



HAL
open science

Associations of Lumbar Scoliosis with Presentation of Suspected Early Axial Spondyloarthritis

Marie Voirin-Hertz, Guillermo Carvajal Alegria, Florent Garrigues, Alexandre Simon, Antoine Feydy, Monique Reijnierse, Désirée van der Heijde, Damien Loeuille, Pascal Claudepierre, Thierry Marhadour, et al.

► To cite this version:

Marie Voirin-Hertz, Guillermo Carvajal Alegria, Florent Garrigues, Alexandre Simon, Antoine Feydy, et al.. Associations of Lumbar Scoliosis with Presentation of Suspected Early Axial Spondyloarthritis. *Seminars in Arthritis and Rheumatism*, WB Saunders, 2019, 10.1016/j.semarthrit.2019.06.008 . hal-02167746

HAL Id: hal-02167746

<https://hal.univ-brest.fr/hal-02167746>

Submitted on 7 Mar 2022

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial | 4.0 International License

1 *Original article*

2

3 **Running head:** Scoliosis and Presentation of Early Axial Spondyloarthritis

4

5 **Associations of Lumbar Scoliosis with Presentation of Suspected Early Axial**
6 **Spondyloarthritis**

7

8 Marie Voirin-Hertz (MD)^{1*}, Guillermo Carvajal Alegria (MD)^{1*}, Florent Garrigues (MD)²,
9 Alexandre Simon (MD)³, Antoine Feydy (MD, PhD)⁴, Monique Reijnierse (MD)⁵, Désirée
10 van der Heijde (MD, PhD)⁶, Damien Loeuille (MD, PhD)⁷, Pascal Claudepierre (MD, PhD)⁸,
11 Thierry Marhadour (MD)¹, and Alain Saraux (MD, PhD)^{1,9}

12

13 ¹Rheumatology Unit, Hôpital de la Cavale Blanche, Brest 29609, France

14 ²Radiology Unit, Hôpital de la Cavale Blanche, Brest 29609, France

15 ³Neurosurgery Unit, Hôpital de la Cavale Blanche, Brest 29609, France

16 ⁴Radiology B Department, Paris Descartes University, Cochin Hospital, Paris France

17 ⁵Department of Radiology, Leiden University Medical Center, Leiden, the Netherlands

18 ⁶Department of Rheumatology, Leiden University Medical Center, Leiden, the Netherlands

19 ⁷Department of Rheumatology, Nancy, France

20 ⁸AP-HP, Groupe Hospitalier Henri-Mondor, Service de Rhumatologie, Créteil, 94000,
21 France; Université Paris Est Créteil, EA 7379 – EpidermE, Créteil, 94000, France;

22 ⁹INSERM 1227, Université de Bretagne Occidentale, LabEx IGO, Brest, France

23 *These two authors contributed equally to the work and should be considered co-first
24 authors.

25

1 **Financial support:** The DESIR cohort used for this study is financially supported by
2 unrestricted grants from both the French Society of Rheumatology and Pfizer Ltd France.

3 **Corresponding author:**

4 Prof. Alain Saraux

5 Rheumatology Unit, Hôpital de la Cavale Blanche, BP 824, F 29609 Brest cedex, France

6 Tel: +33 298 347 268; Fax: +33 298 493 627

7 E-mail: alain.saraux@chu-brest.fr

8

9 **Word count (body of text): 2585**

10 **Number of tables and figures: 4 tables and 1 figure**

11 **Number of references: 34**

12

1 **ABSTRACT (235 words)**

2 **Objective:** Scoliosis may impact the mechanical loading and cause secondary changes of the
3 sacroiliac joints and lumbar spine. Our goal was to look how lumbar scoliosis modify the
4 clinical and imaging-study in patients with recent-onset inflammatory back pain (IBP)
5 suggesting axial spondyloarthritis (axSpA).

6 **Methods:** Baseline weight-bearing lumbar-spine radiographs obtained in the DESIR cohort
7 of patients aged 18-50 years and having IBP for at least 3 months but less than 3 years
8 suggesting axSpA were studied. After training on scoliosis detection based on Cobb's
9 angle $>10^\circ$ plus Nash-Moe grade ≥ 1 , readers blinded to patient data measured spine lumbar
10 scoliosis, sacral horizontal angle, lumbosacral angle and total lordotic angle on the
11 radiograph of the lumbar and scored sacroiliitis on the radiograph of the pelvis. Baseline
12 MRIs T1 and STIR of the lumbar spine and sacroiliac joints were evaluated for respectively
13 degenerative changes and signs of axSpA.

14 **Results:** Of the 360 patients (50.8% females) 88.7% had lumbar pain and 69.3% met ASAS
15 criteria for axSpA. Mean Cobb's angle was $3.2^\circ \pm 5.0^\circ$ and 28 (7.7%) patients had lumbar
16 scoliosis. No statistical differences were observed for radiographic sacroiliitis, MRI
17 sacroiliitis, modified Stoke Ankylosing Spondylitis Spinal Score, Pfirrmann score, high-
18 intensity zone, protrusion, extrusion, MODIC score between patients with and without
19 scoliosis. In both groups, degenerative changes by MRI were rare and predominated at L4-
20 L5 and L5-S1.

21 **Conclusion:** In patients with early IBP suggesting axSpA, lumbar scoliosis was not
22 associated with inflammatory or degenerative changes.

23

24 **Key words:** Ankylosing spondylitis. Axial spondyloarthritis. Lumbar scoliosis. Lumbar
25 lordosis. Sacral slope. Degenerative disease.

