

Analysis of dedicated sacroiliac views to improve reliability of conventional pelvic radiographs

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Abstract

Objective. To compare the antero-posterior (AP) pelvis view with the Ferguson view of the SI joint in order to resolve whether one modality has a clear advantage for grading of sacroiliitis.

Methods. One hundred and nine patients fulfilling Assessment of SpondyloArthritis international Society (ASAS) criteria for axial spondyloarthritis who had AP pelvis and Ferguson views on the same day were identified from an axial spondyloarthritis clinic registry. Two rheumatologists independently scored the AP pelvis and Ferguson views according to modified New York (NY) criteria. Intra- and inter-reader agreements were obtained for both evaluations by using the kappa statistic and intraclass correlation coefficient (ICC). Any change in diagnostic category dictated by the Ferguson vs the AP pelvis views was also evaluated.

Results. A total of 266 radiographs were read from 109 patients. Intra-observer reliability of the observers showed similar ICC scores; this was also reflected in the kappa for diagnosis of AS fulfilling modified NY criteria between the observers. The inter-rater agreement showed similar kappa values between the two modalities. When separately evaluating SI joints with score grading of 0–2, grade 2 showed the lowest kappa, reaching a low of 0.1 and 0.19 for the right SI joint for Ferguson and AP pelvis views, respectively. Both modalities were concordant diagnostically; reclassification from AS to non-AS and vice versa was in the range 5–11%.

Conclusion. There was general agreement between the Ferguson and AP pelvis X-ray ICC and kappa scores. Either modality can be employed to evaluate the SI joint for sacroiliitis with the Ferguson view showing no clear superiority over the standard AP pelvis view.

Key words: spondylarthropathies, ankylosing spondylitis, radiography, sacroiliitis, observer variation

Rheumatology key messages

- The Ferguson has no clear advantage over the antero-posterior pelvis view in grading sacroiliitis.
- Clinicians can use either modality (Ferguson view or antero-posterior pelvis view) in assessing sacroiliitis.

Introduction

Despite the development and utilization of advanced imaging modalities such as MRI and CT, conventional

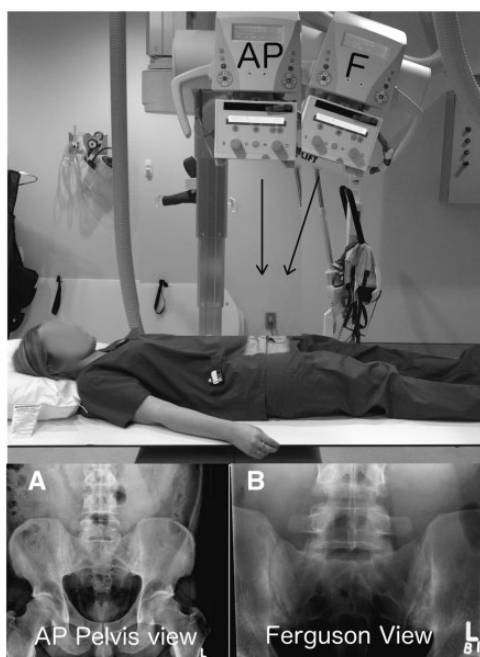
radiography of the SI joint remains the cornerstone of the diagnosis and classification of AS [1]. The antero-posterior (AP) pelvis radiograph has long been the established standard for the screening and grading of sacroiliitis. However, this radiograph has proven exceptionally difficult to read, in part due to the complex anatomy of the SI joint, and even dedicated training does not improve reading outcomes [2].

The shortcomings of the AP pelvis X-ray in terms of reproducibility and reliability have recently been highlighted [3]. While there is increasing interest in CT and MRI evaluation of SI joints, accessibility and cost dictate that plain radiography remains the standard imaging in

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Fig. 1 X-ray positioning of antero-posterior pelvis and Ferguson views



Upper image represents X-ray tube positioning. Lower X-ray images show an example of corresponding X-ray views taken from the same patient. AP: antero-posterior pelvis; F: Ferguson view.

most centres when there is clinical suspicion of axial SpA. We sought to examine whether the poor reliability of the AP pelvis could be improved by employing dedicated views of the SI joints.

