Correlation between clinical outcome and spinopelvic parameters in ankylosing spondylitis

Jong Ki Shin · Jung Sub Lee · Tae Sik Goh ·
Seung Min Son

Received: 3 January 2013 / Revised: 11 June 2013 / Accepted: 22 July 2013 / Published online: 31 July 2013
© Springer-Verlag Berlin Heidelberg 2013

Abstract

Purpose Little data are available on the relationship between sagittal spinopelvic parameters and health related quality of life (HRQOL) in ankylosing spondylitis (AS) patients. The aim of this study was to identify the relationships between spinopelvic parameters and HRQOL in AS.

Methods The study and control groups comprised 107 AS patients and 40 controls. All underwent anteroposterior and lateral radiographs of the whole spine including hip joints and completed clinical questionnaires. The radiographic parameters examined were sacral slope, pelvic tilt, pelvic incidence, thoracic kyphosis, lumbar lordosis, and sagittal vertical axis. A Visual Analogue Scale (VAS: 0–10) score for back pain, the Oswestry disability index (ODI) questionnaire, Scoliosis Research Society (SRS-22) questionnaire and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) were administered to evaluate QOL. Statistical analysis was performed to identify significant differences between the study and control groups. In addition, correlations between radiological parameters and clinical questionnaires were sought.

Results The AS patients and controls were found to be significantly different in terms of sagittal vertical axis, sacral slope, pelvic tilt, pelvic incidence, and lumbar lordosis. However, no significant intergroup difference was observed for thoracic kyphosis ($P > 0.05$). Of the 107 AS patients, there were 18 women and 89 men. Correlation analysis revealed significant relationships between

radiographic parameters and clinical outcomes. Multiple regression analysis was performed to identify predictors of clinical outcome, and the results obtained revealed that sagittal vertical axis and sacral slope significantly predicted VAS, ODI and BASDAI scores and that sagittal vertical axis and lumbar lordosis predicted SRS-22 scores.

Conclusions AS patients and normal controls were found to be significantly different in terms of sagittal spinopelvic parameters. Correlation analysis revealed significant relationships between radiographic parameters and clinical outcomes. In particular, sagittal vertical axis, sacral slope and lumbar lordosis were found to be significant parameters in prediction of clinical outcomes in AS patient.

Keywords Ankylosing spondylitis · Sagittal parameters · Quality of life

Introduction

Ankylosing spondylitis (AS) is a chronic, inflammatory rheumatic disease characterized by inflammatory back pain due to sacroiliitis and spondylitis, and the formation of syndesmophytes leading to ankylosis [24]. AS is believed to be the most common and most typical form of spondyloarthropathy [5]. Advanced stages of the disease are characterized by progressive stiffening of the spine and thorax [23]. Sagittal balance deteriorates during the course of the disease, producing a rigid thoracolumbar kyphosis [23]. A severe thoracolumbar kyphosis results in downward tilting of the head and face [23]. The ability of the patient to see above the level of horizontal gaze progressively worsens [7], and the center of gravity moves anteriorly to cause a stooped, downward-looking posture, which is characteristic of advanced AS [7], and which contributes to

J. K. Shin · J. S. Lee (✉) · T. S. Goh · S. M. Son
Department of Orthopaedic Surgery, Medical Research Institute,
Pusan National University School of Medicine, 1-10 Ami-Dong,
Seo-Gu, Busan 602-739, Republic of Korea
e-mail: jungsublee@pusan.ac.kr

many disabilities including limitation of social activities. Therefore, identification of correlations between sagittal spinopelvic parameters and health related quality of life (HRQOL) would provide beneficial information for treatment decision-making and planning.

The correlations between HRQOL and kyphotic spinal alignment including spinopelvic parameters have been previously reported, but few AS cases were included. Some authors have evaluated radiological and clinical outcomes after surgery [2, 8, 14, 18], but no relationships have been established between sagittal spinopelvic parameters and preoperative HRQOL in AS. We considered that a more comprehensive understanding of relationships between the lumbar spine and pelvis is needed in AS, because correlations between radiographic parameters of the pelvis and HRQOL in AS would be useful for decision-making and surgical planning in patients with spinal disorders. Moreover, the differences and relationships between sagittal radiological parameters can provide clues when examining spinal deformities in AS. Accordingly, the aim of this study was to identify relationships between spinopelvic parameters and HRQOL in AS patients. In addition, we attempted to identify spinopelvic parameters that predict HRQOL.

