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The value of quantitative sacroiliac scintigraphy in detection of sacroiliitis

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SUMMARY To evaluate clinical usefulness of quantitative sacroiliac scintigraphy (QSS) in detecting sacroiliitis, we used a modified, pixel by pixel technique for calculating sacroiliac joint/sacrum uptake ratios (sacroiliac joint index - SII). We studied 90 controls, 18 selected patients with active sacroiliitis, 2 ankylosing spondylitis patients with completely ankylosed sacroiliac joints, 14 patients with nonspecific low back pain and 5 patients with rheumatoid arthritis. In the controls, we found that the SII decreases with increasing age ($P<0.001$) and is higher in males than in females ($P<0.005$). In the patients with active sacroiliitis, 9 out of 14 older than 30 had an abnormal SII; 3 of these patients showed no radiographic or CT abnormalities of the sacroiliac joints. None of the 4 patients with sacroiliitis under 30 years of age had values which fell out of the normal range for their age and sex. Only 1 of the 14 patients with non-inflammatory low back pain had an abnormally high SII. A borderline SII was found in 1 of the 5 patients with rheumatoid arthritis. QSS may be useful in detecting active sacroiliitis, sometimes even before the occurrence of radiologic abnormalities. However, because of its low sensitivity, its clinical usefulness is limited, especially in patients under 30 years of age.

Key words: Quantitative Sacroiliac Scintigraphy, Sacroiliac Joints, Sacroiliitis, Ankylosing Spondylitis, Bone Scintigraphy.

INTRODUCTION

Increased uptake of radioactive materials in the sacroiliac joints of patients with sacroiliitis has been observed since 1969 (1). A numerical representation of the sacroiliac joint uptake (quantitative sacroiliac scintigraphy — QSS) can be obtained by calculating the ratio between the uptake of radio-

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active material in the sacroiliac joints and that in another area - usually sacrum or femur. QSS with Tc-99m phosphates has been performed employing two techniques: the count profile and the region of interest (ROI). In the count profile technique (2) a wide horizontal count profile is created over the midpart of the sacroiliac joints and the ratio between the peak uptake in each sacroiliac joint and the sacrum is calculated. In the ROI technique, separate ROI's are created over the sacroiliac joints, sacrum and/or femur and ratios of uptake in these areas are calculated (3).

The count profile technique was found by some to be very sensitive in diagnosing sacroiliitis associated with ankylosing spondylitis (4), psoriasis (5), Reiter's syndrome (6,7) and Crohn's disease (8), but it has also been found to yield abnormal results in cases of rheumatoid arthritis (2) as well as in women with low back pain without radiographic evidence of sacroiliitis (9,10). Others have found overlap between patients and normal controls as well as false positive cases (patients with metabolic bone disease or structural abnormalities of the low back) (11,12). Furthermore, some have obtained results which are opposite to those mentioned above, leading to the conclusion that the technique is not clinically useful for early diagnosis of sacroiliitis (13,14).

With the ROI technique, the sacroiliac joint/sacrum ratios were found to be useless in diagnosing sacroiliitis in two studies (15,16). Others found a significant difference in uptake ratios of sacroiliac joint/femur (17,18) when compared with a control group.

In order to evaluate usefulness of QSS in detection of sacroiliitis, we have used a modification of the count profile technique which permits analysis of sacroiliac joint uptake in greater detail. We applied it in controls to establish normal values, and in several groups of patients.

PATIENT GROUPS

The study was carried out on 129 subjects, divided into 5 groups:

Group A

comprised 90 controls - 37 males and 53 females - who had bone scintigrams for reasons other than sacroiliitis- e.g. metastatic work-up, osteomyelitis, traumatic lesions of bone, etc. All individuals in this group denied low back pain on direct questioning. Patients with skeletal metastases or disturbances of calcium or phosphorus metabolism were excluded.

Group B

(''Active Sacroiliitis'') included 18 patients - 12 women and 6 men - who were diagnosed as having active sacroiliitis on the basis of history and physical findings. They all had chronic low back pain of insidious onset, worsened with rest and lessened on ambulation and with exercise. The pain was worse at night and the pain and stiffness were prominent at the time of getting out of bed in the morning. On clinical examination there was tenderness over the sacroiliac joints. Fourteen of these 18 patients had roentgenographic and CT evidence of sacroiliitis (9 with primary ankylosing spondylitis, 4 with associated Crohn's disease and 1 with psoriasis). The roentenographic evidence of sacroiliitis was graded according to the New York criteria (19), and these 14 patients had at least Grade 2 bilateral sacroiliitis. The remaining 4 patients (all females) who had symptoms and signs of sacroiliitis but had no roentgenographic or CT abnormalities of their sacroiliac joints, were all HLA-B27 positive.

