine on MRI. Investigators in the Berlin trial compared radiographic changes of the spine measured by the mSASSS with changes in spinal mobility and function over a period of 2 years. They also showed that spinal radiographic progression was associated predominantly with disease activity rather than with spinal mobility or function. In our MRI-study, we found a weak association between spinal mobility and the presence of syndesmophytes that are included in the mSASSS but a much larger association between spinal mobility and osteoproliferative lesions when we included posterior elements visualized on MRI. Spinal mobility and the number of structural lesions was even stronger negatively associated when bridging between vertebral bodies and ankylosis of posterior elements were included in the analysis. However, in multivariate analysis, when age and disease activity of our cohort were taken into account, no association was detected between spinal mobility or function and osteoproliferative lesions of the spine visualized with MRI. Nevertheless, an influence of structural lesions on spinal mobility was suggested by the association of osteoproliferative changes at the lumbar spine with a decrease of spinal flexion measured by the Schober's test.

A significant association between functional impairment measured by the BASFI and structural lesions measured by the mSASSS has been reported for patients with axial SpA [25, 26]. However, the association was weak and more pronounced in patients with short disease duration. We could not find a significant association of radiographic damage visualized by MRI and the impairment of physical function measured by the BASFI, which may partly be explained by the long median disease duration of our cohort.

Although 98% of patients in our cohort showed partial or complete ankylosis of facet joints with an average disease duration of almost 20 years, spinal mobility measured by the BASMI was only about twice as high than in a healthy population [27]. Partial or complete ankylosis of facet joints were found in almost half of the patients in the thoracic spine that is not evaluated by the BASMI and may therefore help to explain the rather low BASMI measured in our cohort. In addition, inter-reader variability for spinal structural lesions was highest for facet joint ankylosis, probably indicating over-estimation of facet joint ankylosis in MRI.

Conclusions

Results of our study showed that MRI is an effective method for identifying not only inflammatory signs but also structural bone lesions, which are key indicators of axial SpA. This non-radiative technique successfully detected structural lesions in the dorsal quadrants of vertebral bodies and, crucially, osteoproliferative lesions in the posterior elements of the spinal column, aspects hitherto under-assessed in clinical settings. The

results demonstrate a significant prevalence of structural bone lesions in the thoracic spine and posterior spinal elements, that could significantly contribute to the characteristic postural changes and progressive spinal immobility associated with axial SpA.

Abbreviations

MRI	Magnetic resonance imaging
SpA	Spondyloarthritis
ASAS	Assessment in Spondyloarthritis International Society
mSASSS	modified Stoke Ankylosing Spondylitis Spine Score
CT	Computer tomography
BASDAI	Bath Ankylosing Spondylitis Disease Activity Index
ASDAS	Ankylosing Spondylitis Disease Activity Score
BASFI	Bath Ankylosing Spondylitis Functional Index
BASMI	Bath Ankylosing Spondylitis Metrology Index
TIRM	Turbo-Inversion Recovery Magnitude
ASspiMRI-c	Ankylosing Spondylitis Spine Magnetic Resonance Imaging chronicity score
S.D.	Standard deviation
CRP	C-reactive protein
SP	Spinous process
LS	Lumbar spine
LSLF	Lumbar spine lateral flexion
TNF	Tumour necrosis factor
IL-17	Interleukin-17
JAK	Januskinase
NSAID	Nonsteroidal anti-inflammatory drug

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13075-024-03465-9.

Supplementary Material 1.

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Authors' contributions
J. H, A.H and G. A. designed the study. A. H, J. H. and E. K. collected the clinical data. G. A and C. S. performed the radiographic readings. F. Q performed all statistical analyses. A. H., G.A and J. H. wrote the manuscript. J. T. and M. F. supervised all aspects of the manuscript. All authors have read and critically commended on the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of Ethics Committee of the Medical University of Graz (protocol code 28-542 ex 15/16; date of 17th October 2017). Informed consent was obtained from all subjects involved in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Division of Rheumatology and Immunology, Department of Internal Medicine, Medical University of Graz, Auenbruggerplatz 15, Graz 8036, Austria. [2]Division of General Radiology, Department of Radiology, Medical University of Graz, Graz, Austria. [3]Southeastern CT-Institute, Feldbach, Austria. [4]Division of Oncology, Department of Internal Medicine, Medical University of Graz, Graz, Austria. [5]Institute for Medical Informatics, Statistics and Documentation, Medical University of Graz, Graz, Austria.

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