1 **Significance and Innovations**

- 2 - A normal to low prevalence of 7.7 % lumbar scoliosis and lordosis is found in
3 patients between 18-50 years who had early IBP in the DESIR cohort. (7.7 % of
4 patients with early IBP suggesting axSpA have lumbar scoliosis)
- 5 - Lumbar scoliosis is not associated with changes in clinical or imaging-study findings
6 in this context.
- 7 - lumbar scoliosis is not associated with secondary changes to mechanical loading as
8 sclerosis or BME of the sacroiliac joints.
- 9 - Lumbar scoliosis has no impact on the MR diagnosis of sacroiliitis on radiographs
10 and MR SI joints.

11

1 INTRODUCTION

2
3 Back pain has a lifetime prevalence of 70% in the general population (1,2). In most
4 patients, back pain is a nonspecific symptom that is related to mechanical factors whose
5 exact cause is identified in fewer than half the cases (3).

6 Scoliosis (4) is a three-dimensional spinal deformity that can cause back pain. The
7 main diagnosis criterion is a coronal curvature with a Cobb's angle greater than 10° on the
8 anteroposterior radiograph. In addition, the assessment of pedicle position according to the
9 Nash-Moe technique shows vertebral rotation (Nash-Moe grade >1) (1,5,6). The prevalence
10 of scoliosis has been estimated at 1%-3%. Idiopathic scoliosis accounts for about 80% of all
11 structural coronal deformities, with a prevalence of 1%-2% among schoolchildren up to age
12 15. In adults, the prevalence of idiopathic scoliosis has been reported to increase with age
13 from 8% starting at 25 years to 68% between 60 and 80 years, due in part to the development
14 of degenerative spinal lesions (1) (2,8-14). Scoliosis causes multifactorial low back pain,
15 whose typically mechanical pattern may be combined with an inflammatory component, for
16 instance in the event of vertebral endplate edema (3,7). The pain may be chronic or
17 recurrent. Scoliosis also restricts spinal mobility.

18 Degenerative disease of the spine on radiographs has a high prevalence in the general
19 population with back pain (121 to 274, 44%) and clinical correlation with MR imaging
20 findings is low (15). These include dehydration of discs and loss of disc height, a high-
21 intensity zone (HIZ) in the posterior annulus of the disk, disk herniation, Modic type
22 vertebral endplate changes, facet-joint osteoarthritis, interspinous bursitis (rare and not
23 scored by us), degenerative spondylolisthesis (3). The presence of scoliosis accelerates the
24 development of degenerative changes of the spine. In addition the change the mechanical
25 loading may cause secondary changes in the SI joints as reactive sclerosis or bone marrow
26 edema.

1 In axial spondyloarthritis (axSpA), back pain is a key manifestation. Thus,
2 inflammatory back pain (IBP) in younger patients predominantly suggests axSpA. The early
3 diagnosis of axSpA is challenging and relies on a convergence of evidence from the medical
4 history, physical examination, laboratory tests, and imaging studies (16–19). Degenerative
5 changes are common in the general population and in axSpA. Thus, in the SPACE cohort,
6 90% of patients classified as having possible or definite axSpA also had degenerative
7 changes by MRI, which predominated at the lumbar spine (15). However, the prevalence of
8 lumbar scoliosis in patients with axSpA has not been reported. Furthermore, no data exist on
9 whether scoliosis is associated with differences in the clinical and/or imaging-study
10 presentation of axSpA.

11 Our objective here was to evaluate whether lumbar scoliosis was associated with
12 differences in clinical manifestations, imaging-study findings, and/or the degree of axSpA
13 diagnosis certainty in the DESIR cohort of patients with recent-onset IBP and suspected
14 axSpA.

1 PATIENTS AND METHODS

2

3 **The DESIR cohort**

4 DESIR (DEvenir des Spondyloarthropathies Indifférenciées Récentes) is a French
5 prospective, multicenter, cohort established between October 2007 and April 2010. Adults
6 aged 18 to 50 years were included if they had inflammatory pain in the thoracic spine,
7 lumbar spine, and/or buttock(s) meeting Calin and/or Berlin criteria (16), of more than 3
8 months' but less than 3 years' duration, leading to a determination by the local investigator
9 that the probability of axSpA was at least 5 on a 0-10 numerical rating scale (0, not
10 suggestive at all; 10, highly suggestive). The baseline characteristics of the patients are
11 described in detail elsewhere (20,21).

12 The DESIR cohort study complied with good clinical practice guidelines, was
13 registered on Clinical Trials.gov (NCT0164 8907), and was approved by the appropriate
14 ethics committee (CPP Ile-de-France III, submission number P070302). Before study
15 inclusion, each patient gave written informed consent and permission to publish any
16 individual anonymized data. A detailed description of the study protocol is available online
17 at <http://www.lacohortedesir.fr/desir-in-english/>. The research project was approved by the
18 DESIR scientific committee. For this study, the database was locked in 2014. Standing,
19 weight-bearing, antero-posterior radiographs of the lumbar spine were used.

20 **Assessment of imaging studies**

21 *Evaluation of scoliosis.* We used Cobb's angle (1,5,6) to quantify spinal curvature in the
22 frontal plane and the Nash-Moe grade to assess vertebral rotation. Cobb's angle is subtended
23 by the line along the superior endplate of the vertebra at the top of the curve and a line along
24 the inferior endplate of the vertebra at the bottom of the curve. The Nash-Moe grade based
25 on pedicle shadow position reflects the degree of rotation of the vertebra at the apex of the

1 curve; the grade can range from 0 (no rotation) to 4 (major rotation) (5,6). Two rheumatology
2 fellows (MVH and GCA) received training from a spine specialist then evaluated the
3 baseline anteroposterior lumbar-spine radiograph (in DICOM format) of each patient for
4 evidence of scoliosis (**Figure 1**), on two separate occasions separated by at least 2 days.
5 Patients with a Cobb's angle $\geq 10^\circ$ and a Nash-Moe grade ≥ 1 were classified as having
6 scoliosis and other patients as being free of scoliosis (1,5,6). Disagreements between the two
7 readers (scoliosis yes/no) were resolved by having the spine specialist (TM) repeat the
8 measurements.

