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Concise report

Spinal-pelvic orientation: potential effect on the diagnosis of spondyloarthritis

Guillermo Carvajal Alegria [1,*], Lucile Deloire [2,*], Marion Herbette [1], Florent Garrigues [2], Laure Gossec [3,4], Alexandre Simon [5], Antoine Feydy [6], Monique Reijnierse [7], Désirée van der Heijde [8], Damien Loeuille [9], Pascal Claudepierre [10,11], Thierry Marhadour [1] and Alain Saraux [1,12]

Abstract

Objective. To assess associations of spinal-pelvic orientation with clinical and imaging-study findings suggesting axial SpA (axSpA) in patients with recent-onset inflammatory back pain.

Methods. Spinal-pelvic orientation was assessed in DESIR cohort patients with recent-onset inflammatory back pain and suspected axSpA, by using lateral lumbar-spine radiographs to categorize sacral horizontal angle ($<40^\circ$ *vs* $\geqslant 40^\circ$), lumbosacral angle ($<15^\circ$ *vs* $\geqslant 15^\circ$) and lumbar lordosis (LL, $<50^\circ$ *vs* $\geqslant 50^\circ$). Associations between these angle groups and variables collected at baseline and 2 years later were assessed using the χ^2 test (or Fisher's exact) and the Mann–Whitney test. With Bonferroni's correction, $P < 0.001$ indicated significant differences.

Results. Of 362 patients, 358, 356 and 357 had available sacral horizontal angle, lumbosacral angle and LL values, respectively; means were 39.3°, 14.6° and 53.0°, respectively. The prevalence of sacroiliitis on both radiographs and MRI was higher in the LL $< 50^\circ$ group than in the LL $\geqslant 50^\circ$ group, but the difference was not statistically significant. Clinical presentation and confidence in a diagnosis of axSpA did not differ across angle groups. No significant differences were identified for degenerative changes according to sacral horizontal angle, lumbosacral angle or LL.

Conclusion. Spinal-pelvic balance was not statistically associated with the clinical or imaging-study findings suggesting axSpA in patients with recent-onset inflammatory back pain.

Key words: ankylosing spondylitis, axial spondyloarthritis, sacroiliitis, sacral slope, lumbar lordosis

CLINICAL SCIENCE

Rheumatology key messages

- The potentially misleading association between spinal/pelvic angle and sacroiliitis has not been studied yet.
- Spinal and pelvic angles are not associated with sacroiliitis in conventional radiography and MRI.
- Clinicians should not take into account these angles for interpretation of sacroiliac imaging.

Introduction

Axial SpA (axSpA) is a group of chronic inflammatory rheumatic diseases characterized by at least an axial distribution, predominant entheseal involvement, a strong association with HLA B27, a tendency to cluster within families, extraarticular manifestations, and no associated autoantibodies [1]. No diagnostic criteria exist, but classification criteria sets are used to assist in the diagnosis. Among them, the most recent is the Assessment of SpondyloArthritis international Society (ASAS) criteria set for axSpA, which distinguishes two arms, a radiological arm defined as sacroiliitis by radiography or MRI [2, 3] plus at least one SpA feature and a clinical arm defined as HLA-B27 plus at least two SpA features, but not necessarily imaging evidence of sacroiliitis.

Diagnosis of axSpA is the most difficult and the place of imaging is pivotal. Spinal imaging-study abnormalities

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in axSpA cover a broad range including inflammation, fatty lesions, erosions, ankylosis and syndesmophytes. In the SPACE cohort of 126 patients meeting ASAS criteria for axSpA, at least five spinal inflammatory or fatty lesions, or at least five sacroiliac erosions or fatty lesions, had over 95% specificity for discriminating between patients with and without axSpA [4]. These findings must be differentiated from those commonly found in patients with degenerative disease or other non-axSpA diseases of the spine [5]. At the sacroiliac joints and spine, axSpA is characterized by the development of syndesmophytes and ankylosis. Thus, patients with advanced axSpA have thoracolumbar kyphosis with pelvic retroversion and loss of the normal lumbar lordosis (LL).

