Technical Aspects of Joint Imaging

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We describe a standardized technique for performing joint scintigraphy. It consists of special patient positioning for imaging the sacroiliac, shoulder, elbow, hand/wrist, knee, ankle, and toe joints. Special computer-assisted data processing for sacroiliac articulation, which results in a quantitative assessment, is also described.

Although many communications have described the clinical assessment of arthritis by radionuclide methods (*1-7*), none has dwelt on the technique necessary for obtaining optimum joint images. We present technical details of such a procedure, using the following protocol.

Radiopharmaceutical Preparation: Methylene diphosphonate (MDP) (New England Nuclear Corp., Boston, MA), the current radiopharmaceutical of choice, is prepared and stored according to the manufacturer's recommendations. In order to avoid any oxidizing contaminant that might interfere with the Tc-99m labeling reaction of the MDP, the first dose withdrawn from the pertechnetate $^{99m}TcO_4^-$ eluate each morning is used to prepare the radiopharmaceutical. Special care is taken to avoid introducing air into the eluate or reaction vials.

Scintigraphy: The patient is injected with 20 mCi of MDP. The only patient preparation necessary before the test is to give the patient six or seven glasses of water after dose injection. Scintigraphy is begun 2½ hr after injection. The scintigraphic instrument used is a large field camera with a parallel hole collimator of high resolution and medium sensitivity attached to an Ohio Nuclear Data System or to a SIMIS-4 Informatek computer for special processing of sacroiliac joint (SIJ) data.

The patient is asked to remove rings, watches, any garment with a metal part, jewelry, cigarette lighters, etc. Immediately before imaging, the patient is asked to void and to wash his hands to minimize possible urine contamination of the hands.

The time for collecting 200,000 counts over reference joints—shoulder for upper extremities, knees for lower—is used for imaging other joints of the respective limb. If counts over other joints of the extremities are less than 50,000, imaging time is doubled. A 300,000 count image is made over the SIJ. See Figs. 1–8 for the details concerning positioning of patients for individual joint images. Typical scintigraphic images are shown on the right panel of each figure.

In order to minimize bladder interference, SIJs are imaged first (Fig. 1). This is followed by images of shoulders (Fig. 2), elbows (Fig. 3.), hands and wrists (Fig. 4), knees (Fig. 5), ankles (Fig. 6), and toes (Fig. 7).

Computer Processing of Sacroiliac Joint Data: Digitized images of SIJ data are stored on magnetic tape for processing by the Informatek system using a series of programs linked together as a single macrofunction. After the image is displayed on the color television screen using the "heated object" color scale, the region of interest (ROI) is chosen over nonosseous tissue, usually between the left iliac crest and inferior pole of the left kidney, and a background subtracted image is generated (Fig. 1, right panel). An option in the program permits rotation of the image to correct any deviations from absolute horizontality of the pelvic image.

The operator defines the SIJ's ROI by marking the upper and lower ends of articulation with a cursor. The program then automatically divides SIJs into three horizontal parallel sections of equal width (upper, middle, lower), as shown (Fig. 8, upper left). Curves are generated over each section (Fig. 8, upper right). For display purposes, curves are normalized to the central sacral (CS) peak, which is assigned an arbitrary value of 100. The curves, reproduced here in black and white, are usually color coded.

The computer then locates the three peaks (right and left SIJ, and CS) and determines the distance (d) between the two SIJ peaks. The area (SIJ max, CS max) of a band

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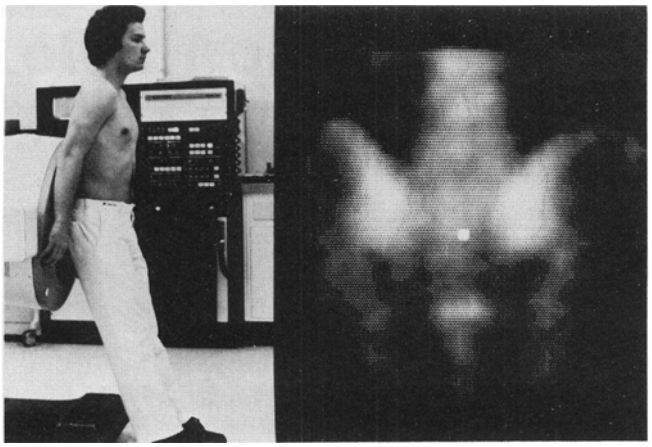

FIG. 1. *Sacroiliac:* "Patient" stands with lumbar and thoracic spine pressed against collimator, iliac crests parallel with detector rotated caudad to approximate plane of sacroiliac joints; legs are extended forward and feet separated; arms are positioned out of field of view. Procedure can also be performed with patient supine, knees flexed with detector under imaging bed. Image in right panel has undergone partial computer processing (digitization and color coding). Light cursor is positioned in mid-sacrum.