9 *Evaluation of degenerative disease.* As part of the DESIR cohort data collection process, the
10 baseline lumbar-spine radiograph and MRI scan of each patient had been previously assessed
11 for degenerative changes by two readers blinded to all patient data (15). Radiographic
12 degenerative changes were recorded as present/absent at L3-L4, L4-L5, and L5-S1, as they
13 are the most affected by degenerative changes. The MRI scans were also assessed for disk
14 degeneration, Modic changes, Pfirrmann grade, canal stenosis, disk herniation/extrusion,
15 HIZ, facet-joint osteoarthritis, spondylolisthesis, and Schmorl's nodes at L3-L4, L4-L5, and
16 L5-S1. For this study, Pfirrmann grades I and II were considered normal and grades III, IV,
17 or V as indicating degenerative disease; disagreements between the two readers were
18 resolved by a third reader.

19 *Angle measurements.* For another DESIR cohort study, two readers used the baseline lateral
20 lumbar-spine radiographs to measure sacral slope (SS) as the angle formed by the line along
21 the upper endplate of S1 and the horizontal plane (22) and total lordotic angle (TLA) formed
22 by the lines drawn along the upper endplates of L1 and S1(22–24). Lumbosacral angle
23 (LSA) formed by two lines drawn along the lower L5 endplate and upper S1 endplate,
24 respectively; sacral horizontal angle (SHA) between the horizontal line and the line along the

1 upper S1 endplate; and the total lordotic angle (TLA) between the lines along the upper L1
2 and S1 endplates. The values were used for the present study.

3 *Imaging abnormalities suggesting axSpA.* We also compared the right or left curved
4 scoliosis to the right and left sacroiliac joints joint for grade of sclerosis on radiograph and
5 bone marrow edema on sacroiliac MRI. As part of the DESIR cohort data collection process,
6 baseline radiographs of the spine and pelvis were used to assess New-York modified criteria
7 for sacroiliitis (25), the modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS
8 score) (26), and the Bath Ankylosing Spondylitis Radiology Index (BASRI) (27); baseline
9 MRI scans were evaluated for evidence of sacroiliitis (28) and determination of the
10 sacroiliac and spinal SPondyloARthritis Research Consortium of Canada MRI inflammation
11 (SPARCC) score (29–30). Ranges of the scoring systems are included in the tables showing
12 the results.

13 **Statistical analysis**

14 Intraobserver repeatability and interobserver reproducibility of the diagnosis of
15 scoliosis were estimated by computing the kappa coefficients, which were interpreted
16 according to Landis and Koch (0.61-0.80, substantial agreement; and 0.81-1, near perfect
17 agreement). Patients with and without scoliosis were compared regarding the clinical
18 presentation (demographics, pain pattern, spinal mobility, and other features), the prevalence
19 of degenerative disease (presence or absence) visible radiographically and by MRI, and the
20 degree of confidence in a diagnosis of axSpA. All data were evaluated at baseline.
21 Associations between these variables and scoliosis were sought by univariate analysis using
22 the chi-square test (or Fisher's exact test when appropriate) or the Mann-Whitney test. We
23 also verified that Cobb' angle was not correlated to either mSASSS or grade of sacroiliitis on
24 X-rays using the Spearman's coefficient.

1 With Bonferroni's correction, *P* values <0.001 were required to indicate significant
2 differences. Statistical analyses were performed using SPSS 23.0 software (IBM, Armonk,
3 NY).

1 RESULTS

2

3 Study group

4 From the DESIR cohort, 362 patients with available standing, weight-bearing,
5 anteroposterior lumbar-spine radiographs were included in the study. Mean Cobb's angle
6 was $3.2^{\circ} \pm 5.0$, with a maximum of 32° . Of the 362 patients, 28 (7.7%) had scoliosis. The
7 Nash-Moe grade was I or II in all patients. No patient had severe scoliosis. In the overall
8 patient population, the intraobserver kappa coefficient was 1, indicating perfect agreement,
9 and the interobserver kappa coefficient was 0.7, indicating substantial agreement.

10 The baseline characteristics of the 362 patients were similar to those of the entire
11 cohort (supplementary table 1): mean age was 33.2 ± 8.4 and 50.8% of patients were female;
12 88.7% of patients had low back pain and 72.7% had buttock pain. The ASAS classification
13 criteria for axSpA were met by 69.3% of patients at baseline (**Table 1**). No patient had
14 spondylolysis and very few patients had spondylolisthesis, Modic changes, canal stenosis, or
15 facet-joint osteoarthritis.

16

17 Associations of scoliosis with clinical presentation and confidence in a diagnosis of

18 *axSpA*

19 **Table 2** compared the clinical characteristics in the groups with and without scoliosis.
20 No statistically significant differences were found for demographic data, site or features of
21 the pain, or motion range of the lumbar spine. Neither range of motion of the lumbar spine
22 nor the degree of confidence in a diagnosis of axSpA differed between the two groups.

23

24 Associations of scoliosis with imaging-study abnormalities

1 **Table 3** reports the results of tests for associations linking scoliosis to SS and TLA
2 values measured on radiographs and to MRI signs of degenerative disease. Overall, MRI
3 abnormalities were extremely uncommon, with no significant between-group differences; for
4 each abnormality, the numbers were too small for statistical analyses. Except for Schmorl's
5 nodes, the MRI abnormalities predominated at L4-L5 and L5-S1.

