The Clinical Utility of Computed Tomography Compared to Conventional Radiography in Diagnosing Sacroiliitis. A Retrospective Study on 910 Patients and Literature Review

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ABSTRACT. ***Objective.*** Ankylosing spondylitis (AS) is a progressive, debilitating disease with complex symptoms, unclear etiology and pathogenesis, and difficult diagnosis. Current imaging methods are useful in diagnosing AS and other spondyloarthropathies, and are frequently used in investigations of sacroiliitis. The radiographic diagnosis of sacroiliitis has large interobserver variations. Computed tomography (CT) has been used for evaluation of sacroiliitis since 1979, and has been evaluated in several studies, most of them with a limited number of patients. These studies have shown a large number of false-negative results from radiography.

Methods. In a retrospective study of clinical data, we evaluated 910 patients with AS who were examined by radiography and CT within a 2-year period. The reported outcomes from radiography and CT were compared.

Results. The agreement between radiography and CT data was only fair, with a kappa value of 0.2418. There were 35.0% false-positive radiography reports, 22.5% false-negative radiography reports, and 86.0% false-equivocal radiography reports. In total, 41.3% of all radiological reports gave a false answer. While the number of false negatives was similar to that previously reported, the number of false positives was much higher than previously reported, and is probably similar to everyday radiology reporting.

Conclusion. Our results indicate that the clinical utility of radiography for evaluation of sacroiliitis is limited. The high rate of inaccurate results should motivate the use of sectional imaging for its superior performance. (First Release June 15 2007; J Rheumatol 2007;34:1561–5)

Key Indexing Terms:

SPONDYLOARTHROPATHIES DIAGNOSIS ANKYLOSING SPONDYLITIS
DIAGNOSIS TOMOGRAPHY X-RAY COMPUTED
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Ankylosing spondylitis (AS) is a progressive, debilitating disease with complex symptoms and unclear etiology and pathogenesis. Diagnosis is difficult, and delayed diagnosis as well as unsatisfactory management and treatment is not uncommon[1]. There is frequently a delay of several years from the start of symptoms until the radiographic diagnosis of sacroiliitis[2].

Diagnostic imaging methods assist in the diagnosis of AS and other spondyloarthropathies, and are used frequently in examination for suspected sacroiliitis. Conventional radiographic evaluation of sacroiliitis is an important part of diagnostic criteria such as the New York criteria[3,4].

It is well known that the radiographic diagnosis of sacroiliitis has large interobserver variations[5,6]. This may account for at least some of the variation in the reported frequencies of false-positive and false-negative diagnoses. Computed tomography (CT) has been used for evaluation of sacroiliitis since 1979[7]. Several studies report a large number of false-negative radiography examinations, whereas CT has been reported to show higher accuracy[8-11].

Most reports comparing the outcome of radiography to CT or magnetic resonance imaging (MRI) are based on small populations and few controls[9-24]. These studies evaluated different diseases of the sacroiliac (SI) joints. Only one study evaluated a larger number of patients[25]. These reports have shown that CT and MRI have higher sensitivity and specificity than radiography for the diagnosis of sacroiliitis. It has been advocated that radiography should be the initial radiological examination and additional imaging should be done only when the radiographic results do not support the clinical diagnosis[26].

We carried out a retrospective study to assess the utility of CT reports compared to radiography reports in everyday clinical practice in a large number of patients with AS. The assumption was that CT is more accurate than radiography, thus improving decision-making and clinical outcome as well

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as saving healthcare resources and possibly decreasing patients' exposure to ionizing radiation.

MATERIALS AND METHODS

CT of the SI joints has been an established examination method at Sahlgrenska University Hospital since 1980. Photocopies of every CT report were archived for research purposes in the period 1981–1992. All reports generated after 1990 are accessible in the radiology information system.

All CT reports and referral forms were retrieved for CT examinations of the SI joints between 1981 and 1997. The reports and referral forms for radiographic examinations of the SI joints on the same patients were also retrieved. In total, 1477 records of CT examinations were located. Two records were false registrations of examinations not performed. In 3 cases, the clinical information on the request form was incomplete, the clinical information on the CT report was incomplete, and the radiographs were missing. In another 3 cases either the referral forms or the radiology reports were missing. In 23 instances cases were excluded since the patients were under the age of 18 years. In 17 cases the examinations were performed for evaluation of a tumor, in 5 cases for evaluation of a fracture, and in 2 cases for evaluation of postoperative pain after spine surgery. These cases were also excluded, since the examinations were not targeted on the SI joints. After exclusions, 1422 CT examinations were available for analysis.