Group C

(''Advanced Ankylosing Spondylitis'') included 2 ankylosing spondylitis patients with completely ankylosed sacroiliac joints (Grade 4) and no sacroiliac pain or tenderness.

Group D

(''Non-inflammatory low back pain'') included 14 patients - 11 women and 3 men -

with low back pain without tenderness over the sacroiliac joints and without roentgenographic, CT or laboratory evidence of inflammatory disease of the sacroiliac joints.

Group E

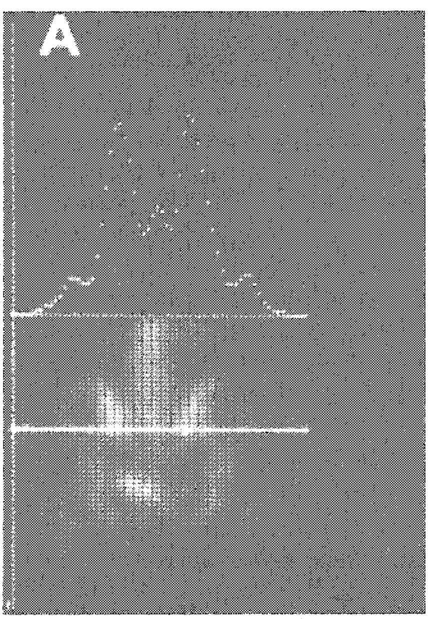
("Rheumatoid Arthritis") included 5 patients - 2 women and 3 men - with known rheumatoid arthritis without symptoms or signs related to the sacroiliac joints, and with normal roentgenograms of the sacroiliac joints.

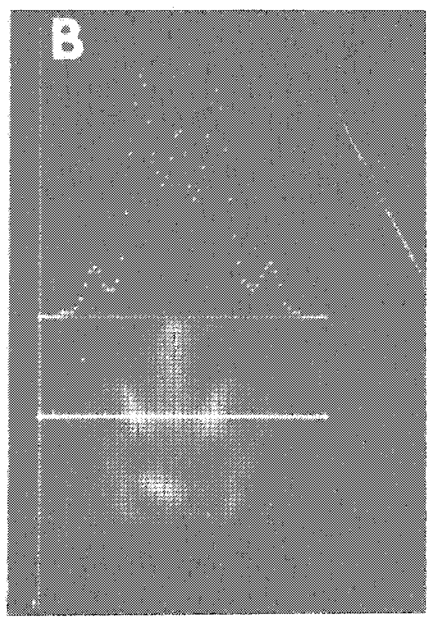
MATERIAL AND METHOD

Three hours after intravenous injection of 20 mCi of Tc-99m methylene diphosphonate, the patient was placed in the prone position and a posterior image of the pelvis was obtained with a large field of view gamma camera (Searle LFOV), using a high resolution parallel hole collimator. The acquisition time was 5 minutes; this allowed for acquisition of 1.5 - 2 million counts. The information was also acquired on a minicomputer (MDS-PAD) in a 64 x 64 pixel array.

The image was first smoothed using a 9-point smoothing technique. We then created multiple horizontal profiles, each only 1 pixel wide. The series of such horizontal profiles covered the entire height of the sacroiliac joints as well as the area above the iliac crests to the lower pole of the kidneys. The computer was used to create an uptake profile curve for each level, thus displaying the total counts in each individual pixel (Fig. 1). From each profile curve we then selected and listed separately, 3 pixels: those with the peak count rates at each sacroiliac joint and that pixel with the peak count rate at the sacrum. For the sacroiliac joint uptake measurement, we selected from this list that pixel which had the highest count at each joint. For sacral uptake we averaged the counts in the pixels with the peak count rate in the sacrum for 6 or 7 profile curves centered at the level of the maximal sacroiliac joint uptake.

For background measurement we selected from the count profiles obtained above the iliac crests the one level in which the horizontal portion of the profile, immediately lateral to the spine, showed the lowest count rate (on either side of the spine) and averaged the values for 3 or 4 of these pixels (Fig. 1D).





