



OPEN ACCESS

## EXTENDED REPORT

# Axial Disease in Psoriatic Arthritis study: defining the clinical and radiographic phenotype of psoriatic spondyloarthritis

Deepak R Jadon,<sup>1,2</sup> Raj Sengupta,<sup>1</sup> Alison Nightingale,<sup>3</sup> Mark Lindsay,<sup>3</sup> Eleanor Korendowych,<sup>1</sup> Graham Robinson,<sup>1</sup> Amelia Jobling,<sup>4</sup> Gavin Shaddick,<sup>4</sup> Jing Bi,<sup>5</sup> Robert Winchester,<sup>5</sup> Jon T Giles,<sup>5</sup> Neil J McHugh<sup>1,3</sup>

Handling editor Tore K Kvien

<sup>1</sup>Department of Rheumatology, Royal National Hospital for Rheumatic Diseases, Bath, UK

<sup>2</sup>Department of Rheumatology, Addenbrooke's Hospital, Cambridge, UK

<sup>3</sup>Department of Pharmacy & Pharmacology, University of Bath, Bath, UK

<sup>4</sup>Department of Mathematical Sciences, University of Bath, Bath, UK

<sup>5</sup>Columbia College of Physicians & Surgeons, New York, New York, USA

## Correspondence to

Dr Deepak Jadon, Rheumatology Department, Royal National Hospital for Rheumatic Disease, Upper Borough Walls, Bath BA1 1RL, UK; jadondr@yahoo.com

Received 6 May 2016

Revised 16 September 2016

Accepted 5 October 2016

Published Online First

2 December 2016

## ABSTRACT

**Objectives** To compare the prevalence, clinical and radiographic characteristics of psoriatic spondyloarthritis (PsSpA) in psoriatic arthritis (PsA), with ankylosing spondylitis (AS).

**Methods** A prospective single-centre cross-sectional observational study recruited consecutive PsA and AS cases. Participants completed outcome measures, and underwent clinical examination, axial radiographic scoring and *HLA*-sequencing. Multivariable analyses are presented.

**Results** The 402 enrolled cases (201 PsA, 201 AS; fulfilling classification criteria for respective conditions) were reclassified based upon radiographic axial disease and psoriasis, as: 118 PsSpA, 127 peripheral-only PsA (pPsA), and 157 AS without psoriasis (AS) cases. A significant proportion of patients with radiographic axial disease had PsSpA (118/275; 42.91%), and often had symptomatically silent axial disease (30/118; 25.42%). Modified New York criteria for AS were fulfilled by 48/201 (23.88%) PsA cases, and Classification of Psoriatic Arthritis criteria by 49/201 (24.38%) AS cases. pPsA compared with PsSpA cases had a lower frequency of *HLA-B\*27* (OR 0.12; 95% CI 0.05 to 0.25). Disease activity, metrology and disability were comparable in PsSpA and AS. A significant proportion of PsSpA cases had spondylitis without sacroiliitis (39/118; 33.05%); they less frequently carried *HLA-B\*27* (OR 0.11; 95% CI 0.04 to 0.33). Sacroiliac joint complete ankylosis (adjusted OR, OR<sub>adj</sub> 2.96; 95% CI 1.42 to 6.15) and bridging syndesmophytes (OR<sub>adj</sub> 2.78; 95% CI 1.49 to 5.18) were more likely in AS than PsSpA. Radiographic axial disease was more severe in AS than PsSpA (Psoriatic Arthritis Spondylitis Radiology Index Score: adjusted incidence risk ratio 1.13; 95% CI 1.09 to 1.19).

**Conclusions** In a combined cohort of patients with either PsA or AS from a single centre, 24% fulfilled classification criteria for both conditions. The pattern of axial disease was influenced significantly by the presence of skin psoriasis and *HLA-B\*27*.

## INTRODUCTION

Psoriatic spondyloarthritis (PsSpA) is a term that can be used for spondyloarthritis (SpA) accompanying psoriasis. PsSpA shares features of both psoriatic arthritis (PsA) and ankylosing spondylitis (AS),<sup>1–17</sup> including axial arthritis, peripheral

arthritis and enthesitis. Only four studies have compared the clinical characteristics of PsSpA and AS,<sup>7 9 11 14</sup> with the following reported to have worse scores in AS compared with PsSpA: metrology,<sup>11 14</sup> occiput to wall distance<sup>14</sup> and Schober's test of lumbar forward flexion.<sup>7 9 14</sup> Composite indices of disease activity (Bath AS Disease Activity Index; BASDAI),<sup>11</sup> function (Bath AS Functional Index; BASFI)<sup>11</sup> and quality of life<sup>11</sup> are reported to be no different in AS and PsSpA.

Only four studies have compared the axial radiographic characteristics of PsSpA and AS.<sup>2 7 9 11</sup> Sacroiliitis appears to be commonly bilateral in AS (even in early disease), but either unilateral or bilateral in PsSpA.<sup>2</sup> While Gladman *et al*<sup>7</sup> demonstrated a higher frequency of grade 4 sacroiliitis in AS compared with PsSpA, the findings were not corroborated in another study.<sup>9</sup> In AS, syndesmophytes have been shown to be symmetrically distributed,<sup>2 9</sup> progressing caudal to cranial, and with a primarily marginal rather than paramarginal shape.<sup>2</sup> In PsSpA, syndesmophytes appear to progress randomly along the spine,<sup>2 9</sup> with equal frequency of marginal and paramarginal syndesmophytes.<sup>2 9</sup> Radiographic severity appears to be worse in AS than in PsSpA, as measured by the Bath AS Radiology Index,<sup>9 11</sup> and number of syndesmophytes.<sup>7</sup>

Since the findings of these studies have not been entirely consistent, we sought to: (1) determine the prevalence of PsSpA in a spondyloarthritis (PsA and AS) cohort; (2) compare the clinical characteristics of PsSpA with both pPsA and AS; (3) compare the radiographic axial characteristics of PsSpA and AS.

## METHODS

A prospective single-centre cross-sectional observational study (Axial Disease in Psoriatic Arthritis study) was conducted (2012–2013) at a secondary care teaching hospital attended by 600 patients with PsA and 750 patients with AS for ongoing clinical care. Consecutive patients, aged  $\geq 18$  years, attending dedicated PsA and AS clinics were invited to participate, aiming to enrol 200 PsA and 200 AS cases. Study inclusion criteria included either: a diagnosis of PsA fulfilling the Classification of Psoriatic Arthritis (CASPAR) criteria<sup>18 19</sup> in those attending the PsA clinic; or a diagnosis of AS



CrossMark

**To cite:** Jadon DR, Sengupta R, Nightingale A, *et al.* *Ann Rheum Dis* 2017;**76**:701–707.

fulfilling the 1987 modified New York (mNY) diagnostic criteria for AS<sup>20</sup> in those attending the AS clinic.