Of the 1422 patients examined by CT, 1150 had also been examined with radiography. It was impossible to ascertain the outcome of the radiographic study for 70 patients due to incomplete or missing reports, and these patients were excluded. Of the remaining 1080 patients who had been examined with both CT and radiography and where radiology reports for both examinations were available, 910 patients had been examined with radiography either on the same day as the CT examination or within 730 days (2 years) before the CT examination. Patients with radiography either after CT or more than 730 days before CT were excluded.

All CT examinations had been performed at Sahlgrenska University Hospital. Radiographic examinations from all radiology departments in the Gothenburg region of Sweden were included in the study.

Radiographic technique. The radiographic techniques varied. Examinations targeted on the SI joints at Sahlgrenska University Hospital, as well as at most other hospitals, were performed with a Ferguson view and one additional anteroposterior (AP) oblique view of each SI joint. Other examinations such as an AP pelvis examination, an AP radiograph of the sacrum, or a posteroanterior (PA) view of the SI joints were also included if the reporting radiologist had commented on the status of the SI joints at the time of the examination.

CT technique. All CT examinations were performed with contiguous slices 3–4 mm thick, angled in a semicoronal fashion parallel to the anterior border of the sacrum[12,17], with a high-resolution algorithm. Studies using older CT scanners with limited gantry tilt ability were done with the patient prone with a pillow under the hips. Studies using modern CT scanners with 30° gantry tilt ability were done with the patient supine. The CT technique remained the same regarding technical factors such as gantry tilt, slice thickness, and kV and mA settings. The spatial resolution increased from a matrix of 320 × 320 pixels on older scanners to 512 × 512 on newer ones. The acquisition time decreased from a scan time of > 30 seconds down to 1–2 seconds, which has led to the elimination of almost all motion artifacts.

All examinations, both radiography and CT, were interpreted using hardcopy films. The radiology reports were generated by radiologists on duty at the time of the examination. The request forms and written radiology reports formed the basis for the study.

Four groups of patients were identified based on the clinical indications for the CT examination, taken from the CT request form. These groups were patients with: (1) inflammatory back pain[27] with symptoms such as morning stiffness and nightly awakening due to pain, and improvement with physical exercise; (2) low back pain of suspected noninflammatory origin, such as sciatica or diffuse lumbago; (3) hypermotility symptoms after pregnancy; and (4) other symptoms or clinical history such as tumor or trauma.

The originally reported outcomes of radiography and CT, respectively, were classified as: (1) normal or normal with degenerative changes, (2) equivocal for sacroiliitis, (3) pathologic, thus uni- or bilateral sacroiliitis, and (4) other findings such as postoperative changes, fractures, or osteitis condensans ilii.

The measure of concordance between the radiography and CT reports was calculated using unweighted kappa. The strength of agreement was judged according to Altman[28].

RESULTS

Physicians referring patients for CT were mainly rheumatologists (586, 64.4%) and orthopedic surgeons (201, 22.1%) with general practitioners as the third group (74, 8.1%). Various other physicians made up the remaining 5.4% (n = 49). The indications for referral for CT were inflammatory back pain in 499 patients (54.8%), mechanical back pain/sciatica in 312 patients (34.3%), hypermotility in 20 patients (2.2%), and other indications in 18 patients (2.0%). There were insufficient data about indications in 61 cases (6.7%). In this latter group, 35 CT examinations had been requested for followup of a previous radiographic examination. More than half the patients thus had clinical symptoms suspicious for inflammatory SI disease.

The radiographic results are reported in Table 1. Equivocal findings were 2.5 times more frequent (250/100) than definitive pathological diagnoses.

The CT results are reported in Table 2. Contrary to the radiographic results, pathologic findings were about 2.6 times more frequent (230/87) than equivocal findings when using CT. The number of pathological diagnoses was thus about 2.3 times more frequent with CT than with radiography, supporting the referring physician's decision to a much greater degree.

Table 1. Outcome of 910 sacroiliac joint radiographs.

Outcome	Number (%)
Sacroiliitis	100 (11.0)
Equivocal findings	250 (27.5)
Normal or degenerative changes	554 (60.9)
Other diagnoses	6 (0.7)
Total	910 (100.0)

Table 2. CT diagnosis in 910 examinations of the sacroiliac joints.