Materials and methods

One hundred and seven consecutive AS patients were enrolled prospectively at the times of examination between January 2011 and February 2012. AS patients were recruited from the patients attending the orthopedic outpatient clinic. Demographic and clinical characteristics and Visual Analogue Scale (VAS: 0–10) scores for back pain were recorded, and the Oswestry disability index (ODI) questionnaire, Scoliosis Research Society (SRS-22) questionnaire and Bath Ankylosing Spondylitis Disease Activity Index (BASDAI) were administered. BASDAI was developed as a composite index, consisting of an evaluation on a visual analogue scale (1–10) of fatigue, axial pain, peripheral pain, stiffness, and enthesopathy [6]. Eighteen female and 89 male AS patients of average age 42.4 ± 10.7 years were recruited. Forty normal subjects who underwent whole spine radiographs for simple health checkup were recruited as control group. The study was approved by the Clinical Research Ethics Committee of our institution.

All 107 AS patients met the most recent modified New York criteria [22]; (Table 1) and were eligible to participate in the trial if they had received medical treatment for at least 1 year. Pain originating from the spine was scored, but pain originating from other parts of the body, such as, hips, knees or shoulders was excluded. The exclusion criteria applied were an age older than 60 years, or

concomitant neurological or psychiatric disease. Patients with a history of and orthopedic disease of the spine (fracture, spinal disc herniation, spinal surgery etc.) or lower extremities (e.g., prosthesis) were also excluded.

Participants underwent anteroposterior and lateral whole spine radiography. Radiographs were taken by one technician at a distance of 72 inches using a standard technique and the same machine in the standing position. All lateral radiographs included both hip joints and the C7 vertebra.

Radiographic parameters included sacral slope, pelvic tilt, pelvic incidence, thoracic kyphosis, lumbar lordosis, and sagittal vertical axis (Fig. 1). Sacral slope was defined as the angle between the sacral end plate and the horizontal. Pelvic tilt was defined as the angle between the line joining the middle of the sacral end plate and hip axis and the vertical. Pelvic incidence was defined as the angle between a line perpendicular to the sacral end plate and a line joining the middle of the sacral plate and the hip axis. Thoracic kyphosis was measured between the upper endplate of the T1 vertebra and the lower endplate of the T12 vertebra using Cobb's method. Lumbar lordosis was measured between the upper endplate of the L1 vertebra and the lower endplate of the L5 vertebra using Cobb's method. Sagittal balance was measured using the sagittal vertical axis, and was defined as the horizontal distance of a C7 plumb line dropped from the center of the C7 body to the posterior–superior corner of the S1 body. Anterior displacement of the sagittal plumb line was defined as positive. All measurements were performed twice independently by three spine surgeons with an interval of 2 weeks between measurements and decrease intra-observer (Pearson correlation coefficient = 0.939, range: 0.904–0.956) and interobserver error (Pearson correlation coefficient = 0.934, range: 0.900–0.955).

Statistical analysis was performed using SPSS 11.5 software for Windows (SPSS, Chicago, IL, USA). Data are expressed by mean $\pm$ standard deviation. The two groups were compared using the *t* test and correlation analyses were also performed using Pearson's correlation to demonstrate the relationship between variables. To identify parameters that predict the clinical outcome effectively, we performed multiple regression analyses. A *P* < 0.05 was regarded as statistically significant.

Results

Measurements of parameters

Table 2 summarizes sagittal parameter measurements in the 107 AS patients and 40 controls. The AS patients and controls were found to be significantly different in terms of sagittal vertical axis, sacral slope, pelvic tilt, pelvic

Table 1 Modified New York criteria for ankylosing spondylitis**A. Diagnosis****1. Clinical criteria**

- Low back pain and stiffness for more than 3 months which improves with exercise, but is not relieved by rest
- Limitation of motion of the lumbar spine in both the sagittal and frontal planes
- Limitation of chest expansion relative to normal values corrected for age and sex

2. Radiologic criterion

Sacroiliitis grade ≥ 2 bilaterally or sacroiliitis grade 3–4 unilaterally

B. Grading

- Definite ankylosing spondylitis if the radiologic criterion is associated with at least one clinical criterion
- Probable ankylosing spondylitis if
 - Three clinical criteria are present
 - The radiologic criterion is present without any signs or symptoms satisfying the clinical criteria

incidence, and lumbar lordosis. However, no significant intergroup difference was observed for thoracic kyphosis ($P > 0.05$).