### Clinical assessment

Participants completed patient reported outcome measures validated for use in PsSpA, including: BASDAI,<sup>21–23</sup> BASFI,<sup>14–24</sup> Health Assessment Questionnaire Disability Index (HAQ),<sup>25–26</sup> and Ankylosing Spondylitis Disease Activity Score (ASDAS).<sup>22–23–27</sup> Participants were questioned by a rheumatologist (DRJ) for a current or past history of: inflammatory axial symptoms (Assessment of Spondyloarthritis Society definition<sup>28</sup>); extra-articular manifestations including dactylitis, peripheral enthesitis, chest wall pain, uveitis and inflammatory bowel disease (IBD); family history in first-degree relatives of SpA, psoriasis, uveitis and IBD; tobacco smoking; synthetic disease modifying antirheumatic drug (sDMARD) use; biologic DMARD use; age at psoriasis symptom onset and diagnosis; and age at arthritis symptom onset and diagnosis. Data were verified using case notes.

All participants were examined by a rheumatologist (DRJ) using these clinical examination indices: Bath Ankylosing Spondylitis Metrology Index (BASMI),<sup>29</sup> chest expansion, Leeds Enthesitis Index (LEI),<sup>30</sup> 68 tender joint count,<sup>31</sup> 66 swollen joint count (SJC),<sup>31</sup> Psoriasis Area and Severity Index (PASI),<sup>32</sup> modified Nail Psoriasis Severity Index (mNAPSI),<sup>33</sup> and body mass index (BMI).

### Laboratory testing

Blood samples were taken for *HLA-B* typing and high-sensitivity C reactive protein testing. All subjects were typed for *HLA-B* alleles by a Sanger sequence-based method,<sup>34</sup> except that the PCR reactions were carried out using a nested two-stage method,<sup>35</sup> involving the heterozygous amplification of exon-2, intron-2 and exon-3 of *HLA-B* and *HLA-C*. Allele assignment was performed using SeqScape software (V.2.5; Applied Biosystems) and a library compiled from the current ImMunoGeneTics database.<sup>36</sup> Allele designations are those recommended by the WHO nomenclature committee, and which separates locus, allelic group and allelic type by an asterisk and colons.<sup>36</sup> Allele frequencies were directly enumerated.

### Axial radiographic scoring

In keeping with previous publications,<sup>37–38</sup> inflammatory radiographic axial disease (RAD) was defined in PsSpA cases as the presence of: New York criteria sacroiliitis (unilateral grade  $\geq 3$  or bilateral grade  $\geq 2$  sacroiliitis on pelvic radiograph) and/or  $\geq 1$  marginal/paramarginal syndesmophyte(s) of the cervical and/or lumbar spine.

The most recent axial radiographs of all participants were scored, blinded to clinical diagnosis, using two validated axial radiographic scoring tools for PsA; the Psoriatic Arthritis Spondylitis Radiology Index (PASRI)<sup>39</sup> and the modified Stoke Ankylosing Spondylitis Spinal Score (mSASSS).<sup>40</sup> The hospital's clinical protocol ensures that all PsA and AS cases have plain radiographs of their cervical spine (lateral in extension), lumbar spine (anteroposterior and lateral) and pelvis (anteroposterior) performed at least once during their care. Therefore radiographs were not at fixed time points relative to the research assessment. Studies in AS report a very slow rate of axial radiographic progression (mean 1.3 unit/year; SD 2.5).<sup>41</sup> As no data exist for PsSpA, a pilot study was undertaken to estimate this rate in PsSpA. Sequential axial radiographs were scored of 22 patients with PsSpA attending the hospital over a period spanning 2–31 years. mSASSS progression in PsSpA was only 0.6 units/year,

justifying the use of historic radiographs ( $\leq 10$  years old) with prospective clinical data in this study.

### Axial radiographic scoring reliability exercise and reading strategy

Two raters (DRJ and AN) underwent training in axial radiographic scoring by an experienced consultant musculoskeletal radiologist (GR). A broad-based horizontal morphology with adjacent degenerative features (intervertebral disc degeneration and/or end plate changes) were deemed to be a degenerative osteophyte. A thorn-like angulated morphology without adjacent degenerative features was deemed to be an inflammatory syndesmophyte. Ten random cases (five PsA, five AS) were selected from the cohort and scored independently by DRJ, AN and GR (the 'gold-standard' rater) using the PASRI and mSASSS, to assess inter-rater reliability. The same 10 cases were scored again a month later to assess intrarater reliability. Axial radiographs of the cohort were scored by two raters (DRJ and AN) using the PASRI and mSASSS. All equivocal cases were discussed with GR before final classification.

### Statistical analysis

Data were analysed using STATA V.12.1 (2011 Texas, USA). Inter-rater and intrarater reliability was tested using the intra-class correlation coefficient (ICC). Univariable and multivariable analyses were performed using the  $\chi^2$  test, independent Student's t-test, Mann-Whitney U test, logistic regression, linear regression, Poisson regression for non-normally distributed count data, and zero-inflated Poisson regression for non-normally distributed count data with an excess of zero values, as appropriate. Reverse stepwise regression was used to adjust for significant covariates, including: sex; age and disease duration at clinical assessment; age and disease duration at radiographic assessment; current or past history of sDMARD use, antitumour necrosis factor- $\alpha$  (anti-TNF) use and smoking; BMI and *HLA-B\*27* status. The  $\alpha$ -level for statistical significance was 0.05.

### Ethical considerations

The study was performed with ethical approval by Frenchay Regional Ethics Committee, written consent from participants, and in accordance with the Declaration of Helsinki.

### RESULTS

The study enrolled 402 participants (201 PsA, 201 AS) and there were no missing clinical data. Complete axial radiographs were available for 392/402 (97.5%) participants; 10 PsA cases with incomplete radiographs to determine RAD, were assumed to have peripheral-only PsA (pPsA). The participants were reclassified as: PsSpA (n=118; 29.35%) based upon psoriasis (past/present) and RAD; pPsA (n=127; 31.60%) based upon psoriasis (past/present), peripheral arthritis and no RAD; and AS (n=157; 39.05%) based upon mNY criteria for AS<sup>20</sup> and no psoriasis (past/present). A substantial proportion of patients with RAD had PsSpA (118/275; 42.91%).

