

## Quantitative sacroiliac joint scintigraphy in normal subjects and patients with sacroiliitis

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The aim of this study is to determine the sacroiliac index (SII) of healthy subjects and to compare these values with patients having sacroiliitis (SI). Quantitative sacroiliac scintigraphy (QSS) was performed with Tc-99m hydroxy methylene diphosphonate (HMDP) and whole sacroiliac joint-to-sacrum ratio was calculated as a SII by the region of interest (ROI) method. Forty-seven nonarthritic healthy subjects and 13 patients with SI were studied. Effects of aging, gender and laterality on SII were evaluated in 47 healthy subjects.

The sacroiliac index was higher in men than women ( $p < 0.05$ ). SII did not change significantly in aged men, but it decreased significantly in aged women ( $p < 0.05$ ). Eleven of 13 patients with SI had a higher SII than healthy subjects ( $> \text{mean} + 2\text{SD}$ ). In the other two cases by using small ROIs, SIIs were found to be higher than the normal range. Our results suggest that QSS is a sensitive method for the diagnosis of early stage SI and every institution should establish its own normal SII.

**Key words:** sacroiliitis, sacroiliac joint, quantitative sacroiliac scintigraphy

### INTRODUCTION

THERE ARE NO INTERNATIONALLY ACCEPTED CRITERIA for the assessment of disease activity in patients with SI.<sup>1</sup> Early diagnosis is important for starting appropriate treatment. Evaluation of the sacroiliac joints by physical examination may not distinguish between inflammatory back pain and other causes of chronic low back pain.<sup>2,3</sup> Laboratory tests have been used to detect disease activity, but all of them are nonspecific.<sup>4-6</sup> X-Ray and CT can detect sacroiliac joint erosion, sclerosis and fusion which are late manifestations of the disease, but these can not help in the diagnosis of early stage SI.<sup>4,6</sup> Bone scintigraphy is a sensitive method for diagnosing early stage SI.<sup>6-8</sup> Sacroiliac joint scintigraphy demonstrates joint inflammation while radiological changes are minimal or absent but the

accumulation of bone scanning agents in sacroiliac joints is normally high and visual assessment is not sensitive.<sup>6,8</sup> The sensitivity of this method can be increased by quantitative assessment and in this way it may be possible to diagnose bilateral SI more objectively. Positive predictive values for early phase SI are 85% by QSS, 46% by CT and 43% by X-Ray.<sup>6</sup> MRI is the most sensitive imaging method for detecting and diagnosing early SI, but the use of MRI in the diagnosis of SI is limited.<sup>6</sup> For these reasons, QSS has been used to measure joint activity.<sup>7</sup> Every institution establishes its own normal range based on the use of quantitative techniques.

The aim of this study is to find the SII of healthy subjects and to compare these values with patients having SI.

### PATIENTS AND METHODS

Forty-seven healthy subjects [36 (13 male, 23 female) aged between 20 and 60 (mean age of  $40.5 \pm 10.3$ ); 11 (5 male, 6 female) aged over 60 (mean age of  $66.4 \pm 3.0$ )] and 13 patients [(9 male, 4 female) aged between 17 and 50 (mean age of  $31.1 \pm 9.4$ )] with SI were included in the study. Three hours after i.v. injection of 740 MBq Tc-99m

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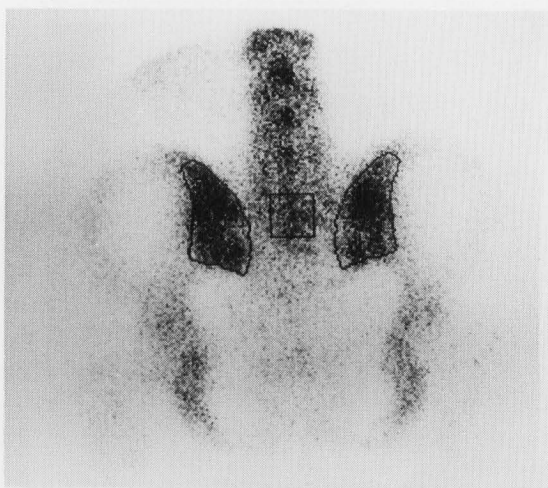
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HMDP, anterior and posterior images of the pelvis were obtained. 256 × 256 computer matrices were used in data collection. 400,000 preset counts per image were stored. Free ROI was drawn for one sacroiliac joint and mirror ROI was used for the other sacroiliac joint for the calculation of SII (Fig. 1). A rectangular 20 × 20 pixel ROI was drawn from the most active part of the sacrum which represented the reference bone. Focal ROIs of equal size were set to the inflamed part of joints in two patients with sacroiliitis. SIIs were calculated for each ROI with the following formula:

$$\text{Left SII} = \frac{\text{Average counts of left sacroiliac joint ROI}}{\text{Average counts of sacrum ROI}}$$