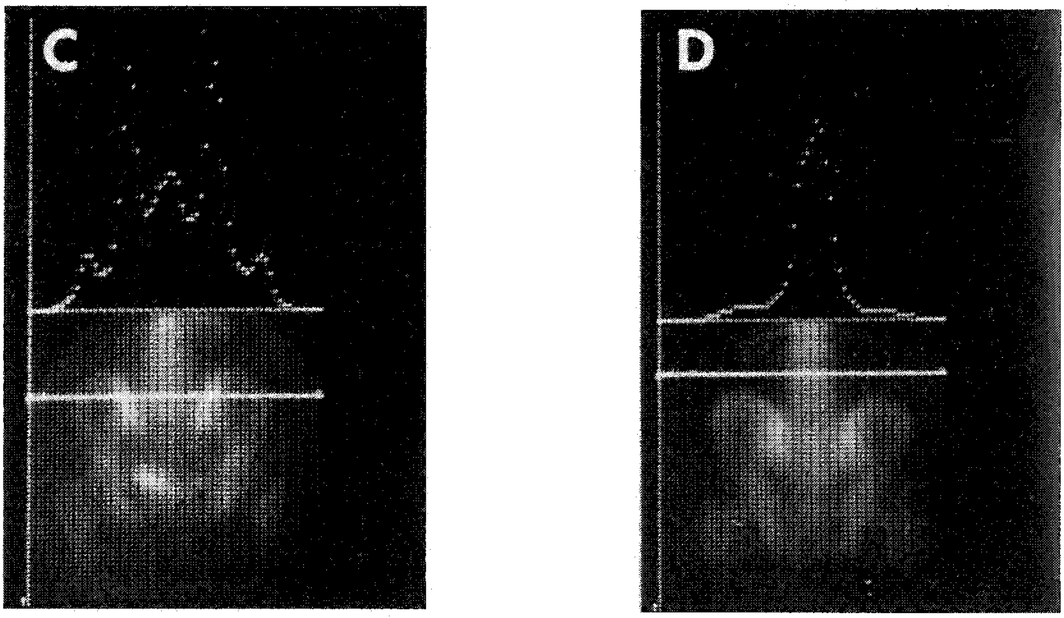


Fig. 1: One-pixel horizontal profiles of the sacroiliac joints and sacrum at four levels: A, B & C — over the sacroiliac joints; D — above the iliac crests.

We then subtracted the background counts from the sacroiliac joint counts as well as from the sacral counts and calculated the ratio of sacroiliac joint/sacrum uptake. This ratio was called sacroiliac index (SII). Results were obtained separately for the left and right joints.

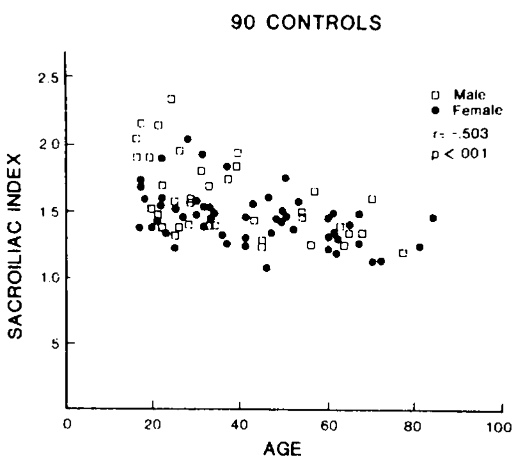


Fig. 2: Sacroiliac index of 90 controls. Correlation with age.

In controls (group A) we averaged the left and right SII for each individual. However, in patients (groups B - E) we studied each sacroiliac joint individually. We classified the patients as abnormal if they had at least one SII which was more than two standard deviations above the normal value for the patient's age and sex group.

In addition to QSS, patients in groups B-E also had a standard anteroposterior radiograph of the pelvis and a CT scan of the sacroiliac joints. For CT, 10 mm sections of the sacroiliac joints were obtained using a GE 8800 scanner (300-400 mA, 9.6 seconds scan time). The standard radiographs and CT scans were interpreted by three radiologists independently and without knowledge of history and physical examination data.

RESULTS

Controls:

In 90 controls (Group A) the SII decreased with advancing age ($r = 0.503$, $p. < 0.001$)

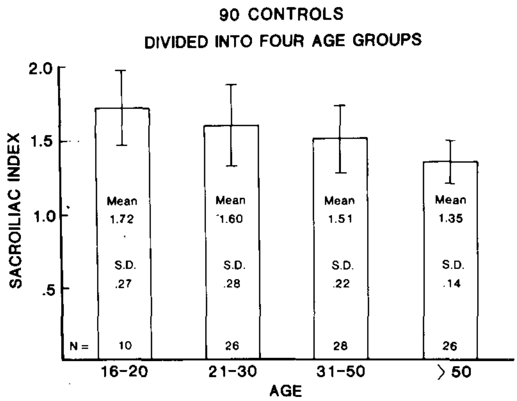


Fig. 3: Sacroiliac index of 90 controls grouped according to age (mean ± 1 SD).