### Fulfilment of CASPAR, mNY and ASAS criteria

Forty-eight of 201 (23.88%) participants with PsA attending the PsA clinic (all fulfilling CASPAR) also fulfilled mNY criteria for AS. Forty-nine of 201 (24.38%) participants with AS attending the AS clinic (all fulfilling mNY criteria) also fulfilled CASPAR criteria for PsA. Although a lack of MRI data prevented us from fully applying the ASAS classification for axial SpA across our cohort, we did find that 157/157 (100%) of AS cases, 85/118

(72%) of PsSpA cases and 9/127 (7%) of pPsA cases fulfilled ASAS criteria for axial SpA by either or both clinical-only or radiographic imaging streams.

### Sociodemographic, treatment, laboratory and genetic characteristics

PsSpA, pPsA and AS cases were broadly similar in terms of age, disease duration, treatment and other sociodemographic characteristics (tables 1 and 2). Any differences were adjusted for in the multivariable models. *HLA-B\*27* alleles (mainly *HLA-B\*27:05:02*) were present in 9/127 (7.09%) pPsA, 47/118 (39.83%) PsSpA and 140/157 (89.17%) AS cases (table 1). Compared with PsSpA cases, the presence of *HLA-B\*27* was significantly more likely in AS (OR 12.44; 95% CI 6.67 to 23.22,  $p<0.001$ ) and significantly less likely in pPsA (OR 0.12; 95% CI 0.05 to 0.25,  $p<0.001$ ).

### Clinical predictors of PsSpA occurrence in PsA cases

Compared with pPsA cases, PsSpA cases had significantly younger age at arthritis symptom onset (median 37.98 years vs 31.27 years,  $p=0.01$ ) (table 2). Male PsA cases were no more likely than female cases to have PsSpA (adjusted OR, OR<sub>adj</sub> 1.48; 95% CI 0.87 to 2.52,  $p=0.18$ ).

### Patient-reported outcome measures

#### Inflammatory axial symptoms

A history (past/present) of inflammatory axial symptoms was present in 77/127 (60.63%) pPsA, 88/118 (74.58%) PsSpA and 156/157 (99.36%) AS cases (table 3). Of note, 30/118 (25.42%) PsSpA cases (with RAD by classification) denied a history of inflammatory axial symptoms. AS cases were significantly more likely to report inflammatory axial symptoms (history/current) than PsSpA cases (OR<sub>adj</sub> 2.76; 95% CI 1.62 to 4.71,  $p<0.001$  and OR<sub>adj</sub> 28.45; 95% CI 3.65 to 221.74,  $p=0.001$ , respectively) (table 3). pPsA cases were significantly less likely to have current inflammatory axial symptoms (OR<sub>adj</sub> 0.57; 95% CI 0.34 to 0.96,  $p=0.03$ ) than PsSpA cases, especially of the thoracic spine (OR<sub>adj</sub> 0.48; 95% CI 0.26 to 0.88,  $p=0.02$ ) and buttocks (OR<sub>adj</sub> 0.38; 95% CI 0.20 to 0.71,  $p=0.003$ ).

#### Personal history of extra-articular manifestations and family history

pPsA cases were significantly less likely to have a history of IBD than PsSpA cases (OR<sub>adj</sub> 0.12; 95% CI 0.03 to 0.55,  $p=0.01$ ) (table 3). AS cases were significantly less likely to have a history of dactylitis than PsSpA cases (OR<sub>adj</sub> 0.18; 95% CI 0.07 to

0.42,  $p<0.001$ ). Family history of SpA, psoriasis, uveitis and IBD were no different between groups.

### Composite clinical indices

Disease activity, as measured by ASDAS, was frequently high (2.1–3.4) or very high ( $\geq 3.5$ ) in both PsSpA (64/118; 54.24%) and AS (80/157; 50.96%), with no statistically significant difference between diseases. Similarly, in both PsSpA and AS cases, BASDAI indicated active ( $\geq 3.5$  units<sup>42</sup>) disease (median 3.60 vs 3.20), with no significant statistical (adjusted incidence risk ratio, IRR<sub>adj</sub> 1.03; 95% CI 0.92 to 1.17) or clinical (minimum clinically important difference, MCID of 1 unit in AS<sup>43</sup>) difference between diseases. Patient global assessment of axial disease activity (PaGA) in both PsSpA and AS indicated active ( $\geq 4$  cm) disease, with no statistically significant differences between diseases (median 3 cm vs 3 cm).

Function, as measured by the BASFI, was poorer in AS compared with PsSpA (median 3.90 vs 3.10), with a clinically (MCID 0.7 units in AS<sup>43</sup>) and a statistically significant difference between diseases (IRR<sub>adj</sub> 1.17 per 0.7 unit increase; 95% CI 1.06 to 1.26,  $p=0.002$ ). No statistically significant differences in disability, as measured by the HAQ (MCID 0.35 units in PsA<sup>44</sup>), was demonstrated between PsSpA and AS (IRR<sub>adj</sub> 1.04 per 0.35 unit increase; 95% CI 0.90 to 1.19), or PsSpA and pPsA (IRR<sub>adj</sub> 1.09 per 0.35 unit increase; 95% CI 0.95 to 1.26).

### Clinical examination indices

#### Peripheral examination indices

Nail disease severity, measured using the mNAPSI, was significantly lower in pPsA than PsSpA (IRR<sub>adj</sub> 0.90 per unit increase; 95% CI 0.83 to 0.97,  $p=0.01$ ). More specifically, nail onycholysis severity was significantly lower in pPsA than PsSpA (IRR<sub>adj</sub> 0.84 per unit increase; 95% CI 0.74 to 0.95,  $p=0.01$ ). pPsA and PsSpA were no different in terms of SJC, enthesitis severity (LEI) or psoriasis severity (PASI). Enthesitis severity (LEI) was higher in AS than PsSpA (IRR<sub>adj</sub> 1.33; 95% CI 1.02 to 1.74,  $p=0.04$ ).

#### Axial metrology

Axial metrology measured using the BASMI was no different in AS and PsSpA (IRR<sub>adj</sub> 1.07 per unit increase; 95% CI 0.95 to 1.21). However, tragus to wall distance (adjusted mean difference 2.00 cm; 95% CI 0.58 to 3.42,  $p=0.006$ ) and modified Schober's test (adjusted mean difference  $-0.65$  cm; 95% CI  $-1.14$  to  $-0.15$ ,  $p=0.01$ ) were poorer in AS than in PsSpA cases. Other BASMI subdomains and chest expansion were no different in PsSpA and AS. Surprisingly, BASMI and its subdomains were no different in PsSpA and pPsA cases.