Standard AP pelvis X-ray readings have been shown to have low to moderate inter- and intra-observer reliability [4–6]. One recent study demonstrated that inter-observer reliability even among highly trained central readers was low to moderate at best [4]. What is particularly challenging is accurately detecting early or minimal abnormalities within the SI joint, in particular grades 1 and 2 in the modified New York (NY) scoring scale. The Ferguson view for the SI joints is a modified AP pelvis X-ray with the central rays angled in a cephalad manner and directed at the midline 5 cm below the anterior superior iliac spine [7, 8] (Fig. 1). The Ferguson view, as a more dedicated SI joint radiographic study, has been advocated by some clinicians for a clearer view of the SI joints [9]. There is sparse data on the differences in SI joint scoring between standard AP views and Ferguson views. One previous study found no major advantage in dedicated bilateral views of the SI joints when compared with the standard AP pelvis view [9]. Our aim was to compare the AP pelvis view with the Ferguson view to clarify whether the latter modality has a clear advantage for diagnosis and grading of sacroiliitis, and to compare intra- and inter-observer reliability for the two modalities.

Methods

Patients attending the Toronto Western Spondylitis Clinic were invited to be registered in the SpA database. All patients provided written consent and the study was approved by the University Health Network research ethics board. Clinical, laboratory and radiological data were collected on a pre-determined schedule. All patients fulfilled the Assessment of SpondyloArthritis international Society (ASAS) classification criteria for non-radiographic axial spondyloarthritis (axSpA), and a subset also fulfilled the modified NY criteria for AS [1, 10]. According to a predetermined cohort protocol, all patients had serial surveillance X-rays of the spine and pelvis. In a review of the clinical database there were 109 axSpA patients who had had simultaneous AP pelvis and Ferguson views, providing a total of 133 X-ray pairs for comparison, as some patients had more than one X-ray study performed over the follow-up period (on average 2 years or more apart).

A study coordinator randomized the sequence of the patients and prepared the X-rays to be read on two separate computer terminals with all patient identifiers removed. A picture archiving and communication system was used to read the digital radiographs. The readers were blinded to patient clinical details, including demographics, prior diagnosis and follow-up status. However, all participants were aware that the radiographs were from the SpA cohort population.

Two rheumatologists independently reviewed both the Ferguson and the AP pelvis radiographs and scored the graphs according to the modified NY (mNY) criteria [1]. The radiographs were graded as follows: grade 0 is normal, grade I is changes suspected, grade II demonstrates minimal abnormalities (small localized areas with erosions or sclerosis without alteration of the joint width), grade III shows unequivocal abnormalities (large erosions, evidence of sclerosis, joint space narrowing or widening or partial ankylosis) and grade IV shows complete ankylosis. Sacroiliitis diagnostic of AS was defined as the presence of changes graded ≥ 2 bilaterally or ≥ 3 unilaterally. Intra-reader and inter-reader agreements were then obtained for both the imaging techniques by using the Cohen-weighted kappa statistic and the intra-class correlation coefficient (ICC). Mean SI joint scores were also calculated. Table 1 outlines how kappa is interpreted according to a previous well-recognized and cited standard [11]. Statistical analyses were performed using SPSS Statistics version 22 (IBM, Armonk, NY, USA).

Results

In total, we studied the radiographs of 109 patients. A total of 266 radiographs were read (133 for each modality). The demographic data are outlined in Table 2. Seventy-five per cent of the patients were male. Sixty-eight per cent of the patients were HLA-B27 positive. The mean age at first visit was 39 years, with mean disease duration of 13.2 years. Eighty per cent of patients were classified as AS according to the mNY criteria.