6 TLA was non-significantly greater in the group with scoliosis (58.9° vs. 52.4°,
7 $P=0.009$). SS was non-significantly greater in the group with scoliosis (42.2° vs. 39.0,
8 $P=0.03$).

9 Scoliosis was not associated with abnormalities suggesting axSpA by radiography
10 (New York criteria, mSASSS score, BASRI score and SPARCC score) or MRI (ASAS
11 criteria and SPARCC score) (**Table 4**). The Cobb'angle was not correlated to either
12 mSASSS ($r -0.28$, $p0.61$) or grade of sacroiliitis on X-rays (left: $r=0.60$, $p0.26$; right: $r=0.01$,
13 $p0.78$).

14
15

16 **DISCUSSION**

17

18 In this study, lumbar scoliosis was not significantly associated with the clinical or
19 imaging-study features of patients with early IBP. Thus, patients with and without scoliosis
20 did not differ regarding nocturnal pain, morning stiffness according to the Berlin criteria,
21 chronicity of the symptoms, and confidence in a diagnosis of axSpA. Moreover, the
22 proportion of patients meeting ASAS criteria was the same in the two groups, indicating that
23 lumbar scoliosis did not increase the risk of mistakenly diagnosing axSpA in this population

1 of patients in whom the local investigators rated the likelihood of axSpA at 5 or more on a
2 10-point scale (32).

3 Lumbar scoliosis might be expected to diminish the range of forward bending. In a
4 study of adolescent idiopathic scoliosis, forward bending was restricted in proportion to the
5 amount of curvature and rotation (10). Furthermore, an association has been reported
6 between scoliosis and spinal degenerative disease. However, the modified Schober's test
7 and finger-floor distance were similar in our groups with and without scoliosis. This finding
8 may be ascribable to the characteristics of our patients, who were young, with little evidence
9 of degenerative disease, and whose lumbar scoliosis was usually mild (23).

10 Sagittal lumbosacral balance as assessed on radiographs did not differ between the
11 groups with and without scoliosis. In patients with scoliosis, total lordosis and SS were non-
12 significantly greater than in patients without scoliosis. In both groups, the TLA and SS
13 values were within the normal ranges. Few studies have addressed sagittal lumbosacral
14 balance in patients with scoliosis (31,32). In 160 patients with adolescent idiopathic scoliosis
15 (34), lumbar lordosis was non-significantly greater in the group with lumbar curves. Some
16 studies suggest that greater lordosis may not be associated with the progression of scoliosis
17 (33,34).

18 Data on potential associations of lumbar lordosis with degenerative changes and low
19 back pain are conflicting. In a study of 112 females aged 40-72 years, the angle of lordosis
20 was not significantly different in the groups with and without radiographic degenerative
21 disease of the lumbar spine (23). The TLA may be associated with spondylolysis and
22 spondylolisthesis but not with other manifestations of spinal degenerative disease (24).

23 MRI abnormalities were rare in both groups, suggesting that lumbar scoliosis may not
24 be associated with an increased risk of spinal degenerative disease in adults with early IBP
25 who are younger than 50 years of age. Nevertheless, scoliosis was associated with

1 degenerative disease in many studies, with some parameters correlating with low back pain.
2 Thus, Modic changes were more common or more marked in patients with scoliosis (13,14)
3 and predominated at the curve apex concavity (9,11). Severe facet-joint degeneration was
4 associated with painful lumbar scoliosis (2,8,10,11). One study found that Schmorl's nodes
5 were associated with pain in pediatric patients with scoliosis who had Schmorl's nodes (9).
6 Other degenerative lesions such as foraminal stenosis and spondylolisthesis may correlate
7 with symptoms in patients with lumbar scoliosis (11). In our study, degenerative changes at
8 the lumbar spine were found in similar proportions of patients with and without lumbar
9 scoliosis. This finding may be ascribable to the relatively young age of the patients and to
10 the mild nature of most of the cases of lumbar scoliosis. Alternatively, any deleterious
11 effects of lumbar scoliosis may have been counterbalanced by an increase in lumbar lordosis.
12 In a study of patients who had two MRI scans of the lumbar spine at a 4-year interval,
13 lordosis was more marked in patients with no degenerative disease progression (14).
14 Scoliosis was not associated with progression. In the SPACE cohort of patients aged 16 to
15 45 years and presenting with chronic back pain, the prevalence of degenerative changes was
16 89% by MRI and 44% by radiography, with no difference across the groups with and
17 without axSpA; the prevalence of each type of degenerative change was far lower, although
18 HIZ were seen at the lumbar spine in 62.4% of patients (19). The main strength of this study
19 is the collection of a vast array of data in a large population. In addition, most of the imaging
20 study assessments were done by experienced radiologists. Among the weaknesses is the
21 focus on lumbar scoliosis. We did not obtain standing AP radiograph of the full-spine to
22 quantify spinal curvature in a uniform and comparable method, as recommended by the
23 American Scoliosis Research Society. Patients with low back pain may also have thoracic
24 spinal pain with or without thoracic or thoracolumbar scoliosis. Thoracolumbar scoliosis can
25 be missed and no information is available on S-shaped curve of the spine. Furthermore,

1 Cobb's angle, although the current reference standard for assessing scoliosis, measures a 2D
2 curve, whereas scoliosis is a 3D deformity (5). However, we also assessed the Nash-Moe
3 grade to evaluate vertebral rotation. Nevertheless, measurement error have been found to
4 result in 2° to 7° differences in Cobb's angle values and the Nash-Moe grade can be properly
5 assessed only on a true frontal view. The number of patients with scoliosis is low and the
6 difference of number between the group with and without scoliosis might have decreased the
7 statistical power of the study. Nevertheless, Cobb'angle was not correlated to either
8 mSASSS or grade of sacroiliitis on X-rays.

