Hand Images: Normal and Abnormal

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Supplemental hand scintigrams with abnormal features were obtained from 29% of patients (134 of 463) who were referred for routine, minified bone imaging with $^{99m}$Tc-Sn-polyphosphate. A wide spectrum of normal activity distribution ranging from well-defined to "wash-out" images is described in 329 cases (71%). In the abnormal images of the joints and individual bones, the changes—although not always characteristic of some particular disease—may often suggest a diagnosis and/or its pathophysiologic status. The joints with heavy uptake correlate well with the presence of active clinical findings, e.g., in the arthritides. The bone features associated with metabolic disease, especially when full-blown, may be fairly characteristic. A potential application is in the assessment of digital circulation, particularly in obliterative vascular diseases such as scleroderma, Buerger's disease, chronic neuropathies, and possibly other collagen or vascular diseases that involve the hands. Interesting images, probably of somewhat limited usefulness, are observed in some congenital anomalies, fractures, camptodactyly, contracture deformities, unilateral lymphedema after mastectomy, etc.


The hand has been immortalized by the artist on canvas, clay, and chords. It has supplemented articulation when words either fell short or went unheeded. Since time immemorial the physician has used the hand as a clinical index in the diagnosis of many local and systemic diseases.

Imaging of the hand in 1895 by a process then yet to be named x-rays resulted in the birth of radiography. Radiography of the hand continues to be very useful in mirroring diseases, whether local or systemic.

This article is an analysis of the supplemental radionuclide images of the hand that were obtained in a large group of patients referred to our department for total-body bone imaging. In undertaking this project, we did not anticipate the large percentage of abnormal findings or the variegated patterns that were subsequently found. A description and discussion of these abnormal findings, as well as a range of normals, are presented. Since scintigrams in general are regarded as physiologic images, a comparison with the more anatomic radionuclide images, when concurrently available, will also be discussed, especially when disparity in findings between the modalities exists.

METHODS

Supplemental images of the hands, recorded on Polaroid film, were obtained in 496 of 550 patients who were referred for minified bone scans. A total of 463 analyzable images were obtained, after exclusion from the study of patients who received the tracer (15 mCi of $^{99m}$Tc-Sn-polyphosphate) in the dorsal aspect of the hand, and of those with evidence of infiltrated injections elsewhere. The images—which included the carpals, metacarpals, and phalanges of both hands—were obtained with a scintillation camera fitted with an ultrafine collimator. A 3-min preset time was used and 35,000–160,000
counts were usually accumulated. The intensity setting was increased above the baseline intensity used for other areas of interest such as the spine, pelvis, or calvarium.

RESULTS

Normal images. A wide range was observed in the distribution and accentuation of activity in the 71% of normals. At one end of the normal spectrum, the images showed concentration of activity in the carpals and metaphyses of the metacarpals and phalanges (J), and at the other extreme a "washed-out" pattern, characterized by absence of definition of the metaphyses of the metacarpals and phalanges, together with absent or minimal activity in the carpals. A large gradation of normals fell between the two extremes, but in each, symmetry of activity in the two hands must be present (Fig. 1A–1C). The well-defined image was usually observed in individuals in their twenties or younger, and in or before adolescence an epiphyseal line of activity is distinctive. The "washed-out" pattern has been classified arbitrarily as normal when the spine, pelvis, and calvarium do not show evidence of osteoporosis either on the same set of images or by radiograph. Conversely we consider it abnormal when concurrent evidence of osteoporosis exists either by scintigram or radiograph.

Abnormal images. Table 1 summarizes the types of abnormal findings in various conditions as recorded in 29% of our patients. Grossly, the abnormalities of uptake are divided into (A) those that manifested generalized, diffuse, symmetric changes both in the bones and joints, which may be either increased or diminished; and (B) those with locally increased uptake involving the bones and/or joints, frequently asymmetric but in some limited situations symmetric. A third type includes a variety of conditions that do not belong in either of the preceding categories. In order to be considered abnormal, the images with a generalized, symmetric, diminished activity or "washed-out" pattern must demonstrate comparable findings of osteoporosis elsewhere, usually in the spine, by scintigram and/or radiograph. Distinction between the normal and abnormal "washed-out" patterns cannot be made by gamma image only.