Correlation between parameters

Table 3 summarizes correlations between spinopelvic parameters. Statistical significant correlations were observed between the following variables after stratification: pelvic incidence and sacral slope ($r = 0.617$, $P < 0.001$), pelvic incidence and pelvic tilt ($r = 0.633$, $P < 0.001$), pelvic incidence and lumbar lordosis ($r = 0.292$, $P = 0.005$), pelvic incidence and thoracic kyphosis ($r = 0.135$, $P = 0.226$), sacral slope and lumbar lordosis ($r = 0.678$, $P < 0.001$), sacral slope and thoracic kyphosis ($r = -0.289$, $P = 0.006$), pelvic tilt and lumbar lordosis ($r = -0.284$, $P = 0.007$), pelvic tilt and thoracic kyphosis ($r = 0.572$, $P < 0.001$), and lumbar lordosis and thoracic kyphosis ($r = -0.232$, $P = 0.028$).

Correlation between spinopelvic parameters and clinical outcomes

Correlation analysis revealed significant relationships between parameters and clinical outcomes (Table 4). However, gender and pelvic incidence were not found to be correlated with any of the four clinical outcome scores.

Multiple regression analysis was performed to identify contributors to clinical outcome. Under multiple regression analysis, sagittal vertical axis and sacral slope were the significant predictors for VAS, ODI and BASDAI, and sagittal vertical axis and lumbar lordosis were those for SRS-22 (Table 5).

Fig. 1 Spinopelvic parameters. *PI* pelvic incidence, *PT* pelvic tilting, *SS* sacral slope, *TK* thoracic kyphosis, *LL* lumbar lordosis**Discussion**

Although the treatment of spinal deformities associated with AS has become an increasingly important component in many spinal surgery practices, the relevance of pelvic measures in AS remains unclear. Earlier studies have addressed postoperative changes of sagittal balance in AS [2, 7, 8, 14, 18, 21], and several authors have investigated relationships between HRQOL instruments and radiographic measurements to define objective criteria for the surgical treatment of adult spinal deformities. However, relatively few studies have addressed relations between AS and specific radiologic pelvic parameters. Furthermore, the relationships established between sagittal spinopelvic parameters and preoperative HRQOL in AS are lacking.

In the normal population, some parameters, that is, sacral inclination, pelvic tilt, and pelvic incidence can be used to assess the effect of lumbosacral pelvic orientation on sagittal alignment of the spine [5, 11, 12, 16, 17]. In the present study, sagittal parameters were found to be significantly different between AS patients and controls, and to be related to each other. Although correlations between sagittal parameters and the development of spinal disorders

Table 2 Details of the patients

	Normal (<i>n</i> = 40)	Range	AS (<i>n</i> = 107)	Range	<i>P</i> value
Gender (F/M)	9/31		18/89		0.5810
Age	41.0 ± 10.6	20 to 55	42.4 ± 10.7	19 to 60	0.4838
Sagittal vertical axis	−12.6 ± 22.7	−49 to 30	27.5 ± 51.9	−46 to 131	<0.001
Sacral slope	35.5 ± 5.9	22 to 47	23.5 ± 8.6	6 to 47	<0.001
Pelvic tilt	13.5 ± 6.0	3 to 23	20.0 ± 8.8	7 to 42	<0.001
Pelvic incidence	48.3 ± 5.5	32 to 55	43.0 ± 10.7	14 to 70	0.0036
Lumbar lordosis	39.3 ± 6.8	21 to 52	28.0 ± 9.1	11 to 63	<0.001
Thoracic kyphosis	38.4 ± 6.7	23 to 51	37.6 ± 13.3	16 to 61	0.7391