9 In conclusion, in a large prospective cohort of patients with early IBP, lumbar scoliosis
10 is infrequently seen and not associated with secondary changes to mechanical loading,
11 sclerosis or bone marrow edema of the sacroiliac joints. Therefore there is no impact on the
12 classification criteria for axSpA. Furthermore, lumbar spine degenerative changes were not
13 more common in the patients with versus without lumbar scoliosis. These results were
14 obtained in patients aged 18-50 years who had early IBP. It would be of interest to assess
15 longitudinal data with AP full spine radiographs from the DESIR cohort with the aim of
16 determining whether lumbar scoliosis is associated with the outcomes of axSpA.

17

1 **ACKNOWLEDGMENTS**

2 The DESIR cohort is managed under the control of the Assistance Publique-Hopitaux de
3 Paris via the Paris-Center Clinical Research Unit and under the umbrella of the French
4 Society of Rheumatology and the INSERM (Institut National de la Santé et de la Recherche
5 Médicale). The database is managed at the Department of Epidemiology and Biostatistics
6 (Prof. Jean-Pierre Daurès, D.I.M., Nîmes, France). An unrestricted grant from Wyeth
7 Pharmaceuticals was allocated for the first 5 years of patient follow-up . We also thank the
8 regional centers that participated in establishing the DESIR cohort: Prof. Maxime Dougados
9 (Paris - Cochin B), Prof. André Kahan (Paris - Cochin A), Prof. Olivier Meyer (Paris -
10 Bichat), Prof. Pierre Bourgeois (Paris - La Pitié-Salpêtrière), Prof. Francis Berenbaum (Paris
11 - Saint Antoine), Prof. Pascal Claudepierre (Créteil), Prof. Maxime Breban (Boulogne
12 Billancourt), Dr Bernadette Saint-Marcoux (Aulnay-sous-Bois), Prof. Philippe Goupille
13 (Tours), Prof. Jean-Francis Maillefert (Dijon), Dr Xavier Puéchal (Le Mans), Prof. Daniel
14 Wendling (Besançon), Prof. Bernard Combe (Montpellier), Prof. Liana Euler-Ziegler
15 (Nice), Prof. Philippe Orcel (Paris - Lariboisière), Prof. Pierre Lafforgue (Marseille), Dr
16 Patrick Boumier (Amiens), Prof. Jean-Michel Ristori (Clermont-Ferrand), Dr Nadia Mehsen
17 (Bordeaux), Prof. Damien Loeuille (Nancy), Prof. René-Marc Flipo (Lille), Prof. Alain
18 Saraux (Brest), Prof. Corinne Miceli (Le Kremlin Bicêtre), Prof. Alain Cantagrel (Toulouse),
19 and Prof. Olivier Vittecoq (Rouen).

20

1 REFERENCES

2

3 1. Trobisch P, Suess O, Schwab F. Idiopathic scoliosis. *Dtsch Arzteblatt Int.*
4 2010;107:875–883; quiz 884.

5 2. Kostuik JP, Bentivoglio J. The incidence of low-back pain in adult scoliosis. *Spine.*
6 1981;6:268–73.

7 3. Ract I, Meadeb J-M, Mercy G, Cueff F, Husson J-L, Guillin R. A review of the value
8 of MRI signs in low back pain. *Diagn Interv Imaging.* 2015;96:239–49.

9 4. Yaman O, Dalbayrak S. Idiopathic scoliosis. *Turk Neurosurg.* 2014;24:646–57.

10 5. Kim H, Kim HS, Moon ES, Yoon CS, Chung TS, Song HT, et al. Scoliosis imaging:
11 what radiologists should know. *Radiographics* 2010;30:1823–42.

12 6. Lam GC, Hill DL, Le LH, Raso JV, Lou EH. Vertebral rotation measurement: a
13 summary and comparison of common radiographic and CT methods. *Scoliosis.* 2008 2;3:16.

14 7. Faundez A, Genevay S. [Adult scoliosis: a misknown etiology of low back pain in the
15 elderly population]. *Rev Med Suisse.* 2010;6:1358–60, 1362.

16 8. Jackson RP, Simmons EH, Stripinis D. Incidence and severity of back pain in adult
17 idiopathic scoliosis. *Spine.* 1983;8:749–56.

18 9. Buttermann GR, Mullin WJ. Pain and disability correlated with disc degeneration via
19 magnetic resonance imaging in scoliosis patients. *Eur Spine J* 2008;17:240–9.

20 10. Kao FC, Lai PL, Chang CH, Tsai TT, Fu TS, Niu CC, et al. Influence of lumbar
21 curvature and rotation on forward flexibility in idiopathic scoliosis. *Biomed J.* 2014;37:78–
22 83.

23 11. Berjano P, Lamartina C. Classification of degenerative segment disease in adults with
24 deformity of the lumbar or thoracolumbar spine. *Eur Spine J* 2014;23:1815–24.