DISCUSSION

A sizable number of our abnormal cases demonstrated monoarticular and polyarticular increased activity due to various types of arthritis, with osteoarthritis being the most frequently encountered. When heavy activity is noted in any of the interphalangeal, metacarpophalangeal, or carpometacarpal joints, it usually signifies the presence of active disease, and this often concurs with the clinical and radiologic findings. In some instances (J), however, the radiographs were negative.

In osteoarthritis the first carpometacarpal joint (Fig. 2A) is one of the earliest and most commonly involved sites in the hand. Figure 2B illustrates polyarticular, asymmetric activity including many joints other than the first carpometacarpal. In contrast, Fig. 2C depicts thickened and widened periarticular activity in most of the joints, but lacks the isolated, intense activity observed in cases that were clinically symptomatic. On physical examination, the periarticular activity corresponded to nontender Heberden's nodes, whose structure was also confirmed by radiograph. Although all forms of arthritis are associated with inflammation of the synovium, they invariably will cause some destruction of adjacent bony tissues, and this may partly account for the increased activity seen on image in some cases. In most instances, however, especially if early, the in-
TABLE 1. ABNORMAL HAND IMAGINGS IN VARIOUS CLINICAL CONDITIONS

1. Generalized changes
   - (A) Symmetric increased activity
     Hyperparathyroidism
     Renal osteodystrophy
     Renal rickets
   - (B) Symmetric diminished activity
     Osteoporosis
   - (C) Unilateral increased activity
     Palmar cellulitis
     Hemiplegia
     Immobilization

2. Localized changes
   - (A) Symmetric increased activity
     Pulmonary osteoarthropathy
     Osteoarthritis
   - (B) Asymmetric increased activity
     Rheumatoid arthritis
     Gout
     Nonspecific arthritis
     Paget's disease
     Fracture
     Metastases
     Fibrous dysplasia

3. Others
   - (A) Absence of activity (autoamputation)
     Scleroderma
     Buerger's disease
     Neuropathy (diabetic & hemiplegic)
   - (B) Anatomical abnormalities
     Dupuytren's contracture
     Camptodactyly
     Missing digits
     Congenital anomalies
     Lymphedema (mastectomy)

disease. In the two other patients, diagnosis was made clinically and biochemically, and the x-rays were additionally characteristic in one of them. Polyostotic fibrous dysplasia, which affects individuals much younger than those suffering from Paget's disease, may probably be differentiated on imaging by the lack of preservation of the outline of the bony structures involved (Fig. 4). Also, as opposed to Paget's disease, metastatic disease to the phalanges or metacarpals, although unusual, shows increased activity but does not preserve or maintain the structural configuration of the bone. Figure 5 illustrates the point well; the patient had a carcinoma of the breast, with the radiograph showing a lytic lesion in the right fourth metacarpal.

A rare and interesting case of parosteal fasciitis was seen in a 34-year-old woman who presented with a painful swelling in the right fifth finger. A soft tissue mass was seen on the roentgenogram but without evidence of any bony destruction (Fig. 6A). The radionuclide image, however, outlined intense

![Image](image-url)
activity in the tumor area and adjacent phalanx (Fig. 6B). The histopathology showed new-bone formation with osteoblasts and cartilage cells, both within the tumor and in the adjacent phalangeal periosteum, a feature considered characteristic of this lesion (6).

FIG. 3. Top, scintigram, phalangeal involvement in Paget's disease. Note preservation of anatomy of second phalanx despite enlargement. Bottom, atypical findings on bone scan, result of gross sparing of usual bone involvement in Paget's disease.


FIG. 5. Abnormal uptake in the fourth metacarpal lacks the definition of the bone. Metastasis from breast carcinoma.

FIG. 6. Radiograph, soft-tissue mass, without destruction of adjacent phalanges. Scintigram of the mass and adjacent phalanx. Micrograph, parosteal fasciitis. Note osteoblasts and cartilage cells (new-bone formation) within the tumor.