Table 3 Correlations of the parameters

	Age	SVA	SS	PT	PI	LL	TK
AS patients (<i>n</i> = 107)							
Age		0.300*	−0.109	0.181	0.051	−0.154	0.420*
Sagittal vertical axis (SVA)	<i>r</i>		−0.286*	0.582*	0.248**	−0.415*	0.890*
Sacral slope (SS)	<i>r</i>			−0.215**	0.617*	0.678*	−0.289*
Pelvic tilt (PT)	<i>r</i>				0.633*	−0.284*	0.572*
Pelvic incidence (PI)	<i>r</i>					0.292*	0.135
Lumbar lordosis (LL)	<i>r</i>						−0.232**
Thoracic kyphosis (TK)	<i>r</i>						
Control (<i>n</i> = 40)							
Age		−0.248	0.009	0.586**	0.494**	0.301	−0.029
Sagittal vertical axis (SVA)	<i>r</i>		−0.358*	−0.310*	−0.576**	−0.411**	−0.212
Sacral slope (SS)	<i>r</i>			−0.264	0.707**	0.723**	0.665**
Pelvic tilt (PT)	<i>r</i>				0.471**	0.175	0.017
Pelvic incidence (PI)	<i>r</i>					0.804**	0.620**
Lumbar lordosis (LL)	<i>r</i>						0.730**
Thoracic kyphosis (TK)	<i>r</i>						

* Significant correlation was established at the 0.01 level

** Significant correlation was established at the 0.05 level

Table 4 Correlations of the spinopelvic parameters and clinical outcomes in AS patients

		VAS(3.8 ± 1.3)	ODI (28.7 ± 8.4)	SRS-22 (64.3 ± 6.2)	BASDAI (10.5 ± 4.5)
Age	<i>r</i>	0.344*	0.299*	−0.341*	0.235**
Sex	<i>r</i>	0.095	0.013	−0.072	−0.006
Sagittal vertical axis	<i>r</i>	0.453*	0.412*	−0.443*	0.377*
Sacral slope	<i>r</i>	−0.412*	−0.353*	0.287*	−0.381*
Pelvic tilt	<i>r</i>	0.426*	0.392*	−0.401*	0.395*
Pelvic incidence	<i>r</i>	0.005	0.023	−0.083	0.005
Lumbar lordosis	<i>r</i>	−0.417*	−0.307*	0.318*	−0.329*
Thoracic kyphosis	<i>r</i>	0.365*	0.340*	−0.385*	0.320*

* Significant correlation was established at the 0.01 level

** Significant correlation was established at the 0.05 level

have not been confirmed in AS, differences and relationships between sagittal radiological parameters can provide clues when examining spinal deformities in AS patients. In

the present study, AS patients exhibited more pelvic tilt and lower levels of pelvic incidence and lumbar hypolordosis, which suggest that spinopelvic orientation was found

Table 5 Multiple regression analysis in AS patients

Variables	Coefficient	<i>t</i>	<i>P</i> value
VAS			
Sagittal vertical axis	0.008	3.916	<0.001
Sacral slope	−0.050	−3.856	<0.001
Constant	4.700		
ODI			
Sagittal vertical axis	0.057	3.479	<0.001
Sacral slope	−0.297	−2.997	0.003
Constant	37.309		
SRS-22			
Sagittal vertical axis	−0.002	−3.648	<0.001
Lumbar lordosis	0.008	2.310	0.023
Constant	3.055		
BASDAI			
Sagittal vertical axis	0.024	3.118	0.002
Sacral slope	−0.174	−3.686	<0.001
Constant	13.895		

to be significantly different in AS. In addition, mean sagittal vertical axis was positive in AS patients. Thus, it appears that spinal misalignment and pelvic abnormality are closely related in AS.

In this study, it was found that pelvic incidence was lower in the AS group than in the control group. In addition, no significant intergroup difference was observed for thoracic kyphosis. However, the sagittal radiological parameters of this study are different in degenerative deformity patients. Bae et al. [3] compared the spinopelvic parameters between LDK and control group, and LDK patients indicated higher level of pelvic incidence. LDK patients showed lower level of thoracic kyphosis. This might be because of thoracic compensation for the sagittal imbalance resulting from a loss of lumbar lordosis in LDK patients.