TABLE 1 Kappa and intraclass correlation coefficient interpretation

Kappa/ICC score	Strength of agreement
<0.00	Less than chance agreement
0.01–0.20	Slight agreement
0.21–0.40	Fair agreement
0.41–0.60	Moderate agreement
0.61–0.80	Substantial agreement
0.81–1	Almost perfect agreement

Adapted with permission from Landis *et al.* The measurement of observer agreement for categorical data *Biometrics* 1977; 33: 159–74. [11]. ICC: intraclass correlation coefficient.

Grading of the SI joints as per mNY criteria was compared for both views to obtain intra- and inter-observer reliability. The data are presented in [Table 3](#) and [Figs 2 and 3](#). For full SI joint grade frequencies for each reader, see supplementary Fig. S1, available at *Rheumatology* Online. In summary, the mean percentage of each grade per observer for all the views (Ferguson and AP pelvis) were as follows: observer 1: grade 0 (0.2%), grade 1 (11.6%), grade 2 (18.3%), grade 3 (45.9%), grade 4 (24%); observer 2: grade 0 (3.8%), grade 1 (17.9%), grade 2 (28.4%), grade 3 (33.2%), grade 4 (16.8%). The rest of the results are further explored under the three subheadings below.

Intra-observer reliability

[Table 3](#) presents the intra-observer reliability data for each individual observer. This depicts the reliability of SI joint X-ray scores by the same individual between the AP pelvis and Ferguson views. Pooled data for each individual SI joint showed very good agreement for the same individual and between the two different modalities as indicated in [Table 3](#). However when looking at specific SI joint grading categories, the intra-observer agreement was only moderate in the diagnostic sacroiliitis grading (bilateral grade 2 or more, or unilateral grade 3 or above) with a kappa score of 0.47 and 0.41 for observers 1 and 2, respectively. For the more subtle and challenging interpretations (grades 1 and 2 range), the reliability was also moderate at best.

Inter-observer agreement

In the inter-observer agreement, direct comparison was carried out between both observers for each radiographic modality. Pooled data for each individual SI joint (right and left) showed substantial agreement for both the Ferguson and AP pelvis views, with ICC scores ranging from 0.64 to 0.75, all within the substantial agreement range.

The kappa score for the diagnostic category with respect to mNY criteria for the Ferguson view was 0.5 (moderate agreement) and higher in comparison with the AP pelvis (fair), reaching a kappa score of only 0.27 ([Table 3](#)). When looking at the lower grades (0–2) for each individual SI joint, the kappa scores were between fair and

TABLE 2 Patient demographics (109 analysed patients)

Variable	Value
Gender, n (%)	
Male	82 (75)
Female	27 (25)
Diagnosis at first visit, n (%)	
AS	87 (80)
ReA	2 (2)
nr-axSpA	20 (18)
B27, n (%)	74 (68)
Age at first visit, mean (s.d.), years	39.1 (14.4)
Disease duration, mean (s.d.), years	13.2 (10.7)
CRP, mean (s.d.), mg/l	11.5 (16.4)
ESR, mean (s.d.), mm/h	13.5 (16.9)
BASMI, mean (s.d.)	2.2 (2.2)
BASDAI, mean (s.d.)	4.7 (2.8)

nr-axSpA: non-radiographic axial spondyloarthritis.

moderate, ranging from 0.38 (right Ferguson view) to a maximum of 0.52 (left AP pelvis).

We examined the kappa scores for the individual SI joint scoring, and grade 2 had the lowest agreement for both the AP pelvis and Ferguson views, but agreement for grade 3 was only marginally better. Grade 4 had very good to excellent agreement ([Fig. 2](#)).

In summary, there were no major differences between the two modalities when looking at the inter-observer reliability. The Ferguson view seems to have slightly better kappa scores in diagnostic category grades, but this advantage is clearly lost within the more subtle and difficult grades 1 and 2.