Global sagittal balance depends on a delicate harmony between the orientations of the spine and pelvis. Spinal orientation is reflected by the degrees of thoracic kyphosis and LL and pelvic orientation by the sacral slope (or sacral horizontal angle, SHA), pelvic tilt and pelvic incidence angles (Supplementary Fig. S1, available at *Rheumatology* online) [6]. These angles are closely associated with one another. Thus, greater lordosis correlates with greater sacral slope, pelvic tilt and pelvic incidence [7]. Abnormalities in spinal and pelvic orientation that affect sagittal balance are associated with low back pain via the development of spondylolysis, isthmic spondylolisthesis and facet joint osteoarthritis. Indeed, modifications of lumbo-sacral imbalance can generate spondylolisthesis and subsequently degenerative changes such as facet joint osteoarthritis and disc degeneration [8]. Sagittal morphology of a normal spine is related to pelvic parameters and thus has been described associated with lumbar disc degeneration [9]. Furthermore, sagittal imbalance due to surgical lumbar fusion has been reported to induce sacroiliac pain with imaging study evidence of degenerative sacroiliac joint abnormalities [10]. Consequently, we hypothesize that patients with abnormalities in sacral and lumbar-spine orientation may present with low back pain and restricted lumbar-spine and sacroiliac mobility, prompting a radiological workup, which may show abnormalities mimicking sacroiliitis and/or Modic 1 changes at the lumbar spine. The postural abnormalities might induce both apparently inflammatory back pain (IBP) with restricted mobility and imaging-study abnormalities suggesting sacroiliitis and/or disc changes. In this situation, the diagnosis of axSpA may prove challenging. Thus, it is of great importance to clarify the potential association between spinal and pelvic angle on one side and sacroiliac joint imaging on the other side to prevent unsuitable spondyloarthritis diagnosis. The objective of this study was to assess associations linking spinal and pelvic angle values to sacroiliitis seen on radiography and MRI, pain, mobility and final confidence in a diagnosis of axSpA among patients suspected of having axSpA due to the recent onset of IBP.

Methods

The DESIR cohort

From December 2007 to April 2010, 708 patients with recent-onset IBP were included in a national, multicentre, prospective cohort under the aegis of the French Society of Rheumatology [11]. The goal was to obtain a vast body of data for studying the diagnosis, prognosis, epidemiology, pathogenesis and medico-economics of recent-onset IBP and SpA. Inclusion criteria were age 18–50 years, IBP for at least 3 months but <3 years, an at-least 5/10 likelihood of SpA according to the rheumatologist, and symptoms suggesting axSpA according to the local study investigator. Each patient was monitored for 5 years. The following data were collected: demographics, disease activity, disease severity, co-morbidities, socioeconomic information, treatments, and radiographic and MRI findings at the spine and pelvis.

The DESIR cohort study was registered on ClinicalTrials.gov (NCT0164 8907) and was approved by the appropriate ethics committee (CPP Ile-de-France III, #P070302). Each patient gave written informed consent and permission to publish any individual anonymized data before study inclusion. A detailed description of the study protocol is available at http://www.lacohortedesir.fr/desir-in-english/. This analysis was conducted on data collected until 2014.

Radiographic parameters

Only patients with standing radiographs were included in the study.

Spinal and pelvic angles

A rheumatologist (M.H.) and a radiologist (L.D.), who were both clinical fellows, received training by a spine specialist then used the sagittal lumbar-spine Digital Imaging And Communications In Medicine-format radiographs obtained in the DESIR cohort patients at baseline to measure the following three angles, in degrees: lumbosacral angle (LS) formed by two lines drawn along the lower L5 endplate and upper S1 endplate, respectively; sacral horizontal angle (SHA, also known as sacral slope) between the horizontal line and the line along the upper S1 endplate; and the LL between the lines along the upper L1 and S1 endplates (Supplementary Fig. S1, available at *Rheumatology* online). All images were assessed by both readers working independently from each other.