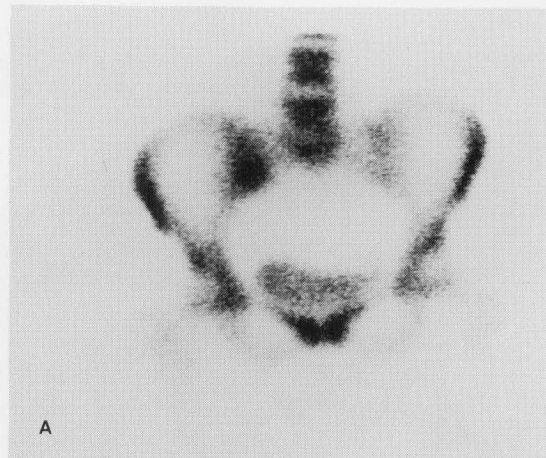
$$\text{Right SII} = \frac{\text{Average counts of right sacroiliac joint ROI}}{\text{Average counts of sacrum ROI}}$$

Student's t-test was used in the statistical analysis of SII in the early and late stage SI and the effects of aging, gender and laterality on SII. Mean ± 2SD SII values for age and gender in healthy subjects were determined. SIIs of patients with SI were regarded as abnormal if out of this range.



**Fig. 1** Whole sacroiliacal free ROIs and sacral rectangular ROI (posterior view) were used in the quantitative analysis of joint activity.

All patients had a radiograph of the sacroiliac joints. The radiological findings of the sacroiliac joints were graded 0–4 according to the atlas of standard radiographs of arthritis (Grade 0 = Normal, Grade 1 = Dubious, Grade 2 = Irregular widening of joints spaces with adjacent bone sclerosis, Grade 3 = Irregularity of joints spaces and noticable adjacent bone sclerosis, Grade 4 = Complete bony ankylosis).<sup>9</sup>



**Fig. 2** The Tc-99m HMDP images of a patient (No. 13) with right-sided early phase (Grade 0) sacroiliitis show increased diffuse uptake in anterior (A) and posterior (B) views.

**Table 1** The effects of aging and gender on SII in healthy subjects (mean ± SD)

	Female		Male	
	20–60y n = 23	> 60y n = 6	20–60y n = 13	> 60y n = 5
Left SII	0.98 ± 0.12	0.88 ± 0.06*	1.09 ± 0.11 <sup>a</sup>	1.07 ± 0.04 <sup>b</sup>
Right SII	0.99 ± 0.14	0.88 ± 0.06**	1.09 ± 0.10 <sup>c</sup>	1.06 ± 0.04 <sup>d</sup>

<sup>a,b,c,d</sup> Significantly higher ( $p < 0.05$ ) than corresponding females

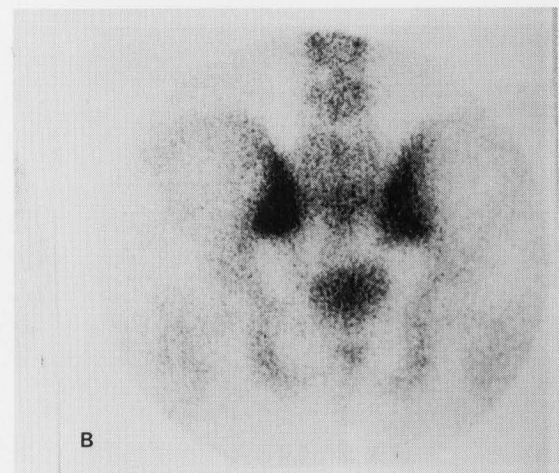
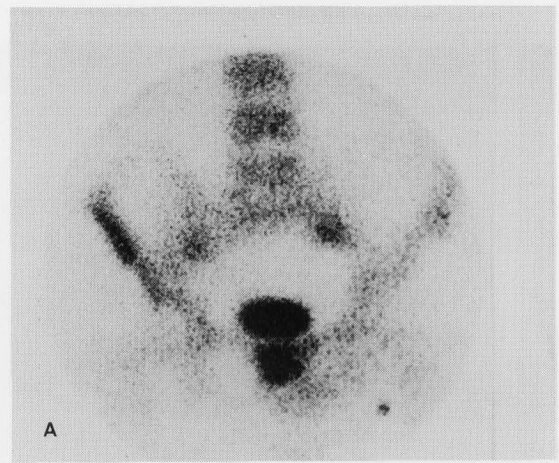
\*,\*\* Significantly lower ( $p < 0.05$ ) than 20–60 years females