**Table 1** Sociodemographic, genetic and treatment characteristics of the PsSpA (n=127), AS (n=157) and pPsA (n=118) cases (categorical variables)

	PsSpA n (%)	AS n (%)	pPsA n (%)	AS versus PsSpA			pPsA versus PsSpA		
				OR	95% CI	p Value	OR	95% CI	p Value
Men	74 (63)	118 (75)	66 (52)	1.80	1.07 to 3.03	0.03*	0.65	0.39 to 1.08	0.09*
Caucasian ancestry (patient-reported)	117 (99)	156 (99)	127 (100)	–	–	–	–	–	–
<i>HLA-B*27</i> presence	47 (40)	140 (89)	9 (7)	12.44	6.67 to 23.22	<0.001*	0.12	0.05 to 0.25	<0.001*
Smoking ever	57/110 (52)	72/157 (46)	67/109 (61)	0.79	0.48 to 1.28	0.34*	1.49	0.87 to 2.56	0.15*
Synthetic DMARD use ever	53 (45)	26 (17)	83 (65)	0.24	0.14 to 0.42	<0.001*	2.33	1.39 to 3.85	0.001*
Anti-TNF use ever	53 (45)	59 (38)	47 (37)	0.74	0.45 to 1.20	0.22*	0.72	0.43 to 1.22	0.21*

\*Continuity adjusted  $\chi^2$  test.

Anti-TNF, antitumour necrosis factor; AS, ankylosing spondylitis.

DMARD, disease modifying antirheumatic drug; *HLA*, human leucocyte antigen; n, number/proportion; pPsA, peripheral psoriatic arthritis; PsSpA, psoriatic spondyloarthritis.

**Table 2** Sociodemographic and laboratory characteristics of the PsSpA (n=118), AS (n=157) and pPsA (n=127) cases (numerical variables)

	PsSpA Median (IQR) Mean (SD)	AS Median (IQR) Mean (SD)	pPsA Median (IQR) Mean (SD)	AS versus PsSpA		pPsA versus PsSpA		
				Mean diff (95% CI)	p Value	Mean diff (95% CI)	p Value	
<b>Age at (years)</b>								
Clinical assessment	58.09 (11.42)	53.44 (13.61)	58.13 (11.71)	-4.63 (-7.68 to -1.58)	0.003*	-0.03 (-2.95 to 2.88)	0.98*	
Arthritis onset	31.27 (21.06, 46.24)	20.00 (16.00, 26.00)	37.98 (28.37, 46.32)	-	-	-	0.01†	
Arthritis diagnosis	35.99 (27.27, 52.00)	29.00 (23.00, 38.00)	39.99 (29.70, 48.73)	-	-	-	0.33†	
Psoriasis onset	31.50 (17.50, 41.50)	-	27.00 (16.00, 14.00)	-	-	-	0.68†	
Psoriasis diagnosis	33.00 (19.00, 43.00)	-	30.00 (19.00, 46.00)	-	-	-	0.20†	
<b>Disease duration at (years)</b>								
Recent axial radiograph	15.50 (7.00, 26.00)	19.00 (10.00, 29.00)	13.00 (6.00, 23.00)	-	0.13†	-	0.41†	
Clinical assessment	18.00 (9.00, 27.00)	22.00 (10.00, 31.00)	15.00 (7.00, 26.00)	-	0.13†	-	0.34†	
C reactive protein	3 (2, 7)	4 (1, 10)	2 (0, 5)	1.06 (0.99 to 1.12)	0.07‡	0.79 (0.74 to 0.84)	<0.0001‡	
Body mass index (BMI)	29.52 (5.16)	29.92 (4.96)	29.69 (5.36)	-1.60 (-2.21 to -0.84)	0.01*	-0.18 (-0.62 to 0.51)	0.81*	

\*Two-tailed Student's t-test.

†Mann-Whitney U test.

‡Poisson regression (adjusted for: sex, age, disease duration, anti-TNF use ever, synthetic DMARD use ever, and BMI).

Anti-TNF, antitumour necrosis factor; AS, ankylosing spondylitis; DMARD, disease modifying antirheumatic drug; Mean diff, mean difference; pPsA, peripheral psoriatic arthritis; PsSpA, psoriatic spondyloarthritis.

**Table 3** Axial inflammatory symptoms, extra-articular manifestations and family history in PsSpA (n=127), AS (n=157) and pPsA (n=118) cases

	PsSpA n (%)	AS n (%)	pPsA n (%)	AS versus PsSpA			pPsA versus PsSpA		
				OR <sub>adj</sub>	95% CI	p Value	OR <sub>adj</sub>	95% CI	p Value
<b>Inflammatory axial symptoms</b>									
<b>Current</b>									
Spine or buttocks	65 (55)	133 (85)	54 (43)	2.76	1.62 to 4.71	<0.001*	0.57	0.34 to 0.96	0.03*
<b>Ever (past/current)</b>									
Spine or buttocks	88 (75)	156 (99)	77 (61)	28.45	3.65 to 221.74	0.001*	0.69	0.38 to 1.25	0.22*
Cervical	71 (60)	132 (84)	54 (43)	1.82	0.94 to 3.55	0.08*	0.73	0.42 to 1.27	0.26*
Thoracic	50 (42)	114 (73)	27 (21)	2.20	1.23 to 3.92	0.01*	0.48	0.26 to 0.88	0.02*
Lumbar	70 (59)	149 (95)	58 (46)	6.75	2.82 to 16.16	<0.001*	0.82	0.47 to 1.43	0.48*
Buttocks	55 (47)	132 (84)	24 (19)	3.19	1.67 to 6.07	<0.001*	0.38	0.20 to 0.71	0.003*
<b>Extra-articular manifestations (ever)</b>									
Dactylitis	37 (31)	8 (5)	50 (39)	0.18	0.07 to 0.42	<0.001*	1.09	0.62 to 1.93	0.76*
Enthesitis	56 (47)	58 (37)	59 (46)	0.70	0.43 to 1.14	0.15*	0.93	0.56 to 1.55	0.79*
Chest wall pain	52 (44)	102 (65)	34 (27)	1.21	0.70 to 2.19	0.52*	0.63	0.35 to 1.15	0.13*
Uveitis	31 (26)	84 (54)	11 (9)	1.44	0.79 to 2.62	0.24*	0.52	0.22 to 1.22	0.13*
Inflammatory bowel disease	13 (11)	15 (10)	2 (2)	0.85	0.36 to 1.98	0.70*	0.12	0.03 to 0.55	0.01*
<b>Family history</b>									
Spondyloarthritis	25 (21)	52 (33)	16 (13)	1.26	0.67 to 2.34	0.47†	0.73	0.34 to 1.53	0.40†
Psoriasis	58 (49)	20 (13)	56 (44)	0.16	0.08 to 0.30	<0.001	0.79	0.46 to 1.36	0.40
Uveitis	7 (6)	37 (24)	4 (3)	2.27	0.94 to 5.51	0.07†	1.84	0.42 to 7.99	0.42†
Inflammatory bowel disease	9 (8)	17 (11)	11 (9)	1.57	0.59 to 4.17	0.37	1.10	0.42 to 2.90	0.84

\*Multivariable reverse-stepwise logistic regression model (adjusted for potential covariates, including: sex, age at assessment, disease duration at assessment, HLA-B\*27 status, synthetic DMARD use ever, anti-TNF use ever, smoking ever and body mass index).