- 1 12. Siribumrungwong K, Gupta S, Gupta MC. Unusual presentation of vertebral endplate
2 Modic changes in congenital scoliosis associated with pain: a report of two cases. *Eur Spine*
3 *J* 2016;25 Suppl 1:94–9.
- 4 13. Wu HL, Ding WY, Shen Y, Zhang YZ, Guo JK, Sun YP, et al. Prevalence of vertebral
5 endplate modic changes in degenerative lumbar scoliosis and its associated factors analysis.
6 *Spine*. 2012;37:1958–64.
- 7 14. Farshad-Amacker NA, Hughes AP, Aichmair A, Herzog RJ, Farshad M. Determinants
8 of evolution of endplate and disc degeneration in the lumbar spine: a multifactorial
9 perspective. *Eur Spine J* 2014;23:1863–8.
- 10 15. de Bruin F, ter Horst S, Bloem HL, van den Berg R, de Hooze M, van Gaalen F, et al.
11 Prevalence of degenerative changes of the spine on magnetic resonance images and
12 radiographs in patients aged 16-45 years with chronic back pain of short duration in the
13 Spondyloarthritis Caught Early (SPACE) cohort. *Rheumatology (Oxford)* 2016;55:56–65.
- 14 16. Raychaudhuri SP, Deodhar A. The classification and diagnostic criteria of ankylosing
15 spondylitis. *J Autoimmun*. 2014;48–49:128–33.
- 16 17. Rudwaleit M, Metter A, Listing J, Sieper J, Braun J. Inflammatory back pain in
17 ankylosing spondylitis: a reassessment of the clinical history for application as classification
18 and diagnostic criteria. *Arthritis Rheum*. 2006;54:569–78.
- 19 18. Wendling D, Lukas C, Paccou J, Claudepierre P, Carton L, Combe B, et al.
20 Recommendations of the French Society for Rheumatology (SFR) on the everyday
21 management of patients with spondyloarthritis. *Joint Bone Spine* 2014;81:6–14.
- 22 19. Rudwaleit M, Haibel H, Baraliakos X, Listing J, Märker-Hermann E, Zeidler H, et al.
23 The early disease stage in axial spondylarthritis: results from the German Spondyloarthritis
24 Inception Cohort. *Arthritis Rheum* 2009;60:717–27.

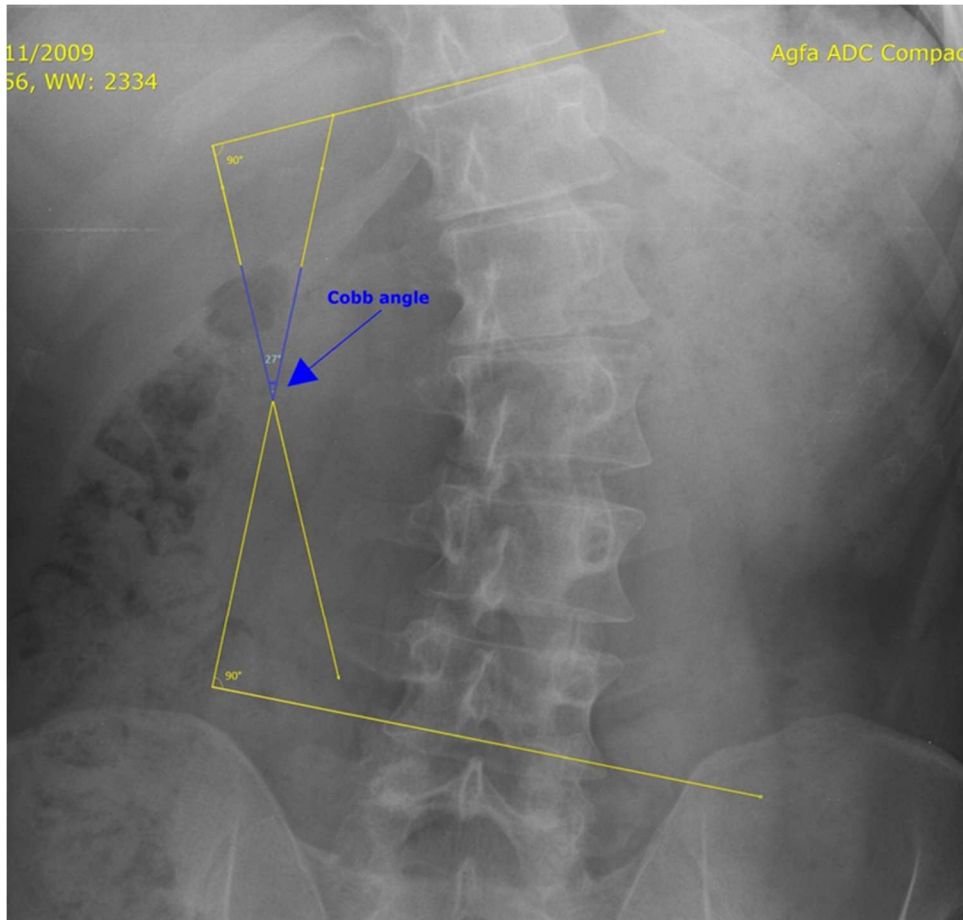
- 1 19. 20. Dougados M, d'Agostino M-A, Benessiano J, Berenbaum F, Breban M,
2 Claudepierre P, et al. The DESIR cohort: a 10-year follow-up of early inflammatory back
3 pain in France: study design and baseline characteristics of the 708 recruited patients. *Joint*
4 *Bone Spine* 2011;78:598–603.
- 5 21. Dougados M, Etcheto A, Molto A, Alonso S, Bouvet S, Daurès J-P, et al. Clinical
6 presentation of patients suffering from recent onset chronic inflammatory back pain
7 suggestive of spondyloarthritis: The DESIR cohort. *Joint Bone Spine* 2015;82:345–51.
- 8 22. Roussouly P, Nnadi C. Sagittal plane deformity: an overview of interpretation and
9 management. *Eur Spine J* 2010;19:1824–36.
- 10 23. Papadakis M, Papadokostakis G, Kampanis N, Sapkas G, Papadakis SA, Katonis P.
11 The association of spinal osteoarthritis with lumbar lordosis. *BMC Musculoskelet Disord.*
12 2010;11:1.
- 13 24. Been E, Kalichman L. Lumbar lordosis. *Spine J* 2014;14:87–97.
- 14 25. van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for
15 ankylosing spondylitis. A proposal for modification of the New York criteria. *Arthritis*
16 *Rheum* 1984;27:361–8.
- 17 26. Creemers MC, Franssen MJ, van't Hof MA, Gribnau FW, van de Putte LB, van Riel
18 PL. Assessment of outcome in ankylosing spondylitis: an extended radiographic scoring
19 system. *Ann Rheum Dis* 2005;64:127–9.
- 20 27. MacKay K, Mack C, Brophy S, Calin A. The Bath Ankylosing Spondylitis Radiology
21 Index (BASRI): a new, validated approach to disease assessment. *Arthritis Rheum.*
22 1998;41:2263–70.
- 23 28. Rudwaleit M, Jurik AG, Hermann K-GA, Landewé R, van der Heijde D, Baraliakos X, et
24 al. Defining active sacroiliitis on magnetic resonance imaging (MRI) for classification of