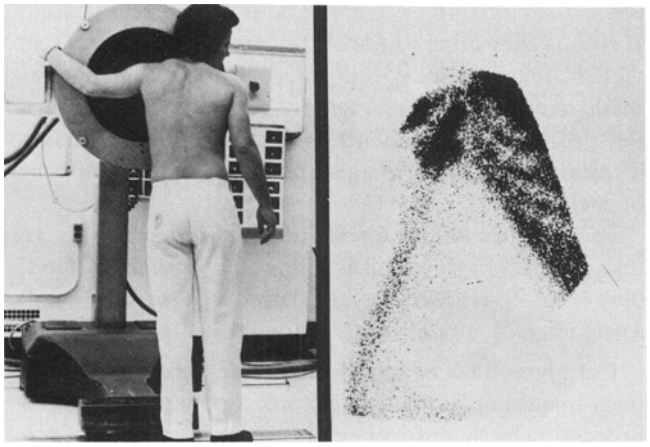

FIG. 2. *Shoulder:* "Patient" stands, facing detector with head lateral to camera and turned away from shoulder; humerus, shoulder, and rib cage are pressed against collimator; left hand rests on detector frame; right arm is held out of field of view.

0.08d wide, centered under each of the three peaks, is determined for each curve.

A sacroiliac index (SII) is calculated for each joint at each level:

$$SII = \frac{SIJ\ max}{CS\ max}.$$

A mean of right and left at each level is also calculated. The SII at each level is then typed by a high-speed printer for the final report (bottom panel, Fig. 8).

Mean SII values obtained in more than 1,000 subjects in our department are:

normal—1.1-1.55;

borderline—1.5-1.75; and

abnormal—1.75 and greater.

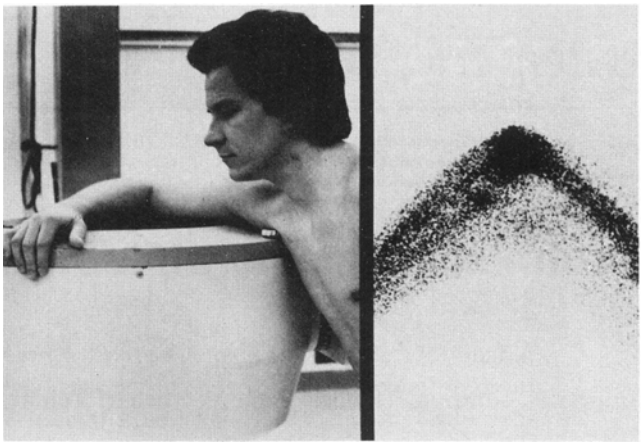

FIG. 3. *Elbow:* "Patient" either sits or stands with arm placed horizontally on detector centered over elbow. Whole arm is draped with lead apron to eliminate extrinsic activity from other parts of body.

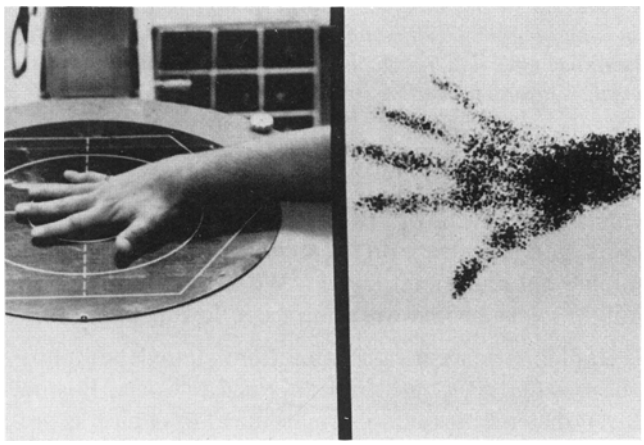

FIG. 4. *Hands and wrists:* Hands and wrists are imaged with palm centered against collimator, digits spread apart. Both hands can sometimes be imaged together.

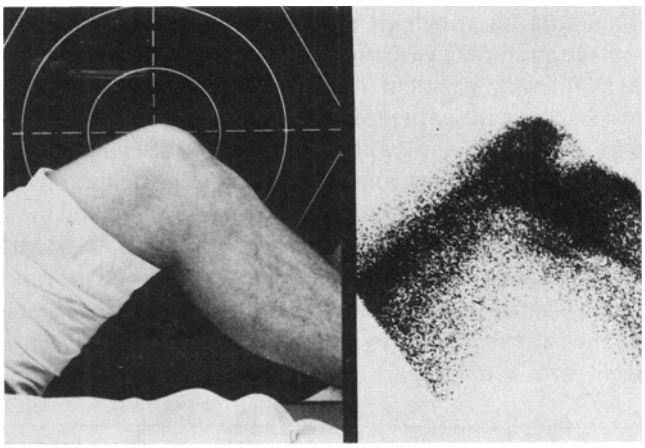

FIG. 5. *Knee:* "Patient" is supine; camera is in vertical position. Knee is flexed at approximately 80-90° with joint centered against detector. Limb is draped with lead apron suspended from detector to eliminate extrinsic body activity.