Diagnosis	No. of Examinations	Sum	%
Sacroiliitis, bilateral	187		
Sacroiliitis, unilateral	43	230	25.3
Equivocal	35		
Followup recommended	52	87	9.6
Severe degenerative changes	2		
Moderate degenerative changes	23		
Mild degenerative changes	194	219	24.1
Osteitis condensans ilii	31		
Normal	335	366	40.2
Tumor	1		
Fracture	1		
Postoperative findings	4		
Miscellaneous	2	8	0.9
Total	910	910	100.0

Comparing the reported diagnoses at radiography and CT, only 65/100 (65.0%) radiographic examinations showing sacroiliitis could be confirmed on CT (Table 3). The kappa value for these comparisons was 0.2418 (standard error 0.0265), indicating only fair agreement. Equivocal radiographic findings were reported as pathological on CT in 88/250 cases (35.2%), and as normal in 127 cases (51.0%). The CT result was pathological in 77/560 (13.8%) radiographic examinations assessed as normal.

Radiography was thus true-positive in 65.0% of the 100 examinations judged as pathologic (Table 4), with CT confirming the positive diagnoses. Radiography was true-negative in 77.5% of the 580 normal radiographic examinations. However, considering all the data for 910 patients, 41.3% of the radiographs were incorrectly diagnosed or the results were equivocal.

Uni- or bilateral sacroiliitis diagnosed by radiography thus showed a high rate of false-positives, as only 65.0% could be confirmed with CT. Radiography also yielded 22.5% false-negative examinations. Normal radiography, where CT showed equivocal changes, was encountered in 5.4% of the patients. In summary, there was a lack of agreement between CT and radiography in a large proportion of patients.

Considering a subset of 363 patients where radiography had been obtained within 90 days before the CT examination, the figures were similar. In this subset, radiography was true-positive in 69.6% (32/46 patients) and false-negative in 20.2% of the examinations (41/203). This gave a total of 42.7% false outcomes in this subset.

DISCUSSION

The techniques for both radiography and CT remained unaltered for the duration of the study. PA views of SI joints were accepted as equal to special projections in daily practice[29], and examinations consisting of PA radiographs of the SI joint without special projections were included. A number of radiographic techniques for examining the SI joints have been described[30,31], and the many different projections may be an indication of the difficulty in radiographically diagnosing sacroiliitis. The use of a single AP pelvis radiograph has been advocated[32,33].

Table 4. True- and false-positive, negative, and equivocal findings of 910 radiographs of the sacroiliac compared to CT. The CT diagnoses are regarded as correct.

	True		False		Total
	n	%	n	%	n
Positive	65	65.0	35	35.0	100
Negative	434	77.5	126	22.5	560
Equivocal	35	14.0	215	86.0	250
Total	534	58.7	376	41.3	910

Borlaza, *et al* reported the entrance skin dose for CT to be about twice that of a routine AP radiograph of the SI joints[13]. The effective dose to female gonads has been reported to be 2.5 times lower for a semicoronal CT than for an AP radiograph[34], but higher to male gonads. Jurik, *et al*[34] recommend using semicoronal CT instead of radiography in women due to lower radiation dose. In men, an AP radiograph may be justified from a radiation point of view, but the higher diagnostic capacity of CT may offset this. In all cases, semicoronal CT gave less effective dose than axial CT[34]. In a study by Damilakis, *et al*[35], skin dose was reduced by more than half and the 8.5 cm depth dose was slightly lower for CT compared to radiography or conventional tomography when using a high-resolution protocol of CT slices 1.5 mm thick and in 5 mm increments. With this protocol, they reported the CT dose was significantly reduced compared to using 5-mm contiguous slices. The use of a partial CT examination has been proposed by Friedman, *et al*[36]. They used 3 representative 3-mm slices through the SI joints instead of the full series, in conjunction with a reduction of tube current. They reported a dose reduction of half compared to radiography, and a 20-fold reduction compared to the full CT series using normal tube current. In their retrospective study on 21 patients with sacroiliitis, the diagnosis would in all cases have been made with the 3-slice series. To our knowledge, no dose calculations or examination protocols using multi-detector CT technology have been published.

There is a high degree of observer variation in evaluating sacroiliitis on radiographs[5,6]. It has been suggested as the cause of "sacroiliitis" reported in certain disease states[37]. This

Table 3. Differences in reported outcome between CT and radiography in 910 patients referred for suspected sacroiliitis. Cases with degenerative findings and osteitis condensans ilii are included among normal findings. Percentages shown are for the entire data set. Kappa value 0.2418, standard error 0.0265, indicating only fair agreement.