†Reverse-stepwise logistic regression model adjusted for HLA-B\*27 status.

Anti-TNF, antitumour necrosis factor; AS, ankylosing spondylitis; DMARD, disease modifying antirheumatic drug; n, proportion; OR<sub>adj</sub>, adjusted OR; pPsA, peripheral psoriatic arthritis; PsSpA, psoriatic spondyloarthritis.

**Axial radiographic comparison of PsSpA and AS cases**

Excellent<sup>34</sup> inter-rater (ICC ≥0.85) and intrarater (ICC ≥0.88) reliability was achieved by raters for the PASRI, mSASSS and regional subdomains.

**Axial radiographic pattern**

The predominant pattern of sacroiliitis in both AS (142/147; 96.60%) and PsSpA (65/79; 82.28%) cases was bilateral (table 4), albeit statistically different (p=0.001) (table 4). Symmetrical grade

sacroiliitis was the predominant pattern in both PsSpA (60/79; 75.95%) and AS (119/147; 80.95%), with no difference between diseases (p=0.65). There was no significant difference between AS and PsSpA in terms of the occurrence of spondylitis (cervical and/or lumbar), cervical vertebrae spondylitis, cervical facet joint fusion or lumbar vertebrae spondylitis.

Of 118 cases classified as PsSpA: 45/118 (38.14%) had sacroiliitis with spondylitis, 39/118 (33.05%) had spondylitis alone and 34/118 (28.81%) had sacroiliitis alone. The majority of



**Table 4** Axial radiographic pattern and morphology in PsSpA (n=118) and AS (n=157) cases

	PsSpA n (%)	AS n (%)	AS versus PsSpA		
			OR	95% CI	p Value
<i>Pattern</i>					
Radiographic					
Sacroiliitis	79 (67)	157 (100)	–	–	–
Spondylitis (cervical and/or lumbar)	84 (71)	109 (69)	0.94	0.52 to 1.69	0.83
Sacroiliitis pattern					
Bilateral	65/79 (82)	142/147 (97)	6.14	2.08 to 18.15	0.001
Symmetrical grade	60/79 (76)	119/147 (81)	1.17	0.59 to 2.32	0.65
Spondylitis pattern					
Cervical vertebrae	52/116 (45)	85 (54)	1.20	0.65 to 2.25	0.56
Cervical facet joint	29 (25)	60 (38)	1.48	0.81 to 2.72	0.20
Lumbar vertebrae	50/117 (43)	85 (54)	1.37	0.75 to 2.50	0.30
<i>Morphology</i>					
Sacral joint					
Sclerosis bilaterally (grade 2)	6 (5)	9 (6)	1.75	0.56 to 5.48	0.34
Erosion (grade 3)	42 (36)	53 (34)	1.07	0.63 to 1.81	0.80
Partial ankylosis (grade 3)	25 (21)	46 (29)	1.08	0.56 to 2.10	0.81
Complete ankylosis (grade 4)	18 (15)	68 (43)	2.96	1.42 to 6.15	0.004
Vertebral					
Erosion, n (%)	3 (3)	6 (4)	1.58	0.38 to 6.57	0.53
Non-bridging syndesmophyte	47 (40)	58 (37)	0.93	0.57 to 1.56	0.79
Bridging syndesmophyte	12 (10)	36 (23)	2.78	1.49 to 5.18	0.001

\*Multivariate reverse-stepwise logistic regression model (adjusted as required for the following potential covariates: sex, age at radiographic assessment, disease duration at radiographic assessment, *HLA-B\*27* status, anti-TNF use ever, synthetic DMARD use ever, smoking and BMI).

Anti-TNF, antitumour necrosis factor; AS, ankylosing spondylitis; BMI, body mass index; DMARD, disease modifying antirheumatic drug; PsSpA, psoriatic spondyloarthritis.

PsSpA cases with spondylitis alone were symptomatic (22/39; 56.41%); although were less likely to be symptomatic than PsSpA cases with sacroiliitis with or without spondylitis (66/79; 83.54%) (OR 0.26; 95% CI 0.11 to 0.61,  $p=0.002$ ). Thoracic spine radiographs, MRI and CT scans were available on 32/39 PsSpA cases with spondylitis alone, and none demonstrated diffuse idiopathic hyperostosis (DISH), defined as per the criteria of Resnick.<sup>45</sup>

#### Correlation of radiographic pattern with *HLA-B\*27* status in PsSpA cases

*HLA-B\*27* was present in 6/39 (15.38%) of PsSpA cases with spondylitis alone, 11/34 (32.35%) of cases with sacroiliitis alone and 30/45 (66.67%) of cases with both sacroiliitis and spondylitis. Logistic regression (adjusted for sex, age and disease duration) demonstrated a significantly increased probability for the presence of *HLA-B\*27* in PsSpA cases with both sacroiliitis and spondylitis, compared with spondylitis alone (OR<sub>adj</sub> 9.10; 95% CI 3.01 to 27.47,  $p<0.001$ ).

#### Axial radiographic morphology

AS cases were more likely than PsSpA cases to have complete SIJ ankylosis (OR<sub>adj</sub> 2.96; 95% CI 1.42 to 6.15,  $p=0.004$ ), vertebral bridging syndesmophytes (OR<sub>adj</sub> 2.78; 95% CI 1.49 to 5.18,  $p=0.001$ ), but not partial SIJ ankylosis, SIJ erosion, SIJ sclerosis, vertebral non-bridging syndesmophytes or vertebral erosions (table 4).

#### Axial radiographic severity

Axial radiographic severity measured using the PASRI (and mSASSS) was lower in women compared with men in both PsSpA (median 5.5 vs 7.0; IRR<sub>adj</sub> 0.62 per unit increase; 95%

CI 0.57 to 0.67,  $p<0.001$ ) and AS cases (median 8 vs 18; IRR<sub>adj</sub> 0.67 per unit increase; 95% CI 0.61 to 0.73,  $p<0.001$ ).