FIG. 7. Clubbing in pulmonary osteoarthropathy.
(Fig. 6C). This new-bone formation undoubtedly is responsible for the intense radioactivity both in the tumor and the nearby phalanx.

In a case report Rosenthal and Kirsh (7) postulated that the increased activity seen in the ungual tufts, in patients with clubbing due to pulmonary osteoarthropathy, results from hyperemia occurring in those areas. We have seen heavy uptake in the terminal phalanges of five patients who had pulmonary malignancy, but only three of whom manifested clubbing and pulmonary osteoarthropathy. Hyperemia certainly contributes to the increased activity, but enhanced local bone metabolism in the terminal phalanges may coexist and enhance the uptake (Fig. 7).

A probably useful application of hand imaging is in the assessment of the circulatory status of the hands, particularly the distal phalanges in some obliterative vascular diseases that could potentially cause autoamputation. In a 76-year-old woman with scleroderma proved by skin biopsy (Fig. 8A), the distal phalanges of one hand (Fig. 8B) were not demonstrable because of the severance of circulation to those areas. In another case, a 58-year-old man with a known diagnosis of Buerger’s disease of 10-yr duration had undergone amputation of the distal phalanges of both middle fingers 5 yr earlier because of gangrene. On current admission he showed signs of gangrene again at the stumps as well as in the distal phalanges of other fingers (Fig. 9). The image outlined the lack of blood supply distally (auto-amputation), and in addition areas of increased activity demarcated the gangrenous parts from the hyperemic normal tissues. Comparable findings may be seen in some cases of chronic diabetic or hemiplegic neuropathy.

Systemic metabolic disease affecting the skeletal system, such as hyperparathyroidism and renal osteodystrophy, demonstrate symmetric abnormal activity in the hands (8), either showing diffuse increased activity in the shaft and ends of the phalanges and metacarpals (Fig. 10), or limited to localized periarticular changes. Other more variable findings, especially in the face of fractures, may also be observed at times. Another condition that demonstrated heavy symmetric increased activity in the hands was observed in a 26-year-old patient with a history of renal rickets 5 years prior to the image shown in Fig. 11A. The concurrent radiographs of the hands (Fig. 11C) showed closure of the epiphyseal band and evidence of healed process—as distinct from an earlier radiograph (Fig. 11B) that demonstrated cupping of the distal radius and ulna. The gamma images, however, still demonstrated very heavy activity in periarticular areas and carpals, and in addition a rather broad band of activity is present in the epiphyseal-metaphyseal region. This should be distinguished from the much narrower epiphyseal line that is observed normally in the adolescent (Fig. 1A). The presence of this epiphyseal line of activity in individuals beyond their early twenties is probably abnormal. The short, stubby fingers observed in this
case fit well with the patient's failure to attain normal stature. Another interesting pattern is diffuse increased activity noted in one hand only. In two patients who had hemiplegia due to a stroke 5–6 months earlier, we have observed marked generalized disparity between the uptakes of the two hands, more pronounced on the involved side. An identical pattern was observed in another patient whose hand had been splinted for six weeks during therapy for chronic palmar cellulitis (Fig. 12).

Increased skeletal hyperemia may occur in paralyzed limbs, as demonstrated in animal experiments following sciatic nerve section (9), and this may account for the concentration of the bone-seeker. There is also suggestion that in disuse osteoporosis bone turnover is increased if the condition is ongoing but decreased if it is long-standing (10,11).

Other abnormalities of uptake that are interesting, although of limited clinical usefulness are observed in a variety of conditions, including bilateral camp-todactyly, healing fractures, contractural deformities in hemiplegics, unilateral lymphedema after radical mastectomy, missing digits, and congenital anomalies.

Routine imaging of the hands after a miniﬁed bone scan often adds meaningful data to the evaluation of the skeletal system, and sometimes totally unexpected findings are uncovered, which might have been overlooked in the clinical examination. Radiophosphate and radiographs, will “mirror” diseases and their clinical status much more than has been realized. For these reasons, and for a more thorough approach to bone scans in general, we recommend its application in patients who undergo the procedure.

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REFERENCES