	Radiography							
	Pathologic		Equivocal		Normal		Total	
	n	%	n	%	n	%	n	%
CT								
Pathologic	65	7.1	88	9.7	77	8.5	230	25.3
Equivocal	3	0.3	35	3.8	49	5.4	87	9.6
Normal	32	3.5	127	14.0	434	47.7	593	65.2
Total	100	11.0	250	27.5	560	61.5	910	100.0

factor may account for at least some of the variation in the frequencies of false-positive and false-negative diagnoses in our study, and the need for followup studies after equivocal results from radiography. It has been argued that the results from population studies can be improved by careful training and by using example radiographs[32], but another report showed that training did not improve either sensitivity or specificity for sacroiliitis on radiography[38].

The 41.3% incorrect radiographic diagnoses and the insecurity regarding the validity of true-positive and -negative diagnoses emphasizes the comparatively low value of radiography as a diagnostic tool for evaluation of sacroiliitis. The rate of false-negative radiographic diagnoses we observed is similar to previous reports giving figures such as 6/17[18], 12/37[21], and 20/30 patients[9]. The high rate of false-positive radiographic diagnoses (35.0%) in our findings cannot readily be compared with other reports as reliable frequency figures are lacking, and the focus in earlier reports has been on false-negative results, not false-positive findings. The possibility of false-positives has been mentioned in single cases[13,39], and in one study a result of 8% false-positives was given[40]. The numbers presented in our study are most likely not remarkably high, as good techniques were used at both radiography and CT. The frequency of false-positives in our study is probably similar to the accuracy in everyday radiology reporting, and would not be the same as in a study situation. In a study situation according to protocols, or in reviews, participants tend to be more careful and concerned with accuracy and exactness than in everyday clinical practice. This is known as the Hawthorne effect — the phenomenon of altered behavior resulting from the awareness of being part of an experimental study[41,42]. It is well known in the orthopedic field that the outcome of all procedures improves when patients are included in a study, compared to everyday practice.

Neither clinical data on the referral form nor the radiology report have been controlled, since the aim was to assess which radiology technique best served the treating physician in real-life decision-making. Thus we have not attempted to assess the technical efficacy of the methods. It has been argued that case notes are useful in retrospective evaluation of clinical performance[43]. As most patients were referred by specialists in rheumatology and orthopedics, the selection of the patients for radiology examinations based on clinical findings was the best obtainable. The decision to include radiographs obtained up to 2 years before the CT examination was felt to be reasonable, since the progression from initial symptoms to radiographic findings is slow. In a study by Mau, *et al*[2] the development of radiological sacroiliitis was reported to occur after an average disease duration of 9 years. In another study, the progression of disease was estimated to be 35% for every 10 years of disease[44]. There were no obvious differences in the results from subsets of 2-year-old and 90-day-old radiographs. In both cases, true-positives ranged between 65.0% and 69.6%, and true-negatives between 77.5% and 79.8%. However, in both subsets the outcome of 41.3% to 42.7% of all radiography examinations was false, to a large extent because so many of the radiography examinations were reported as equivocal, which was not the case with CT.

The main conclusions drawn from our study are based on the acceptance of CT as an adequate, readily available diagnostic technique[8,9,12,13]. MRI has a similar capacity to detect manifest disease, but has better capability to detect early stages of sacroiliitis[11], due to its ability to detect bone marrow edema[45] before morphologic changes can be detected by CT. Thus, MRI also has the capacity to monitor response to treatment.

All CT diagnoses in our study cannot be considered correct. Early inflammation will be overlooked before erosions or inflammatory sclerosis are apparent. In 9.6% of the 910 CT studies the diagnosis was equivocal or followup was recommended. These results indicate that even with good experience and good technique the interpretation of images is not always clear, and observer variation is probably the reason for borderline cases also with CT and MRI. It is not unlikely that false-negatives occur in CT especially prior to erosions. The discrete inflammatory sclerosis that frequently is the first sign of inflammatory disease may be overlooked. False-positives may be caused by inadequately interpreted synovial cysts[46].

A common algorithm proposed for investigating the SI joint is to use radiography as the first imaging method after evaluation of clinical and laboratory findings, and then after negative radiography, proceed to more advanced imaging such as CT or MRI[26]. Costs and radiation dose are frequent arguments for performing radiography first and using advanced imaging when the results are not in agreement with the clinical findings.

In conclusion, there are several flaws with the use of radiography for the diagnosis of sacroiliitis, and our results indicate that its clinical utility for evaluation of sacroiliitis is limited. The number of insufficient radiographic diagnoses (false-positive, false-negative, and equivocal) was more than one-third of the total material, and several of the true radiographic diagnoses could not be trusted because of the overall low accuracy rate. The use of radiography for evaluation of sacroiliitis might thus be seriously questioned. The necessity of acquiring positive or negative imaging findings for a correct diagnosis of sacroiliitis speaks for sectional imaging as the method of choice.

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