## RESULTS

The normal range of SII values for females and males are given in Table 1. When the subjects are separated by gender, significant difference was found between SII of females and males. SII was higher in men than women ( $p < 0.05$ ). SII did not change significantly in aged men, but it decreased significantly in aged women ( $p < 0.05$ ) (Table 1). In all healthy subjects no significant difference could be found between the left and right SII (Table 2).

The clinical details, radiological findings and SII values of 13 patients (4 females and 9 males; age 17–50 years) with SI are shown in Table 3. The subjects having values greater than mean + 2SD were accepted as having sacroiliitis. Eleven of 13 patients demonstrated higher SII than healthy subjects (11/13, 85%). In two patients (Nos. 8 and 9) SII of the whole joints were within normal range while focal increased activity was visualized in lower part of sacroiliac joints. And, the inflamed sacroiliac joints were divided into two small regions for calculating SIIs. Using this method, SII of inflamed areas were found to be higher than normal range (1.35 versus 1.28 and 1.31 versus 1.22; small region versus whole region respectively). In patients with early phase SI (Grade 0, 1, 2) (Fig. 2), SII was higher than the patients with advanced disease (Grade 3, 4) (Fig. 3) (Mean  $\pm$  SD;  $1.37 \pm 10.07$  versus  $1.22 \pm 0.07$ ;  $p < 0.0005$ ).

In patients with unilateral SI, the inflamed part of the joint could be seen easily in the anterior view. However,



**Fig. 3** In a patient with bilateral sacroiliitis (No. 1), left side shows increased uptake (early phase, Grade 2), right side shows normal uptake (late phase, Grade 4), in the anterior (A) and posterior (B) views.

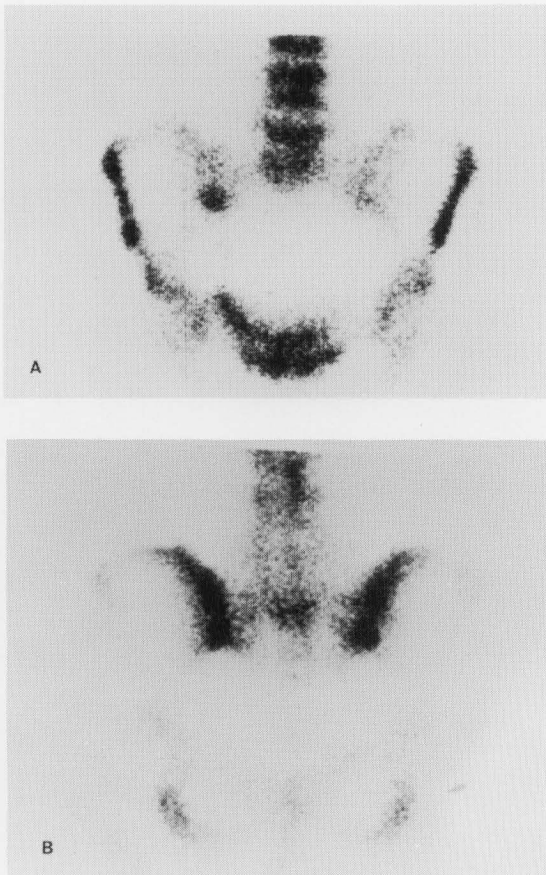
**Table 2** SII of healthy subjects in range with mean  $\pm$  2SD

	Female		Male	
	20–60y n = 23	> 60y n = 6	20–60y n = 13	> 60y n = 5
Left SII	0.74–1.22	0.76–1.00	0.87–1.31	0.99–1.15
Right SII	0.72–1.27	0.76–1.00	0.89–1.29	0.98–1.14