Diagnostic change and agreement

Diagnostic agreements for each individual observer between the two different radiographic modalities are shown in [Fig. 3](#). There was 86.4 and 78.1% diagnostic agreement between the Ferguson and AP pelvis for observers 1 and 2, respectively. We addressed whether the use of the Ferguson view would lead to a change in the diagnostic category previously categorized by the AP pelvis view. Using the mNY criteria, the results show relatively small changes. Reclassification of non-AS to AS was low at 8.3 and 10.9% for observers 1 and 2, respectively. Reclassification of AS to non-AS was similarly low, with a change in 5.3% of cases for observer 1 and 10.9% for observer 2.

Overall, there were no significant differences between the two modalities. The inter-observer reliability scores were largely similar, with no clear-cut advantage for the dedicated Ferguson SI joint view.

Discussion

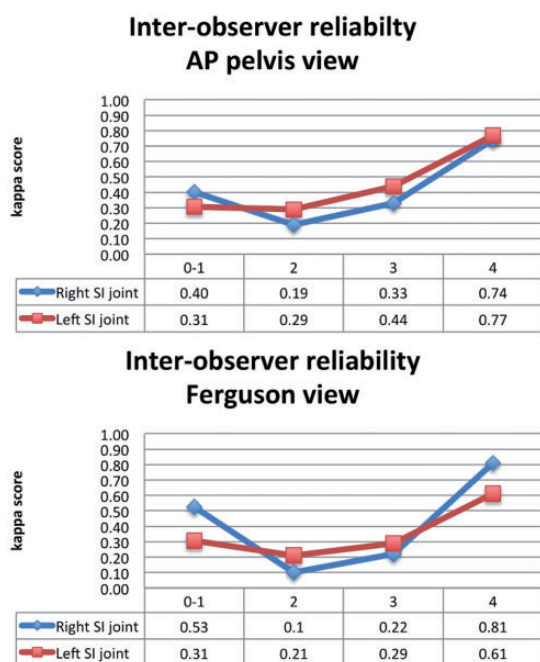
The plain radiograph remains the cornerstone of the classification of AS and is one of the major tools to categorize suspected patients within the spectrum of axial SpA [10]. However, the use of the AP pelvis radiograph to assess SI joints has continued to generate ever-increasing

TABLE 3 Intra-observer reliability and inter-observer reliability results

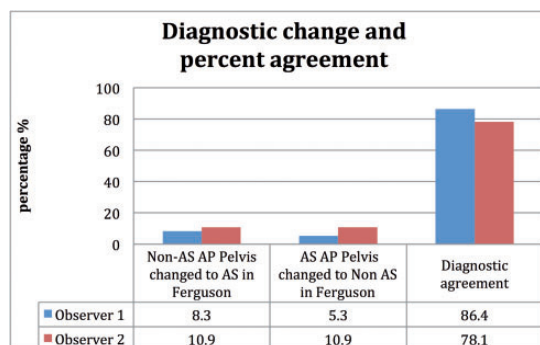
Intra-observer reliability (AP pelvis vs Ferguson)	Observer 1	Observer 2
Right SI joint (ICC+ confidence intervals) ^a	0.73 (0.64, 0.80)	0.69 (0.59, 0.77)
Left SI joint (ICC+ confidence intervals) ^a	0.74 (0.65, 0.80)	0.61 (0.49, 0.71)
Diagnostic	0.47	0.41
Right side (grades 0, 1 and 2)	0.57	0.55
Left side (grades 0, 1 and 2)	0.53	0.46