Axial radiographic severity was higher in AS than PsSpA, as measured by the PASRI (median 15 vs 6; IRR<sub>adj</sub> 1.13 per unit increase; 95% CI 1.09 to 1.19,  $p<0.001$ ) and the mSASSS (median 10 vs 3; IRR<sub>adj</sub> 1.09 per unit increase; 95% CI 1.04 to 1.14,  $p<0.001$ ). Severity in AS was also greater than PsSpA when analysed by axial region: cervical vertebral PASRI (IRR<sub>adj</sub> 1.57 per unit increase; 95% CI 1.35 to 1.83,  $p<0.001$ ), cervical facet joint PASRI (IRR<sub>adj</sub> 1.47 per unit increase; 95% CI 1.08 to 1.99,  $p=0.01$ ) and lumbar vertebral PASRI (IRR<sub>adj</sub> 1.42 per unit increase; 95% CI 1.29 to 1.58,  $p<0.001$ ).

Using the mSASSS in PsSpA, the cervical region was more severely affected than the lumbar spine (IRR<sub>adj</sub> 1.54 per unit increase; 95% CI 1.20 to 1.74,  $p<0.001$ ), but similar in AS. Vertebral osteoproliferative severity, as measured by the PASRI, (bridging and/or non-bridging syndesmophytes) was higher in AS than PsSpA (median 6 vs 2; IRR<sub>adj</sub> 1.31 per unit increase; 95% CI 1.09 to 1.57,  $p=0.004$ ). Vertebral erosion severity was no different in the two diseases.

## DISCUSSION

Studies suggest a high degree of overlap between pPsA, PsSpA and AS; but are few in number and frequently of small sample size. We therefore sought to further define the similarities and differences between these conditions, and whether these could be explained by clinical and genetic parameters. Axial disease was defined radiographically, due to the robustness and reproducibility of doing so. Accordingly, a significant proportion of PsA cases were reclassified to the PsSpA phenotype, and found to often be asymptomatic. Importantly, a quarter of PsA and AS

cases were classifiable as the other disease using the currently available classification systems.

In PsSpA cases, spondylitis without sacroiliitis was common and usually symptomatic. Our methods ensured we were not scoring degenerative lesions as being inflammatory, and the thoracic imaging of these cases confirmed that they did not simply have DISH. Previous studies have shown similarly high prevalence of spondylitis without sacroiliitis,<sup>3–4</sup> and proposed it as a feature distinguishing PsSpA from AS.<sup>46</sup> The differing prevalence of *HLA-B\*27* alleles in our radiographic subphenotypes of PsSpA offers a unique insight, and implies aetiopathogenic differences between sacroiliitis and spondylitis in PsSpA.

AS cases were more likely than PsSpA cases to have complete SIJ ankylosis and bridging syndesmophytes. These features may prove more useful than syndesmophyte shape<sup>47</sup> to distinguish PsSpA from AS. Unilateral or asymmetrical grade sacroiliitis, reported to be characteristic of PsSpA,<sup>9</sup> were not found in the current study, possibly as we have a more established disease cohort at a later stage of radiographic disease. We do plan to explore the association between certain *HLA-B* alleles and their haplotypes, with symmetry of sacroiliitis, as has recently been described by Haroon *et al.*<sup>48</sup>

Previous studies have found clinical predictors for PsSpA occurrence in PsA include: male sex,<sup>3–4–9</sup> the presence of *HLA-B\*27*,<sup>15</sup> nail dystrophy,<sup>15</sup> higher number of radiographically damaged joints,<sup>15</sup> high erythrocyte sedimentation rate,<sup>15</sup> and longer disease duration, with axial disease being a late-onset feature.<sup>8–12</sup> The latter clinical predictor may explain much of the variation in estimated prevalence of PsSpA in PsA cohorts, as many studies have investigated PsA cases with relatively recent onset disease, allowing insufficient time for the PsSpA phenotype to have fully expressed. We acknowledge that to truly understand the natural history of axial disease in PsA, a longitudinal inception cohort study is required. Predictors of PsSpA occurrence in our PsA cohort included: the presence of *HLA-B\*27*, younger age at arthritis onset, higher nail onycholysis severity, axial inflammatory symptoms and IBD. Onycholysis may be a more specific marker of synovial-enthesal complex inflammation, a process considered important in SpA pathogenesis,<sup>49</sup> and giving further biological credence to our finding. The presence of psoriatic nail disease has been shown in another study to be a biomarker of higher systemic enthesopathy burden and higher inflammation scores, measured using ultrasound.<sup>50</sup>

PsSpA is not a clinically less impactful form of AS; measures of disease activity (ASDAS, BASDAI and PaGA), disability (HAQ) and metrology (BASMI) were high in both PsSpA and AS cases, with no statistically significant difference between groups. Of note, 74% of PsSpA cases had peripheral arthritis, and erosions were observed in 64% (48/75) of those with available radiographs, hence the additional burden of peripheral joint disease may have influenced at least some of these measures.

The reliability of our results is improved by a large sample size, single-centre follow-up, excellent inter-rater reliability for radiographic scoring, no missing clinical data, limited (<3%) missing radiographic data and a single rheumatologist performing clinical assessments; the inter-rater reliability of clinical assessments in PsA is known to be poor.<sup>51</sup> A limitation of our study was the lack of MRI, inclusion of which on all patients would have made the study unfeasible, and introduced selection bias if only analysed for some of the cohort. Quantitative radiographic scoring with embedded morphological data improved the study's power to detect differences between groups. Inclusion of comprehensive covariate data in multivariable

models allowed adjustment for potential confounders, in particular disease duration. Our findings are generalisable because the study was conducted in a secondary care hospital taking unselected PsA and AS referrals.

The impact of recall bias is likely curtailed by a similar magnitude and direction of effect in each SpA group. Unfortunately the cross-sectional study design reduced the ability to entirely adjust for: time-varying variables such as smoking, BMI and medication use; and unmeasured confounders such as NSAID<sup>52</sup> use, delayed diagnosis and physiotherapy. While anti-TNF therapy may inhibit<sup>53–54</sup> or have no effect<sup>55–56</sup> on syndesmophyte formation in AS, no data exist in PsSpA.

To conclude, this study indicates that PsSpA forms part of the SpA spectrum, flanked by pPsA and AS. In terms of most clinical indices of disease activity, PsSpA has a similar disease burden as AS, despite being less severe radiographically. This may be of relevance in the development of future treatment guidelines. Furthermore, PsSpA may represent a distinct endophenotype influenced by factors related to the presence of psoriasis, psoriatic nail disease and *HLA-B\*27* variants. In future work we plan to use our data set to further explore whether genetic variants are closely linked with more homogeneously defined patterns of disease.