- 1 axial spondyloarthritis: a consensual approach by the ASAS/OMERACT MRI group. *Ann*
2 *Rheum Dis.* 2009;68:1520–7.29.
- 3 29. Weber U, Lambert RGW, Østergaard M et al. The diagnostic utility of magnetic
4 resonance imaging in spondylarthritis: an international multicenter evaluation of one
5 hundred eighty-seven subjects. *Arthritis Rheum* 2010;62:3048–58 30.
- 6 30. Dougados M, Sepriano A, Molto A, van Lunteren M, RamiroS, de Hooge M, van den
7 Berg R, Navarro Compan V, Demattei C, Landewé R, van der Heijde D. Sacroiliac
8 radiographic progression in recent onset axial spondyloarthritis: the 5-year data of the
9 DESIR cohort. *Ann Rheum Dis.* 2017;76:1823-1828.
- 10 31. Clément J-L, Geoffray A, Yagoubi F, Chau E, Solla F, Oborocianu I, et al. Relationship
11 between thoracic hypokyphosis, lumbar lordosis and sagittal pelvic parameters in adolescent
12 idiopathic scoliosis. *Eur Spine J* 2013;22:2414–20.
- 13 32. Mac-Thiong JM, Labelle H, Charlebois M, Huot MP, de Guise JA. Sagittal plane
14 analysis of the spine and pelvis in adolescent idiopathic scoliosis according to the coronal
15 curve type. *Spine.* 2003;28:1404–9.
- 16 33. Faraj SSA, Holewijn RM, van Hooff ML, de Kleuver M, Pellisé F, Haanstra TM. De
17 novo degenerative lumbar scoliosis: a systematic review of prognostic factors for curve
18 progression. *Eur Spine J* 2016;25:2347–58.
- 19 34. Jimbo S, Kobayashi T, Aono K, Atsuta Y, Matsuno T. Epidemiology of degenerative
20 lumbar scoliosis: a community-based cohort study. *Spine.* 2012;37:1763–70.

21

22

1 **Figure 1.** Cobb's angle measurement on an anteroposterior radiograph of the lumbar spine



2

3

1 **Table 1. Main patient characteristics at baseline (n=362)**

Age (years), mean±SD	33.2 ± 8.4
Males, n (%)	178 (49.2%)
BMI (m/kg ²), mean±SD	24.1±4.3
Low-back pain, ^a n (%)	321 (88.7%)
Buttock pain, ^a n (%)	263 (72.7%)
Morning stiffness (Berlin criteria), n/N (%)	329 (90.9%)
Nocturnal pain (Berlin criteria), n/N (%)	319 (88.1%)
Modified Schober test (10+Xcm), mean±SD	3.7 ± 1.1
Finger-floor distance (cm), mean±SD	13.0 ± 12.9
HLA B27 positivity, n (%) (n=674)	224 (61.9%)
ASAS criteria, n (%) (n:669)	251 (69.3%)
Confidence in a diagnosis of SpA at baseline, ^b mean±SD	7.4 ± 2.1
Sacral slope, °, mean±SD	39.3 ± 9.2
Lumbosacral angle, °, mean±SD	14.6 ± 4.6
TLA, °, mean±SD	53.0 ± 13.1
Lumbar scoliosis, n (%)	28 (7.7%)

2 ^a inclusion criterion

3 ^b assessed on a 1-10 scale by the investigator at each study center

4 BMI, body mass index; HLA, human leukocyte antigen; ASAS, Assessment of
 5 SpondyloArthritis international Society; SpA, spondyloarthritis; TLA, total lordotic angle

6

1 **Table 2.** Associations of scoliosis with the clinical presentation and confidence in a
 2 diagnosis of axSpA at baseline; ASAS criteria and confidence in a diagnosis of
 3 spondyloarthritis are also reported after 2 years

Characteristics	No scoliosis N=327	Scoliosis N=28	P value*
Age (years), mean±SD	33.2 ± 8.4	31.9 ± 7.5	0.49
Males, n (%) (N=327)	163 (49.8)	12 (42.9)	0.48
Weight (kg), mean±SD	70.3 ± 13.4	67.0 ± 15.6	0.23
Height (cm), mean±SD	170.2 ± 9.3	168.6 ± 10.3	0.46
BMI (m/kg ²), mean±SD	24.1 ± 4.3	24.3 ± 3.4	0.41
Low back pain, n (%) (N=327)	289 (88.4)	26 (92.9)	0.47
Buttock pain, n (%) (N=327)	241 (73.7)	18 (62.3)	0.28
Morning stiffness (Berlin criteria), n (%) (N=327)	301 (92.0)	22 (78.6)	0.02
Nocturnal pain (Berlin criteria), n (%)	287 (87.8)	26 (92.9)	0.42
Modified Schober test (10+Xcm), mean±SD	3.7 ± 1.1	3.5 ± 1.0	0.18
Finger-floor distance (cm), mean±SD	12.9 ± 12.8	15.6 ± 14.2	0.23
HLA B27 positivity, n (%)	202 (61.8)	19 (67.8)	0.52
ASAS criteria met at baseline, n (%)	226/325 (69.5)	22 (78.6)	0.32
Confidence in a diagnosis of SpA at baseline, mean±SD ^a	7.3 ± 2.1	8.0 ± 2.1	0.06