Inter-observer reliability	Ferguson view (n = 133)	AP pelvis view (n = 133)
Right SI joint (ICC+ confidence intervals) ^a	0.75 (0.66, 0.82)	0.64 (0.53, 0.73)
Left SI joint (ICC+ confidence intervals) ^a	0.69 (0.59, 0.77)	0.66 (0.55, 0.75)
Diagnostic	0.50	0.27
Right SI joint (grades 0 and 1)	0.53	0.40
Left SI joint (grades 0 and 1)	0.31	0.31
Right SI joint (grade 2)	0.10	0.19
Left SI joint (grade 2)	0.21	0.29
Right SI joint combined grades: 0, 1 and 2	0.38	0.41
Left SI joint combined grades: 0, 1 and 2	0.51	0.52
Right SI joint (grade 3)	0.22	0.33
Left SI joint (grade 3)	0.29	0.44
Right SI joint (grade 4)	0.81	0.74
Left SI joint (grade 4)	0.61	0.77

Reproducibility of the methods and reliability of observers were evaluated by means of the single measures intraclass correlation coefficient (ICC) values and kappa statistics where appropriate. ^aICC and the rest of the tests were performed with kappa. Diagnostic category is per modified NY diagnostic criteria [1]. Note that each modality has 133-x-rays. AP: antero-posterior.

FIG. 2 Inter-observer reliability: antero-posterior pelvis vs Ferguson view

Kappa scores included for individual sacroiliac scores. AP: antero-posterior.

FIG. 3 Diagnostic change and agreement between Ferguson and antero-posterior pelvis views for each observer

AP: antero-posterior.

controversy given its poor inter-observer reliability. The SI joint anatomy is complex and thus not readily amenable to clear-cut and reproducible radiographic changes [12]. Even dedicated training does not seem to lead to improved diagnostic performance [2].

In a recent study using AP pelvis radiographs, Van den Berg *et al.* [4] showed that inter-reader agreement between local readers (rheumatologists and radiologists) and central readers (trained specialists) achieved only a moderate degree of agreement at best ($\kappa = 0.54$).

Given the difficulty and inconsistency of AP pelvis views, an important question is whether dedicated radiographs of the SI joint would be advantageous. Data are limited on this issue. One study by Battistone *et al.* [9] addressed this question, where a comparison between AP pelvis and dedicated SI joint radiographs (an oblique view for each SI joint) was obtained. The results of the analysis showed an agreement rate between AP views and dedicated SI joint views of 89.7% for the right SI joint and 86.4% for the left SI joint. The authors' conclusion was that there was very close agreement between the two techniques but they specified that future research is needed to assess the Ferguson view.

Other studies to confirm these findings have been inconsistent [13–15]. There is a trend for better inter-observer reliability towards extreme ends of the grading spectrum, that is, better for grade 0 (normal) and grade 4 (total ankylosis). Understandably, these tend to be easier to read, with the subtle grades 1 and 2 being more difficult to interpret and thus more prone to subjective variability. Consequently the inter-observer reliability is lower for this specific category.

When comparing radiographs with a CT scans, one study from 2007 showed a kappa of only 0.24 (fair), and 41.3% of all the SI joint radiographs gave a discordant result [16].

To the best of our knowledge, no previous study looked specifically at the Ferguson view vs the standard AP pelvis view. Our data show that the Ferguson view shows similar performance to the standard AP pelvis view, revealing no clear advantage. The pooled data for each individual SI joint showed good agreement for both modalities. However, we show that the inter-observer reliability for the diagnostic category seems to be slightly better for the Ferguson view. The higher grades of sacroiliitis (grades 3 and 4) perform comparably in both views, whereas the dedicated view may make subtle structural changes more pronounced as previously shown with other dedicated SI joint modalities [14]. There was a trend towards improvement in reliability for grades 3 and 4.

One of the primary goals of our study was to determine whether the Ferguson view would offer an advantage over the AP pelvis in the grade 1 and 2 categories. Our data show no advantage of the Ferguson over the AP view for these categories. Both views showed similar results for the inter-observer reliability with kappa scores ranging from 0.38 to 0.52 for the combined grades 1 and 2 and a further drop for the more ambiguous grade 2, with an average kappa score of around 0.2 (slight to fair agreement). The intra-observer reliability also showed similar kappa/ICC scores for this specific category. This is likely due to the fact that it relies on the presence of subtle sclerotic and erosive changes, with the latter being difficult to interpret.