(Fig. 2). Consequently, we divided the controls into 4 age groups (15-20 years old, 21-30, 31-50, and over 50) and calculated the average SII and the standard deviation for each group (Fig. 3).

The average SII was significantly higher in men (SII = 1.59, SD = 0.29) than in women (SII = 1.45, SD = 0.2) ($p < 0.005$). Consequently, each age group was divided by sex (Fig. 4).

There was no significant difference between the right and left sacroiliac joints (mean SII = 1.51 on both sides).

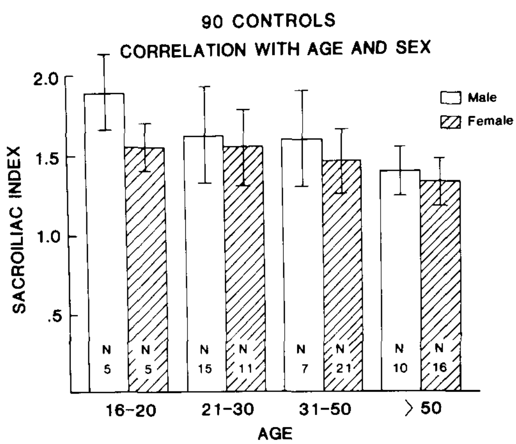


Fig. 4: Sacroiliac index of 90 controls grouped according to sex and age (mean ± 1 SD).

There was no significant difference between the right and left sacroiliac joints (mean SII = 1.51 on both sides).

Patient Groups:

Among 18 patients with signs and symptoms of active sacroiliitis (Group B), 8 of the 14 patients over 30 years of age had a definitely abnormal SII for their age and sex group and one patient had a borderline index (Fig. 5). Three of these 8 patients, all HLA-B27 positive, had no radiographic or CT abnormalities at the sacroiliac joints. The SII of all 4 patients under age 30 fell within the normal range.

Both patients with completely ankylosed sacroiliac joints (Group C) had a normal SII.

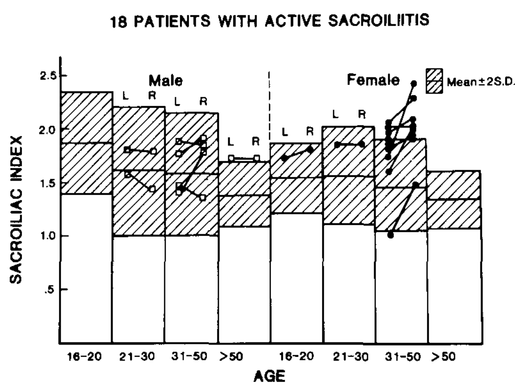


Fig. 5: Sacroiliac index of 18 patients with active sacroiliitis. Histogram represents SII (mean ± 2 SD) in controls divided into sex and age groups. Each of the 18 patients with active sacroiliitis is represented by a bar connecting the left and right SII, superimposed on the normal values for corresponding sex and age groups.

Only 1 of the 14 patients with low back pain without clinical, radiographic or CT evidence of sacroiliitis (Group D) had an abnormally high SII (Fig. 6).

Only 1 of the 5 patients with rheumatoid arthritis without clinical, radiographic or CT evidence of sacroiliitis (Group E) had a borderline SII (Fig. 7).

When CT scans were compared with standard radiographs, CT never showed changes when the standard radiographs were normal. However, in the patients who had only mild sacroiliitis on standard radiography, the abnormalities were more clearly visible on CT.

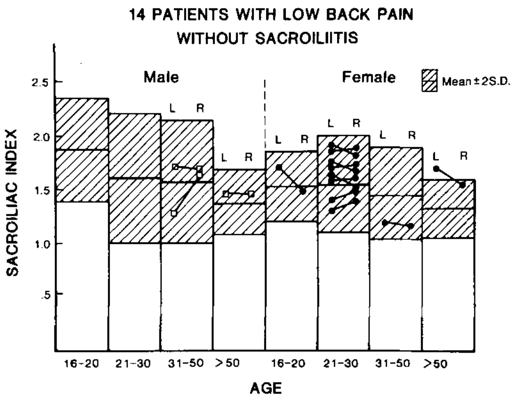


Fig. 6: Sacroiliac index of 14 patients with low back pain without clinical or radiographic evidence of sacroiliitis.