**Table 3** Clinical details, radiological findings and SII values in 13 patients with sacroiliitis

No.	Age	Sex	Clinical diagnosis	Radiological grade		Sacroiliac index	
				Left	Right	Left	Right
1	39	M	Bilateral SI	G2	G4	1.35	1.16
2	25	M	Bilateral SI	G4	G2	1.13	1.34
3	50	M	Bilateral SI	G1	G1	1.56	1.50
4	34	M	Bilateral SI	G4	G3	1.22	1.33
5	35	M	Bilateral SI	G1	G1	1.34	1.36
6	25	M	Left SI	G2	G0	1.34	1.08
7	28	M	Right SI	G0	G1	1.26	1.34
8	20	M	Right SI	G0	G2	1.15	1.28*
9	40	M	Right SI	G0	G3	1.00	1.22*
10	26	F	Bilateral SI	G1	G1	1.33	1.35
11	35	F	Bilateral SI	G1	G3	1.32	1.28
12	17	F	Bilateral SI	G1	G1	1.34	1.36
13	30	F	Right SI	G0	G0	1.01	1.29

\*SII values of whole ROIs were within normal range but using small ROIs, SII values were found to be high.



**Fig. 4** The inflamed part of the joint was visible in the anterior view (A), but in the posterior view (B) focal increased uptake couldn't be observed because of normally high sacroiliac activity in a patient with right sided sacroiliitis (No. 8).

in the posterior view the normal high sacroiliac activity may result false negative interpretation (Fig. 4). When in the visual evaluation neither anterior nor posterior views can objectively diagnose bilateral SI, SII was valuable to detect the disease in all pathologic cases.

## DISCUSSION

Clinical diagnosis of early stage SI is difficult. Laboratory findings are nonspecific. The radiological changes may appear several years after onset of the disease.<sup>4,6</sup> However, early diagnosis is important to start an appropriate treatment.

QSS is a sensitive method to detect early phase SI. The accumulation of bone scanning agents in sacroiliac joints is high in healthy subjects and visual assessment is not sensitive enough to detect the increased uptake of inflamed joints.<sup>8</sup> For these reasons quantitative techniques have been used to measure the joint activity more objectively.<sup>6,7</sup>

The aim of this study is to find the SII of healthy subjects using Tc-99m HMDP and to compare these

values with patients having SI. In our study right and left SII for females and males ranged, 0.72–1.27, 0.74–1.22; 0.89–1.29, 0.87–1.31 respectively. Vays et al.<sup>10</sup> studied 20 females and 28 males aged 21–60 years and SII values ranged for the right and left sacroiliac joints 0.92–1.48, 0.88–1.32; 0.87–1.67, 0.82–1.62 respectively. Our values were lower than Vays et al. Since SII varies according to the quantitative method and bone scanning agents used<sup>11–13</sup> every institution should establish its own normal range.

Our study showed that SII of men was higher than women in healthy subjects. This result is consistent with the report of Vays et al.<sup>10</sup> Although Pitkanen et al. have demonstrated a regression with age both in women and men,<sup>14</sup> our study demonstrated that in females SII decreased with age ( $p < 0.05$ ) while in males age did not have any significant effect on SII ( $p > 0.05$ ). Tuomo Lantto reported a trend of decreasing SII with increasing age which was not statistically significant.<sup>7</sup> The possible reason for the decrease of SII with age in women may be postmenopausal osteoporosis.

In healthy subjects we found no difference of left and right SII. This result is consistent with previous reports.<sup>10,11</sup> In this study, we evaluated 13 patients with SI. In unilateral SI patients, the inflamed part of joint was visible in anterior views. In posterior views, sacroiliac joints demonstrated normally high activity and it was difficult to notice the increased focal uptake of joints. In addition, anterior view was not useful in the visual evaluation of the sacroiliac joints in patients with bilateral SI. For these reasons, quantitative analysis was used to evaluate the sacroiliac joint uptake more objectively. Eleven of 13 patients demonstrated higher SII than healthy subjects. In the other two patients with focal increased activity in the lower part of sacroiliac joint, SII was within normal range. This result was due to average the counts of every pixel in whole sacroiliac ROI. Therefore the inflamed sacroiliac joints were divided into two small regions and the SIIs were calculated for each small region. The sensitivity of this method can be increased by using smaller ROIs. Tuomo Lantto suggested that by using smaller ROIs, the sensitivity of the method seemed to increase.<sup>7</sup> We noticed that patients with long-standing disease had normal SII. In patients with early phase SI in whom radiological changes are minimal or absent, SII was significantly higher than the control group.

In conclusion, our results suggest that, QSS is a sensitive method in the diagnosis of early stage SI and every institution should establish its own normal range based on the use of quantitative technique and bone scanning agents.

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