Degenerative disease

The baseline radiographs and MRI scans were read centrally by two blinded independent readers for evidence of degenerative disease as part of the data collection process for the DESIR cohort according to a methodology previously used in the SPACE cohort [4]. On the radiographs, degenerative disc disease (narrowing of the disc space compared with two adjacent healthy discs and considering the expected increase from L3 to S1) was recorded as present or absent at L3-L4, L4-L5 and L5-S1. MRI scans were examined for Modic endplate

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changes, canal stenosis, disc extrusion, disc protrusion and high-intensity zones, at L3-L4, L4-L5 and L5-S1. The Pfirrmann grade was determined on a five-point scale, and degenerative disc disease was defined as grade 3 or higher. Disagreements between the two readers were resolved by consensus with a third reader.

Imaging abnormalities suggesting *axSpA*

For the assessment of imaging-study findings suggesting axSpA, we used results obtained previously in the DESIR cohort: radiographic sacroiliitis was evaluated based on the modified New York criteria [12], MRI was evaluated using SPondyloArthritis Research Consortium of Canada (SPARCC) sacroiliac score [3] and ASAS criteria [2]. The Modified Stoke Ankylosing Spondylitis Spinal Score [13] and BASRI [14] were determined on spinal radiographs. MRI spinal inflammation was assessed using the SPARCC spine score [15].

Statistical analysis

The intraobserver reproducibility was assessed on 30 randomly selected baseline radiographs read a second time after an interval of at least 2 days, interobserver reproducibility on the whole population, using the intraclass correlation coefficient for SHA, LS and LL.

We compared patients with SHA $< 40^\circ$ *vs* $\geqslant 40^\circ$, LS $< 15^\circ$ *vs* $\geqslant 15^\circ$, and LL $< 50^\circ$ *vs* $\geqslant 50^\circ$. The variables compared across groups were the clinical features, diagnosis at inclusion in the DESIR cohort, diagnosis 2 years later as established by the rheumatologist and classification criteria sets, and imaging-study abnormalities. For these comparisons, we performed univariate analyses using the χ^2 test (or Fisher's exact test where appropriate) and the Mann–Whitney test. With Bonferroni's correction, P values <0.001 indicated significant differences. All statistical analyses were performed using SPSS 23.0 software (IBM, Armonk, NY).

Results

Patients

Of the 362 patients included, 358 had valid SHA measurements, 356 valid LS measurements, and 357 valid LL measurements. Baseline features in the 362 patients (Supplementary Table S1, available at *Rheumatology* online) were similar to those of the entire cohort. Mean age was 33 years and 50.8% of patients were female. Mean values were 39.3° for SHA, 14.6° for LS and 53.0° for LL. SHA was $<40^\circ$ in 173/358 (48.3%) patients, LS $<15^\circ$ in 185/356 (52.0%) patients and LL $<50^\circ$ in 227/357 (63.6%) patients.

Inter and intra reproducibility

SHA, LS and LL intraobserver intraclass correlation coefficients were 0.84, 0.88 and 0.95 for reader 1 and 0.94, 0.95 and 0.98 for reader 2, respectively. Intraclass coefficients were 0.89, 0.71 and 0.94 for SHA, LS and LL, respectively.

Associations of angle groups with clinical presentation and confidence in a diagnosis of SpA at baseline

Table 1 reports the clinical features in the SHA, LS and LL groups.

Associations of angle groups with prevalence of MRI sacroiliitis or spinal changes suggesting SpA

The prevalence of radiographic sacroiliitis according to New York criteria, the prevalence of ASAS MRI sacroiliitis and MRI sacroiliac SPARCC score did not differ between the two SHA or two LS groups but were non-significantly higher in the LL $< 50^\circ$ group than in the total lordotic angle $\geqslant 50^\circ$ group (Table 2). No significant differences between angle groups were found for the Modified Stoke Ankylosing Spondylitis Spinal Score, BASRI or SPARCC spinal score.

Associations of angle groups with imaging-study evidence of degenerative spinal disease

In all angle groups, signs of degenerative disc disease (Pfirrmann grade, high-intensity zone and disc extrusion) predominated at L5-S1. At L5-S1, the LL $< 50^\circ$ group had higher prevalences of Modic 1 or 2 changes compared with LL $> 50^\circ$ ($P < 0.001$ for all comparisons) (Supplementary Table S2, available at *Rheumatology* online).