With regard to relationship between HRQOL instruments and radiographic measurements, gross orientation and spinopelvic balance are believed to be important in spinal deformity [9, 10, 16, 19]. However, evidence supporting this concept is not strong [1]. In an early study on 95 patients, Schwab et al. [19] identified radiologic parameters correlated with self-perceived pain measured by a VAS scale. In a later report, loss of lordosis was found to be correlated with lower Short Form 36 (SF-36) scores [20]. This study also confirms the relationship between lumbar lordosis and clinical outcomes. This parameter appeared to be significantly correlated with HRQOL measures and evidently is a key parameter to take into account when analyzing radiographic alignment. Lefage et al. [16] found that pelvic tilt is associated with HRQOL in the setting of adult deformity and Glassman et al. [9, 10]

reported that global alignment of the sagittal vertical axis is associated with pain and reduced function, which is consistent with our findings. In fact, in the present study, sagittal vertical axis measured from the C7 plumb line with respect to S1 was significantly related to HRQOL and was found to be one of the significant predictors for the determination of clinical outcomes in AS patients at multiple regression analysis. Contrary to the observations of Glassman et al. [10], clinical outcome scores were significantly influenced by age in the present cohort, which suggests younger patients may be able to better compensate for their spinal deformities.

In the present study, clinical outcome scores were significantly correlated to sagittal vertical axis, sacral slope, pelvic tilt, lumbar lordosis, and thoracic kyphosis. In particular, sagittal vertical axis, sacral slope and lumbar lordosis were significant predictors of HRQOL in AS by multiple regression analysis. In general, correlations between lumbar lordosis and sacral slope or pelvic tilt at the pelvic level are stronger for sacral slope than for pelvic tilt [4, 15, 16], which are consistent with our observations. To some extent, a reduction in lumbar lordosis can be compensated for by a similar reduction in sacral slope to maintain the relative position of the C7 plumb line [13], which is in line with sacral slope and lumbar lordosis that were significant parameters of HRQOL in current study. Thus, it appears that spinal misalignment and pelvic abnormalities are closely related in AS. Furthermore, this unbalanced condition caused by decreased lumbar lordosis and/or thoracic kyphosis can increase pain severity, and should be considered by surgeons when treating AS.

This study has several limitations that require consideration. First, the number of normal controls tested was relatively small, which diminished the statistical power of this study and its ability to detect correlations. Second, Although AS patients who had received medical treatment for at least 1 year, AS group can be heterogeneous in terms of disease activity and deformity and the ability to compensate for the deformity. Third, sagittal vertical axis was used to determine sagittal balance and recently described more relevant indexes of global sagittal balance based on analyzing the position of C7 were not utilized. Fourth, because the correlations between the spinopelvic parameters with the HRQOL questionnaires were relatively weak, the clinical outcomes could be contributed by other factors. Furthermore, we did not include interactions with hematologic factors such as erythrocyte sedimentation rate or C-reactive protein levels in the analysis, and these are important considerations in AS because they influence pain.

This study shows significant relationships between sagittal spinopelvic parameters in AS patients. Furthermore, AS patients and normal controls were found to be

significantly different in terms of sagittal spinopelvic parameters. In addition, correlation analysis revealed significant relationships between parameters and clinical outcomes. Sagittal vertical axis, sacral slope and lumbar lordosis were found to be significant parameters in prediction of clinical outcomes in AS patient.

Conflict of interest None.