**Acknowledgements** The authors thank Dr William Tillett (Consultant Rheumatologist), Nicola Waldron (Rheumatology Specialist Nurse), Charlotte Cavill (database manager) and Mandy Knight (database administrator) for their contribution to this study.

**Contributors** All contributors to this manuscript and study have been acknowledged as coauthors or in the 'acknowledgement' section of the manuscript.

**Funding** This study was funded through an unrestricted Investigator-Initiated Research grant by Pfizer Limited.

**Competing interests** None declared.

**Patient consent** Obtained.

**Ethics approval** Frenchay Regional Ethics Committee, Bristol, UK.

**Provenance and peer review** Not commissioned; externally peer reviewed.

**Open Access** This is an Open Access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

## REFERENCES

- 1 Bywaters EG, Dixon AS. Paravertebral ossification in psoriatic arthritis. *Ann Rheum Dis* 1965;24:313–31.
- 2 McEwen C, DiTata D, Lingg C, *et al.* Ankylosing spondylitis and spondylitis accompanying ulcerative colitis, regional enteritis, psoriasis and Reiter's disease. A comparative study. *Arthritis Rheum* 1971;14:291–318.
- 3 Lambert JR, Wright V. Psoriatic spondylitis: a clinical and radiological description of the spine in psoriatic arthritis. *Q J Med* 1977;46:411–25.
- 4 Hanly JG, Russell ML, Gladman DD. Psoriatic spondyloarthropathy: a long term prospective study. *Ann Rheum Dis* 1988;47:386–93.
- 5 Scarpa R, Oriente P, Pucino A, *et al.* The clinical spectrum of psoriatic spondylitis. *Br J Rheumatol* 1988;27:133–7.
- 6 Salvarani C, Macchioni P, Cremonesi T, *et al.* The cervical spine in patients with psoriatic arthritis: a clinical, radiological and immunogenetic study. *Ann Rheum Dis* 1992;51:73–7.
- 7 Gladman DD, Brubacher B, Buskila D, *et al.* Differences in the expression of spondyloarthropathy: a comparison between ankylosing spondylitis and psoriatic arthritis. *Clin Invest Med* 1993;16:1–7.
- 8 Jenkinson T, Armas J, Evison G, *et al.* The cervical spine in psoriatic arthritis: a clinical and radiological study. *Rheumatology (Oxford)* 1994;33:255–9.
- 9 Helliwell PS, Hickling P, Wright V. Do the radiological changes of classic ankylosing spondylitis differ from the changes found in the spondylitis associated with inflammatory bowel disease, psoriasis, and reactive arthritis? *Ann Rheum Dis* 1998;57:135–40.
- 10 Laiho K, Kauppi M. The cervical spine in patients with psoriatic arthritis. *Ann Rheum Dis* 2002;61:650–2.