Discussion

In the DESIR cohort, the prevalence of MRI sacroiliitis according to ASAS criteria for axSpA was not associated with the SHA or LS and was non-significantly higher in the group with LL $< 50^\circ$. These data argue against spinal-pelvic imbalance inducing symptoms that may lead to a mistaken diagnosis of non-radiographic axSpA. At L5-S1, a narrower LL was associated with Modic changes indicating inflammation (type 1) or fatty marrow conversion (type 2). Degenerative disease at the lumbar spine was common despite the young age of the patients, in keeping with earlier reports [16]. Degenerative disease was associated with lower values for LL. Among previous studies of spinal-pelvic imbalance, some did [8] and others did not [17] find a relationship with degenerative disease of the spine.

Limitations of our study include the absence of normal values of parameters measuring sagittal spinal-pelvic balance are not available. These values vary to such a considerable extent across asymptomatic individuals that no normal range can be defined. For example, in a cohort of 149 patients free of spinal disorders, LL ranged from 44° to 87° [18]. Finally, the associations with clinical manifestations varied across spinal-pelvic angle values, although the three angles used for our study are interdependent [19]. This finding may indicate different effects of each angle on symptoms.

The radiographs did not include the femoral heads. We were therefore unable to measure pelvic incidence, which is the angle between the line perpendicular to the sacral

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Table 1 Association between clinical manifestations and angle groups

Degree	SHA			LS			TLA		
	<40°	⩾40°	*P*-value	<15°	⩾15°	*P*-value	<50°	⩾50°	*P*-value
Age, years	32.7 (8.4)	33.4 (8.3)	0.39	332.5 (8.6)	33.5 (8.1)	0.26	33.1 (8.0)	33.0 (8.5)	0.84
Males	103/185 (55.7%)	73/173 (42.2%)	0.01	71/171 (41.5%)	105/185 (56.7%)	0.004	71/130 (54.6%)	105/227 (46.2%)	0.15
BMI	23.8 (3.8)	24.3 (4.8)	0.29	23.8 (4.4)	24.3 (4.2)	0.38	24.4 (3.9)	23.9 (4.5)	0.18
Buttock pain	131/185 (70.8%)	131/173 (75.7%)	0.29	127/171 (74.2%)	133/185 (71.9%)	0.61	90/130 (69.2%)	171/227 (75.3%)	0.21
Low back pain	166/185 (89.7%)	152/173 (87.9%)	0.57	152/171 (88.9%)	164/185 (88.6%)	0.94	118/130 (90.8%)	199/227 (87.7%)	0.37
Morning stiffness >30 min	168/185 (90.8%)	158/173 (91.3%)	0.86	156/171 (91.2%)	168/185 (90.8%)	0.89	115/130 (88.5%)	210/227 (92.5%)	0.20
Nocturnal pain	162/185 (87.6%)	154/173 (89.0%)	0.67	142/171 (83.0%)	172/185 (93.0%)	0.004	112/130 (86.1%)	203/227 (89.4%)	0.36
Finger-floor distance	13.3 (12.4)	12.7 (1342)	0.43	12.8 (13.3)	13.1 (12.5)	0.73	13.1 (13.4)	12.8 (12.6)	0.90
Schober's index	3.7 (0.1)	3.8 (1.3)	0.29	3.7 (1.1)	3.7 (1.1)	0.87	3.7 (1.0)	3.7 (1.1)	0.49
HLA B27 positive	116/185 (62.7%)	106/173 (61.3%)	0.83	105/171 (61.4%)	117/185 (63.2%)	0.74	81/130 (62.3%)	141/227 (62.1%)	1.00
BASDAI	42.3 (20.8)	46.0 (19.9)	0.08	42.8 (20.4)	45.1 (20.1)	0.31	43.7 (20.4)	44.0 (20.2)	0.99
BASMI	2.4 (1.0)	2.4 (1.2)	0.81	2.3 (1.2)	2.5 (1.0)	0.27	2.6 (1.2)	2.3 (1.0)	0.38
BASFI	27.1 (22.7)	32.2 (23.9)	0.03	29.5 (23.1)	29.3 (23.3)	0.83	28.3 (22.9)	29.9 (23.3)	0.48
ASDAS-CRP	2.49 (1.00)	2.63 (1.00)	0.15	2.45 (0.92)	2.65 (0.95)	0.06	2.56 (0.99)	2.55 (0.92)	0.95
ASAS criteria met	131/184 (71.2%)	118/172 (68.6%)	0.64	120/170 (70.6%)	128/184 (69.6%)	0.91	92/129 (71.3%)	157/226 (69.5%)	0.81
ESSG criteria met	148/185 (80.0%)	145/173 (83.8%)	0.41	141/171 (82.4%)	150/185 (81.1%)	0.78	106/130 (81.5%)	186/227 (81.9%)	1.00
M0 SpA confidence[a]	7.5 (2.1)	7.3 (2.1)	0.24	7.1 (2.3)	7.7 (1.9)	0.01	7.2 (2.1)	7.5 (2.1)	0.10