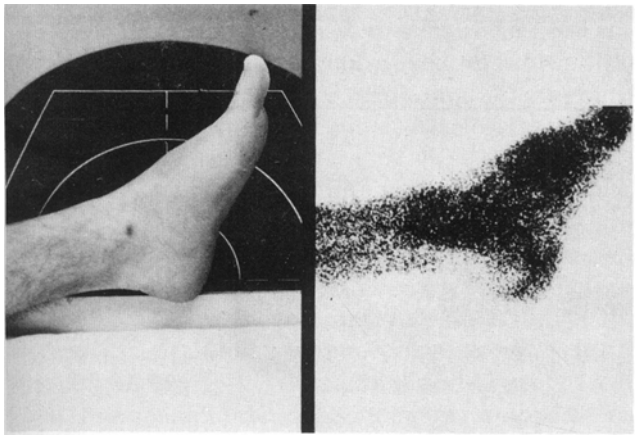

FIG. 6. *Ankle:* "Patient" is supine with leg extended; ankle is imaged flush against collimator. Foot is draped with lead apron suspended from detector and opposite leg is moved out of field of view.

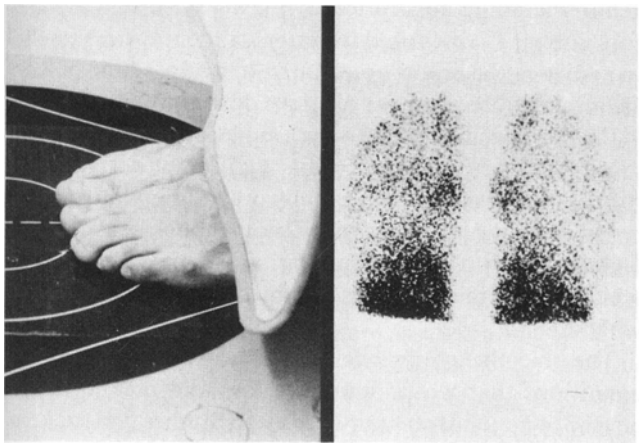

FIG. 7. *Toes:* "Patient" is sitting and detector face is positioned horizontally; feet are placed flat against collimator with only phalanges and metatarsals in field of view. Legs and ankles are draped with lead apron to minimize extrinsic activity.

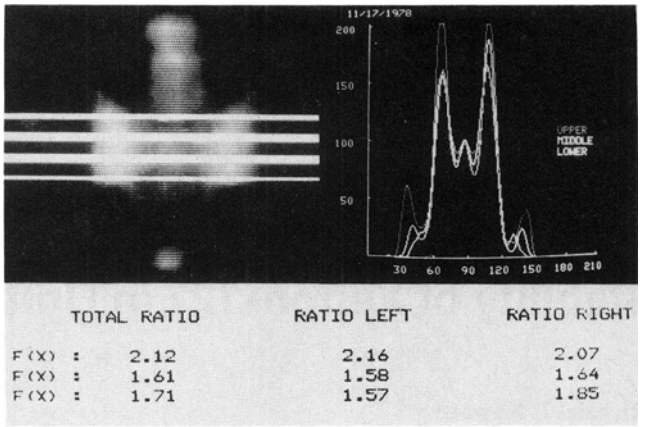

FIG. 8. Background substracted computer processed sacroiliac images indicate three region-of-interest bands over SIJ (upper left). Superimposed counting rate profiles through these regions of interest are (upper right) shown, normalized to central sacrum maximum. Ratios of central sacral maxima to SI maxima are calculated for each side separately and together at each level. Data are printed out below. In this case, study indicates active sacroiliitis.

Summary

Standardized joint imaging is an important diagnostic tool to: screen patients with arthralgias for the presence of inflammatory disease; document pattern and extent of inflammatory articular disease; disclose affected joints not clinically suspected; detect extension or improvement of disease during follow-up; and rule out inflammatory disease.

Scintigraphy has proven to be a more sensitive method for detection of inflammatory joint disease than radiography, particularly in early phases of the disease (*7*). Joint imaging also appears to be a sensitive technique for evaluation of inflammatory synovitis involving elbows, wrists, hands, ankles, knees, and feet. Positive visualization using Tc-99m MDP often precedes clinical evidence of arthritis by several days to months—particularly in patients with psoriatic arthritis, Reiter's syndrome, or ankylosing spondylitis. The distribution pattern of joint hyperactivity is a more important diagnostic feature than the uptake pattern of a single joint.

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