References

- Angevine PD, McCormick PC (2007) The importance of sagittal balance: how good is the evidence? *J Neurosurg Spine* 6:101–103
- Arun R, Dabke HV, Mehdian H (2011) Comparison of three types of lumbar osteotomy for ankylosing spondylitis: a case series and evolution of a safe technique for instrumented reduction. *Eur Spine J* 20:2252–2260
- Bae JS, Jang JS, Lee SH, Kim JU (2012) Radiological analysis of lumbar degenerative kyphosis in relation to pelvic incidence. *Spine J* 12:1045–1051
- Berthonnaud E, Dimnet J, Roussouly P, Labelle H (2005) Analysis of the sagittal balance of the spine and pelvis using shape and orientation parameters. *J Spinal Disord Tech* 18:40–47
- Boulay C, Tardieu C, Hecquet J, Benaim C, Mouilleseaux B, Marty C, Prat-Pradal D, Legaye J, Duval-Beaupère G, Pélissier J (2006) Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis. *Eur Spine J* 15:415–422
- Calin A, Garrett S, Whitelock H, Kennedy LG, O’Hea J, Mallorie P, Jenkinson T (1994) A new approach to defining functional ability in ankylosing spondylitis: the development of the bath ankylosing spondylitis functional index. *J Rheumatol* 21:2281–2285
- Debarge R, Demey G, Roussouly P (2010) Radiological analysis of ankylosing spondylitis patients with severe kyphosis before and after pedicle subtraction osteotomy. *Eur Spine J* 19:65–70
- Debarge R, Demey G, Roussouly P (2011) Sagittal balance analysis after pedicle subtraction osteotomy in ankylosing spondylitis. *Eur Spine J* 20:619–625
- Glassman SD, Berven S, Bridwell K, Horton W, Dimar JR (2005) Correlation of radiographic parameters and clinical symptoms in adult scoliosis. *Spine* 30:682–688
- Glassman SD, Bridwell K, Dimar JR, Horton W, Berven S, Schwab F (2005) The impact of positive sagittal balance in adult spinal deformity. *Spine* 30:2024–2029
- Jackson RP, Hales C (2000) Congruent spinopelvic alignment on standing lateral radiographs of adult volunteers. *Spine* 25:2808–2815
- Jackson RP, Kanemura T, Kawakami N, Hales C (2000) Lumbo-pelvic lordosis and pelvic balance on repeated standing lateral radiographs of adult volunteers and untreated patients with constant low back pain. *Spine* 25:575–586
- Jackson RP, Peterson MD, McManus AC, Hales C (1998) Compensatory spinopelvic balance over the hip axis and better reliability in measuring lordosis to the pelvic radius on standing lateral radiographs of adult volunteers and patients. *Spine* 23:1750–1767
- Kim KT, Lee SH, Suk KS, Lee JH, Im YJ (2007) Spinal pseudarthrosis in advanced ankylosing spondylitis with sagittal plane deformity: clinical characteristics and outcome analysis. *Spine* 32:1641–1647
- Lee JH, Kim KT, Suk KS, Lee SH, Jeong BO, Kim JS, Eoh JH, Kim YJ (2010) Analysis of spinopelvic parameters in lumbar degenerative kyphosis: correlation with spinal stenosis and spondylolisthesis. *Spine* 35:E1386–E1391
- Lefage V, Schwab F, Patel A, Hawkinson N, Farcy JP (2009) Pelvic tilt and truncal inclination: two key radiographic parameters in the setting of adults with spinal deformity. *Spine* 34:E599–E606
- Legaye J, Duval-Beaupère G, Hecquet J, Marty C (1998) Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J* 7:99–103
- Qian BP, Qiu Y, Wang B, Sun X, Zhu ZZ, Jiang J, Ji ML (2012) Pedicle subtraction osteotomy through pseudarthrosis to correct thoracolumbar kyphotic deformity in advanced ankylosing spondylitis. *Eur Spine J* 21:711–718
- Schwab FJ, Smith VA, Biseri M, Gamez L, Farcy JP, Pagala M (2002) Adult scoliosis: a quantitative radiographic and clinical analysis. *Spine* 27:387–392
- Schwab F, Dubey A, Pagala M, Gamez L, Farcy JP (2003) Adult scoliosis: a health assessment analysis by SF-36. *Spine* 28:602–606
- Suk KS, Kim KT, Lee SH, Kim JM (2003) Significance of chin-brow vertical angle in correction of kyphotic deformity of ankylosing spondylitis patients. *Spine* 28:2001–2005
- van der Linden S, Valkenburg HA, Cats A (1984) Evaluation of diagnostic criteria for ankylosing spondylitis. A proposal for modification of the New York criteria. *Arth Rheum* 27:361–368
- White AA 3rd, Panjabi MM, Thomas CL (1977) The clinical biomechanics of kyphotic deformities. *Clin Orthop Relat Res* 128:8–17
- Zochling J, van der Heijde D, Burgos-Vargas R, Collantes E, Davis JC Jr, Dijkmans B, Dougados M, Géher P, Inman RD, Khan MA, Kvien TK, Leirisalo-Repo M, Olivieri I, Pavelka K, Sieper J, Stucki G, Sturrock RD, van der Linden S, Wendling D, Böhm H, van Royen BJ, Braun J (2006) ASAS/EULAR recommendations for the management of ankylosing spondylitis. *Ann Rheum Dis* 65:442–452