A recent study looked at the potential drivers of inter-reader disagreement of AP pelvic X-rays using the mNY criteria lesion types (sclerosis, erosions, joint space narrowing, joint space widening and ankylosis). The results indicated that sclerosis and erosions had the largest

variations between individual readers and among patients with discordant classification, with erosions having the lowest agreement (25%) and the highest odds ratio (13.5) for disagreement [17].

Due to the fact that radiographic scoring plays such an important role for classification and thus potentially for management, it was important to see if there were any significant changes in diagnoses when comparing the two modalities. This is especially important since in certain jurisdictions the presence of diagnostic changes in the SI joints are a necessary precondition for initiating biologic therapies.

In terms of diagnostic change when using the Ferguson view vs the AP pelvic view, the mean diagnostic change from non-AS to AS was 9.6% and for AS to non-AS was 8.1%.

There was an overall diagnostic agreement between modalities of 78.1 and 86.4% for observers 2 and 1, respectively. Our study group had an average disease duration of 13.2 years, and thus the overall radiographic changes may be more established and therefore easier to recognize.

This pattern of diagnostic change seems to be replicated also when using AP pelvis alone but between different readers as indicated in previous studies that looked at diagnostic changes between different readers (central vs local) when using the AP pelvis view. Rudwaleit *et al.* [18] showed that there was an 11.4% recategorization of patients from AS to non-AS when the radiographs were centrally read. A more recent study showed a much higher percentage of 41.5–45.9% recategorization from AS to non-AS [4]. However, this patient population had a shorter disease duration, with potentially less clear radiographic changes, making it more challenging to diagnose locally vs the more trained central readers.

One limitation of our study is that we did not have an external imaging modality for comparisons, such as a CT or MRI, something that has been previously studied when investigating radiographic SI joint imaging [16]. Another potential limitation is that our patient population is from an established SpA clinic with a likely high prevalence of radiographic SI joint changes. It would be useful in future studies to include healthy or non-SpA controls, such as patients with OA. A previous study using CT imaging as a comparator concluded that obtaining an extra oblique X-ray after an initial screening radiograph would only be beneficial if this primary study was equivocal [14].

We have thus shown that dedicated sacroiliac joint radiographic imaging using the Ferguson modality offers no clear advantage over the standard AP pelvis view. Both techniques show similar inter- and intra-observer reliability. Specifically, there was no advantage in the lower grades of sacroiliitis, which are the more technically challenging grades to interpret.

One potential approach to mitigate the limited reliability of radiographic interpretation of sacroiliitis would be to employ a simpler grading system as opposed to the current mNY five-grade classification scheme. Something similar to this was utilized by Moltó *et al.* [19], who

adjusted the mNY criteria by merging grades 2 and 3 into one grade resulting in the following grading system: 0 = normal; 1 = doubtful; 2 = obviously abnormal; 3 = fused. This seems to offer a less ambiguous method, but further research is needed to test this approach to address comparison with the classic mNY criteria.

Due to difficulty of interpretation and poor to moderate inter-observer reliability, there is growing evidence and increasing calls to revisit the role of the plain radiograph in the SpA diagnostic process. CT scans and MRI are currently the most likely alternatives. Available evidence suggests that MRI scanning is especially useful for detecting bone marrow oedema [20] and CT scanning for erosions and ankylosis [21]. However, more research is required to define the diagnostic role for MRI or CT scans before they can be routinely utilized for this purpose. Despite all the described restrictions, accessibility and cost factors dictate that plain radiographs will continue to be applied in the management of axSpA in many centres.

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Supplementary data

Supplementary data are available at *Rheumatology* Online.

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