4

5

6 ^ainclusion criterion

7 ^bassessed on a 1-10 scale by the investigator at each study center

8 BMI, body mass index; HLA, human leukocyte antigen; ASAS, Assessment of

9 SpondyloArthritis international Society; SpA, spondyloarthritis

10

1 **Table 3.** Associations of scoliosis with radiographic sagittal balance and MRI signs of
 2 degenerative disease at baseline

Characteristics at baseline	No scoliosis (n= 306)	Scoliosis (n= 27)	P value*
Pfirschmann L3-L4 ≥ 3 , n (%)	14 (4.6)	2 (7.4)	0.51
Pfirschmann L4-L5 ≥ 3 , n (%)	46 (15.0)	2 (7.4)	0.28
Pfirschmann L5-S1 ≥ 3 , n (%)	75 (24.5)	6 (22.2)	0.79
HIZ L3-L4, n (%)	5 (1.6)	0 (0.0)	0.5
HIZ L4-L5, n (%)	45 (12.5)	0 (0.0)	0.32
HIZ L5-S1, n (%)	62 (20.3)	3 (11.1)	0.25
Protrusion L3-L4, n/ (%)	6 (2.0)	0 (0.0)	1.00
Protrusion L4-L5, n (%)	21 (6.9)	0 (0.0)	0.39
Protrusion L5-S1, n (%)	39 (12.7)	1 (3.7)	0.22
Extrusion L3-L4, n (%)	2 (0.6)	0 (0.0)	1.00
Extrusion L4-L5, n (%)	18 (5.9)	2 (7.4)	0.67
Extrusion L5-S1, n (%)	26 (8.5)	3 (11.1)	0.72
Modic L3-L4, n (%)			0.09
- 1	2 (0.6)	0 (0.0)	
- 2	1 (0.3)	1 (3.7)	
- 3	0 (0.0)	0 (0.0)	
Modic L4-L5, n (%)			0.70
- 1	4 (1.3)	0 (0.0)	
- 2	4 (1.3)	0 (0.0)	
- 3	0 (0.0)	0 (0.0)	
Modic L5-S1, n (%)			0.41
- 1	7 (2.3)	1 (3.7)	
- 2	3 (1.0)	1 (3.7)	
- 3	0 (0.0)	0 (0.0)	
Sacral horizontal angle, °, mean \pm SD	39.0 \pm 9.2	42.2 \pm 8.9	0.09
Lumbosacral angle, °, mean \pm SD	14.6 \pm 4.6	14.0 \pm 4.6	0.45
Lumbar lordosis, °, mean \pm SD	52.4 \pm 13.2	58.9 \pm 11.4	0.009

3

4

5 HIZ, high-intensity zone; SD, standard deviation

6

1 **Table 4.** Associations of scoliosis and radiographic and/or MRI signs suggesting axSpAat
 2 baseline

	No scoliosis (n=362)	Scoliosis (n= 28)	<i>P</i> value
Sacroiliac joints			
New York criteria, radiographs	61/327 (18.6%)	8/28 (28.6%)	0.20
ASAS criteria, MRI, mean±SD	102/322 (31.7%)	12/28 (42.8%)	0.23
SPARCC score, MRI, mean±SD (n=640)	3.8±8.0	4.4±7.1	0.20
Spine			
mSASSS score, radiographs, mean±SD (n=640)	0.4±1.7	1.2±3.5	0.48
SPARCC score, MRI, mean±SD (n=651)	5.0±9.3	6.4±8.9	0.06
BASRI , radiographs mean±SD (n=651)	0.2±0.7	0.5±1.2	0.65

3
 4 SPARCC, SPondyloArthritis Research Consortium of Canada score; mSASSS, modified Stoke
 5 Ankylosing Spondylitis Spinal Score; BASRI, Bath Ankylosing Spondylitis Radiology Index

6

Supplementary table 1: Description of patients of this study and the whole DESIR cohort

Characteristics	Patients in our study (n=362)	Patients from the DESIR cohort (n=708)
Age (years), mean±SD	33.2 ± 8.4	33.8 ± 8.6
Males, n (%)	178 (49.2%)	327 (46.2%)
BMI (m/kg ²), mean±SD	24.1±4.3	24.0 ± 4.6
Low-back pain, ^a n (%)	321 (88.7%)	(67.1%)
Buttock pain, ^a n (%)	263 (72.7%)	(39.6%)
Morning stiffness (Berlin criteria), n/N (%)	329 (90.9%)	623 (88.0%)
Nocturnal pain (Berlin criteria), n/N (%)	319 (88.1%)	630 (89.0%)
Modified Schober test (10+Xcm), mean±SD	3.7 ± 1.1	3.7 ± 1.3
Finger-floor distance (cm), mean±SD	13.0 ± 12.9	13.2 ± 13.0
HLA B27 positivity, n (%) (n=674)	224 (61.9%)	(57.3%)
ASAS criteria, n (%) (n:669)	251 (69.3%)	447 (63.1%)
Confidence in a diagnosis of SpA at baseline, ^b mean±SD	7.4 ± 2.1	6.8 ± 2.6