The data are *n* of patients with the symptom over total number of patients with information on the symptom (%) or mean (S.D.). [a]The local investigator rated his or her confidence in a diagnosis of spondyloarthritis on a 10-point scale at baseline (month 0, M0) and 2 years later (M24). ASAS: Assessment of SpondyloArthritis international Society; ASDAS-CRP: ankylosing spondylitis disease activity score with CRP; LS: lumbosacral angle; SHA: sacral horizontal angle; TLA: total lordotic angle.

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TABLE 2 Association between baseline imaging study findings and angle groups

	SHA			LS			TLA		
	<40°	⩾40°	*P*-value	<15°	⩾15°	*P*-value	<50°	⩾50°	*P*-value
Sacroiliacs									
MRI									
ASAS MRI sacroiliitis	66/183 (36.1%)	48/169 (28.4%)	0.14	57/169 (33.7%)	57/181 (31.5%)	0.73	49/128 (38.3%)	65/223 (29.1%)	0.09
SPARCC sacroiliac score	4.5 (9.1)	3.1 (6.3)	0.67	3.8 (8.0)	3.9 (7.9)	0.93	4.7 (9.9)	3.3 (6.4)	0.59
Radiographs									
New York sacroiliitis	37/185 (20.0%)	32/173 (18.5%)	0.79	39/171 (22.8%)	30/185 (16.2%)	0.14	32/130 (24.6%)	37/227 (16.3%)	0.07
Spine									
MRI									
SPARCC spine score	5.8 (10.3)	4.4 (8.0)	0.68	5.1 (9.1)	5.1 (9.5)	0.95	6.0 (11.1)	4.6 (8.1)	0.30
Radiographs									
mSASSS score	0.6 (2.2)	0.3 (1.2)	0.16	0.4 (1.6)	0.6 (2.0)	0.05	0.5 (2.1)	0.5 (1.6)	0.26
BASRI	0.3 (0.8)	0.2 (0.6)	0.07	0.2 (0.7)	0.3 (0.8)	0.26	0.3 (0.8)	0.2 (0.6)	0.60

The data are *n* (%) or mean (S.D.). ASAS: Assessment of SpondyloArthritis international Society; LS: lumbosacral angle; mSASSS: modified-Stoke Ankylosing Spondylitis Spinal Score; SHA: sacral horizontal angle; SPARCC score: Spondyloarthritis Research Consortium of Canada score; TLA: total lordotic angle.

endplate at its midpoint and the line connecting this midpoint to the line through both femoral-head centres. This angle is unique to each individual and independent from age, pelvic position [20] and degenerative changes [6]. Pelvic incidence reflects sagittal balance. EOS imaging shows the femoral heads and provides reproducible radiographs due to the standardized position of the patient in the machine, and so could be a better way to evaluate angles.

To conclude, spinal-pelvic balance was not associated with clinical symptoms or with radiographic or MRI changes suggesting axSpA.

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Supplementary data

Supplementary data are available at *Rheumatology* online.

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