- 11 Pérez-Alamino R, Maldonado-Cocco JA, Citera G, *et al.* Differential features between primary ankylosing spondylitis and spondylitis associated with psoriasis and inflammatory bowel disease. *J Rheumatol* 2011;38:1656–60.
- 12 Gladman DD, Brubacher B, Buskila D, *et al.* Psoriatic spondyloarthropathy in men and women: a clinical, radiographic, and HLA study. *Clin Invest Med* 1992;15:371–5.
- 13 Baek HJ, Yoo CD, Shin KC, *et al.* Spondylitis is the most common pattern of psoriatic arthritis in Korea. *Rheumatol Int* 2000;19:89–94.
- 14 Fernández-Sueiro JL, Willis A, Pértiga-Díaz S, *et al.* Evaluation of ankylosing spondylitis spinal mobility measurements in the assessment of spinal involvement in psoriatic arthritis. *Arthritis Rheum* 2009;61:386–92.
- 15 Chandran V, Toluoso DC, Cook RJ, *et al.* Risk factors for axial inflammatory arthritis in patients with psoriatic arthritis. *J Rheumatol* 2010;37:809–15.
- 16 Leung Y-y, Ho KW, Tam LS, *et al.* Evaluation of spinal mobility measurements in predicting axial psoriatic arthritis. *Clin Rheumatol* 2011; 30:1157–62.
- 17 Queiro R, Belzunegui J, Gonzalez C, *et al.* Clinically asymptomatic axial disease in psoriatic spondyloarthropathy. A retrospective study. *Clin Rheumatol* 2002;21:10–13.
- 18 Taylor W, Gladman D, Helliwell P, *et al.* Classification criteria for psoriatic arthritis: development of new criteria from a large international study. *Arthritis Rheum* 2006;54:2665–73.
- 19 Tillett W, Jadon D, Costa L, *et al.* The Classification for Psoriatic Arthritis (CASPAR) criteria—a retrospective feasibility, sensitivity, and specificity study. *J Rheumatol* 2012;39:154–6.
- 20 van der Linden S, Valkenburg HA, Cats A. Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. *Arthritis Rheum* 1984;27:361–8.
- 21 Garrett S, Jenkinson T, Kennedy LG, *et al.* A new approach to defining disease status in ankylosing spondylitis: the Bath Ankylosing Spondylitis Disease Activity Index. *J Rheumatol* 1994;21:2286–91.
- 22 Eder L, Chandran V, Shen H, *et al.* Is ASDAS better than BASDAI as a measure of disease activity in axial psoriatic arthritis? *Ann Rheum Dis* 2010;69:2160–4.
- 23 Kılıç G, Kılıç E, Nas K, *et al.* Comparison of ASDAS and BASDAI as a measure of disease activity in axial psoriatic arthritis. *Clin Rheumatol* 2015;34:515–21.
- 24 Calin A, Garrett S, Whitelock H, *et al.* A new approach to defining functional ability in ankylosing spondylitis: the development of the Bath Ankylosing Spondylitis Functional Index. *J Rheumatol* 1994;21:2281–5.
- 25 Fries JF, Spitz PW, Young DY. The dimensions of health outcomes: the health assessment questionnaire, disability and pain scales. *J Rheumatol* 1982;9:789–93.
- 26 Mease PJ, Antoni CE, Gladman DD, *et al.* Psoriatic arthritis assessment tools in clinical trials. *Ann Rheum Dis* 2005;64(Suppl 2):ii49–54.
- 27 Lukas C, Landewé R, Sieper J, *et al.* Development of an ASAS-endorsed disease activity score (ASDAS) in patients with ankylosing spondylitis. *Ann Rheum Dis* 2009;68:18–24.
- 28 Sieper J, Rudwaleit M, Baraliakos X, *et al.* The Assessment of SpondyloArthritis international Society (ASAS) handbook: a guide to assess spondyloarthritis. *Ann Rheum Dis* 2009;68(Suppl 2):ii1–44.
- 29 Jenkinson TR, Mallorie PA, Whitelock HC, *et al.* Defining spinal mobility in ankylosing spondylitis (AS). The Bath AS Metrology Index. *J Rheumatol* 1994;21:1694.
- 30 Healy PJ, Helliwell PS. Measuring clinical enthesitis in psoriatic arthritis: assessment of existing measures and development of an instrument specific to psoriatic arthritis. *Arthritis Rheum* 2008;59:686–91.
- 31 Franssen J, Antoni C, Mease PJ, *et al.* Performance of response criteria for assessing peripheral arthritis in patients with psoriatic arthritis: analysis of data from randomised controlled trials of two tumour necrosis factor inhibitors. *Ann Rheum Dis* 2006;65:1373–8.
- 32 Fredriksson T, Pettersson U. Severe psoriasis—oral therapy with a new retinoid. *Dermatologica* 1978;157:238–44.
- 33 Cassell SE, Bieber JD, Rich P, *et al.* The modified Nail Psoriasis Severity Index: validation of an instrument to assess psoriatic nail involvement in patients with psoriatic arthritis. *J Rheumatol* 2007;34:123–9.
- 34 Winchester R, Minevich G, Steshenko V, *et al.* HLA associations reveal genetic heterogeneity in psoriatic arthritis and in the psoriasis phenotype. *Arthritis Rheum* 2012;64:1134–44.
- 35 Cotton LA, Abdur Rahman M, Ng C, *et al.* HLA class I sequence-based typing using DNA recovered from frozen plasma. *J Immunol Methods* 2012;382:40–7.
- 36 Robinson J, Mistry K, McWilliam H, *et al.* The IMGT/HLA database. *Nucleic Acids Res* 2011;39(Database issue):D1171–6.
- 37 Jadon D, Tillett W, Wallis D, *et al.* Exploring ankylosing spondylitis-associated ERAP1, IL23R and IL12B gene polymorphisms in subphenotypes of psoriatic arthritis. *Rheumatology (Oxford)* 2013;52:261–6.
- 38 Chandran V, Barrett J, Schentag CT, *et al.* Axial psoriatic arthritis: update on a longterm prospective study. *J Rheumatol* 2009;36:2744–50.
- 39 Lubrano E, Marchesoni A, Olivieri I, *et al.* Psoriatic arthritis spondylitis radiology index: a modified index for radiologic assessment of axial involvement in psoriatic arthritis. *J Rheumatol* 2009;36:1006–11.
- 40 Creemers MC, Franssen MJ, van't Hof MA, *et al.* Assessment of outcome in ankylosing spondylitis: an extended radiographic scoring system. *Ann Rheum Dis* 2005;64:127–9.
- 41 Baraliakos X, Listing J, von der Recke A, *et al.* The natural course of radiographic progression in ankylosing spondylitis—evidence for major individual variations in a large proportion of patients. *J Rheumatol* 2009;36:997–1002.
- 42 Breban M, Ravaut P, Claudepierre P, *et al.* Maintenance of infliximab treatment in ankylosing spondylitis: results of a one-year randomized controlled trial comparing systematic versus on-demand treatment. *Arthritis Rheum* 2008;58:88–97.
- 43 Pavy S, Brophy S, Calin A. Establishment of the minimum clinically important difference for the bath ankylosing spondylitis indices: a prospective study. *J Rheumatol* 2005;32:80–5.
- 44 Mease PJ, Woolley JM, Bitman B, *et al.* Minimally important difference of Health Assessment Questionnaire in psoriatic arthritis: relating thresholds of improvement in functional ability to patient-rated importance and satisfaction. *J Rheumatol* 2011;38:2461–5.
- 45 Resnick D, Niwayama G. Radiographic and pathologic features of spinal involvement in diffuse idiopathic skeletal hyperostosis (DISH). *Radiology* 1976;119:559–68.
- 46 Taylor WJ, Marchesoni A, Arreghini M, *et al.* A comparison of the performance characteristics of classification criteria for the diagnosis of psoriatic arthritis. *Semin Arthritis Rheum* 2004;34:575–84.
- 47 Resnick D, Niwayama G. *Diagnosis of bone and joint disorders*. W B Saunders, 1981.
- 48 Haroon M, Winchester R, Giles JT, *et al.* Certain class I HLA alleles and haplotypes implicated in susceptibility play a role in determining specific features of the psoriatic arthritis phenotype. *Ann Rheum Dis* 2016;75:155–62.
- 49 McGonagle D, Lories RJU, Tan AL, *et al.* The concept of a “synovio-enthesal complex” and its implications for understanding joint inflammation and damage in psoriatic arthritis and beyond. *Arthritis Rheum* 2007;56:2482–91.
- 50 Ash ZR, Tinazzi I, Gallego CC, *et al.* Psoriasis patients with nail disease have a greater magnitude of underlying systemic subclinical enthesopathy than those with normal nails. *Ann Rheum Dis* 2012;71:553–6.
- 51 Tillett W, Shaddick G, Korendowych E, *et al.* Joint count reliability in psoriatic arthritis observational trials—an unreported problem. *Rheumatology (Oxford)* 2012;51:1333–4.
- 52 Poddubnyy D, Rudwaleit M, Haibel H, *et al.* Effect of non-steroidal anti-inflammatory drugs on radiographic spinal progression in patients with axial spondyloarthritis: results from the German Spondyloarthritis Inception Cohort. *Ann Rheum Dis* 2012;71:1616–22.
- 53 Haroon N, Inman RD, Learch T, *et al.* Anti-TNF therapy slows radiographic progression of ankylosing spondylitis and opposes the effects of smoking and inflammation. *8th International Congress on Spondyloarthropathy*; Ghent, Belgium; 2013. p. 644.
- 54 Haroon N, Inman RD, Learch TJ, *et al.* The Impact of Tumor Necrosis Factor alpha Inhibitors on Radiographic Progression in Ankylosing Spondylitis. *Arthritis Rheum* 2013;65:2645–54.
- 55 van der Heijde D, Landewe R, Baraliakos X, *et al.* Radiographic findings following two years of infliximab therapy in patients with ankylosing spondylitis. *Arthritis Rheum* 2008;58:3063–70.
- 56 van der Heijde D, Landewe R, Einstein S, *et al.* Radiographic progression of ankylosing spondylitis after up to two years of treatment with etanercept. *Arthritis Rheum* 2008;58:1324–31.