DISCUSSION

When planning this study, we assumed that both the single, wide horizontal count profile technique and the ROI technique have a common inherent drawback: they create a tremendous averaging of information obtained from relatively large areas. This assumption is supported by Namey (20), who created not one but three separate non-overlapping horizontal profiles and chose the highest of the three values found for the inferior, middle or superior horizontal profiles as representative for calculating the SII. He also used background subtraction. Using this modified technique, he found QSS useful in assessing patients for sacroiliitis and in following them after therapy.

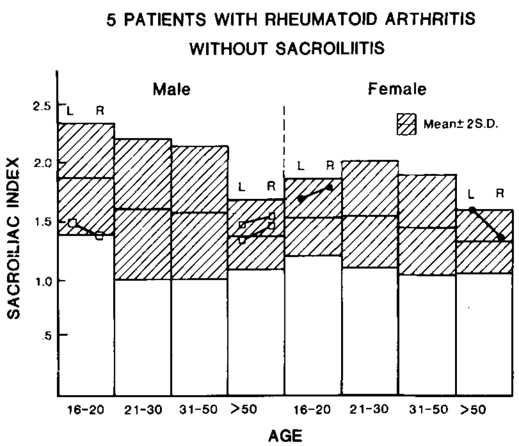


Fig. 7: Sacroiliac index of 5 patients with rheumatoid arthritis without clinical or radiographic evidence of sacroiliitis.

In the present study, we minimized the averaging effect of using large areas of interest by analyzing the information pixel by pixel in each sacroiliac joint separately. In order to avoid statistical variation due to a small region of interest (one pixel), we acquired a high number of counts (at least 1.5 million). In addition, before analyzing each piwel, we performed 9 point smoothing of the image. We used a 64 x 64 pixel matrix in which - for a large field of view camera - each pixel covers an area of 6 mm x 6 mm. We considered this area as being adequately large. The pixels with high activity in the sacroiliac joints always had more than 1,000 counts and in younger patients often more than 2,000 counts.

By using this technique, we found a significant decrease of the SII with advancing age in 90 controls, confirming the findings of Buell (3,21) and Snaith (17). Other authors have not found any correlation with age (11,22). A possible explanation for the decreased SII with age is mentioned by Buell (3), who assumed that there is progressive decrease in "storage capacity" (for bone-seeking tracers) with increasing age which occurs in a sequence: the most rapid decrease occurs in the joints, a lesser decrease occurs in cancellous bone and the least decrease in compact bone. His conclusions were based on studies with regions of interest centered over sacroiliac joints, sacrum (cancellous bone) and femoral shafts (compact bone).

Like Vyas (22) we found a significant difference in SII between sexes, with men having a higher index than women. However, unlike Vyas, we found no difference between the right and left SII, agreeing in this respect with Buell (3).

Among the 18 patients with clinically active sacroiliitis, the SII was abnormal in 9 out 14 patients over 30 years of age, including 3 patients with no radiographic or CT abnormalities of the sacroiliac joints. It fell within the normal range in all the 4 patients with sacroiliitis who were less than 30 years of age.

Unlike others (9,10), our findings in patients without sacroiliitis were generally negative. We found an increased SII in only one of the 10 patients with nonspecific low back pain; all 10 had normal radiographs and CT scans of the sacroiliac joints. Likewise, we found a borderline SII in only 1 of the 5 patients with rheumatoid arthritis without clinical, radiographic or CT evidence of involvement of the sacroiliac joints. While Lentle (2) found that the mean SII was significantly increased in a group of patients with rheumatoid arthritis, he did not exclude from his study the patients who had symptoms and signs of sacroiliitis.

CT scans did not improve detection of early sacroiliitis over plain radiographs in our study, confirming the findings of Borlaza (23). At the time this study was done, our CT scanner did not have the capability of obtaining slices thinner than 10 mm. It is possible that we might have obtained better results had a higher resolution scanner been employed as others did (24).

In conclusion, employing this modified, pixel by pixel analysis of sacroiliac uptake we have observed a significant difference between the two sexes and a significant decrease of SII with increasing age in both sexes. Compared with age and sex-matched controls, abnormal SII's were observed in some HLA-B27 positive patients with clinical evidence of sacroiliitis but with normal radiographs of the sacroiliac joints. However, this technique showed a low sensitivity: only 9 of the 18 patients with clinically active sacroiliitis gave results in the abnormal range. This was most marked in patients under the age of 30, in all of whom SII was normal. The low sensitivity, particularly in young patients, probably limits the usefulness of this technique in clinical practice, since diseases characterized by sacroiliitis tend to present as diagnostic challenges before the age of 30. On the other hand, our findings suggest that this technique is relatively specific; further studies to fully evaluate specificity are required.

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