Coregistration imaging of the foot
A NEW LOCALISATION TECHNIQUE

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We describe a new technique, known as coregistration imaging, which superimposes $^{99m}$Tc isotope bone scans on to plain radiographs. We used the technique selectively in cases in which the nuclear medicine physician, who reported the isotope scan, had difficulty in localising the anatomical site of the abnormality.

In the forefoot, coregistration of isotope scans did not help to localise pathology; the scan alone gave sufficient detail.

In 17 patients with pain in the hind- and midfoot, isotope scanning identified eight sites of abnormality in those with normal radiographs. In those with more than one abnormality on plain radiographs the isotope scan eliminated 12 sites of suspicion. Coregistration of the images significantly increased the certainty of localisation of disease ($p < 0.001$).

We recommend the selective use of coregistration scanning as a useful technique for investigating patients with pain in the foot and ankle.

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The localisation of pathology is critical to the surgical treatment. In the foot there are many bones and joints in a small area and inflammatory or degenerative disease can produce severe disability. Arthrodesis is the standard treatment for the relief of pain and maintenance of stability in these weight-bearing joints. There is increasing evidence that multiple joint fusions can lead to secondary degeneration of the adjacent joints, and it is essential that disease is accurately localised to limit fusion to the affected joint.

Pain in the foot and ankle of unknown cause is a common indication for isotope bone scanning. Maurice, Newman and Watt reported that, in a series of 76 patients, no patient with a normal scan developed pathology. Unfortunately, the low spatial resolution and lack of anatomical landmarks on a bone scan make the accurate localisation of areas of increased uptake difficult.

We present a new technique which accurately superimposes radiological and scintigraphic images to give a ‘coregistration image’. The method has been evaluated in a series of patients who had pain in the foot and ankle.

Patients and Methods

Coregistration imaging. A flat radiolucent box which holds a standard 24 x 30 cm X-ray cassette and a 3 mm lead sheet was constructed. This protects the crystal of the gamma camera from the full intensity of the X-ray beam and the cassette can be independently inserted and removed. Seven lead discs which are 2 cm in diameter are attached to the face of the box. In the centre of each disc is a 2 mm hole.

The coregistration box is laid flat on the face of the gamma camera. The foot is positioned on top of the box with the area of interest placed in the centre (Fig. 1). The X-ray tube is then positioned as high as possible above the foot to maximise the fixed focal distance.

The radiograph and gamma scan can be taken in either order, but the latter is usually done first using a 300 second acquisition. The lead sheet and the cassette are then inserted into the coregistration box and the radiograph taken without moving the foot.

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The lead markers appear clearly on the radiograph. After removing the patient’s foot the position of the bone scan is then coregistered by passing a $^{57}$ cobalt source over the 2 mm holes in the centre of the lead discs.

Coregistration processing. The radiograph is processed and digitised on a UMAX Vist S8 flat bed scanner at 75 dpi. The co-ordinates of the position of the equivalent markers in the two images are identified. From the sets of pairs of markers a transformation matrix is devised which coregisters the radiograph and isotope scan so that these
images can be superimposed on each other. Although the minimum number of markers required is three, we used seven in our study to confirm accuracy.

**Patients.** In our orthopaedic service, $^{99m}$Tc MDP bone scanning is part of the regular investigation of patients with foot pain of uncertain origin. The criterion for the use of coregistration imaging was that the nuclear medicine physician who reported the scan, was unable to localise the disease accurately from the radiographs and bone scan alone. To assess the value of this method, a review of the clinical details, radiographs, scintigram and coregistration scan was undertaken by an orthopaedic surgeon, a radiologist and a nuclear medicine physician.

The localisation of disease was initially reported from the radiographs and clinical details and the proposed site, or sites, of abnormality noted. The certainty of this localisation was recorded on a visual analogue scale. The isotope bone scan was then added and the scores recalculated. Finally, coregistration images were presented. From these data and the knowledge of the subsequent clinical progress.
the contribution of coregistration to the localisation of the
disease was recorded on a further visual analogue scale.
The data are presented with standard deviations. We used
the paired Student's $t$-test to establish the degree of
significance.

Twenty-two consecutive patients were entered into the
trial. Five had forefoot disease and were accurately
assessed from plain films and scintigrams alone. Adding
coregistration gave no additional information. This became
apparent early in the series and a selective policy for
obtaining coregistration scans was then adopted. It was not
judged necessary to coregister forefoot scans again, and
only mid- and hindfoot scans were assessed.

This left 17 patients in the trial. The site of disease was
in the midfoot (from the midtarsal to tarsometatarsal joints)
in 11 patients (Fig. 2), and in the ankle or subtalar joint in
six (Fig. 3).

In the 11 patients with midfoot disease, five had normal
radiographs. Of the remaining six, three had two radi-
ological sites of abnormality which could have accounted for
their symptoms, two had three sites and one had four.

**Results**

Evaluation of the technique has shown it to be accurate to
1 mm (unpublished data). In our series the extra time taken
to obtain the coregistration image was 25 minutes. The
extra costs were those of the additional radiographs taken
and a further bone scan. It is not necessary to use any more
isotope since the second scan is taken using the first
dose.

Table I summarises the results after radiological and
clinical assessment. The site of disease localisation as
determined on the visual analogue scale was $69 \pm 12\%$.

Scanning showed a single area of active disease in seven
patients and two areas in four. Six new sites of disease were
identified in the five patients with normal radiographs. In
the other six patients, eight sites of radiological abnormal-
ity were shown to be areas of low uptake on the isotope
bone scans and were excluded as a cause of symptoms.

The degree of certainty that the ‘hot spot’ seen on the
bone scan was localised to a specific anatomical area was
$47 \pm 25\%$. After coregistration the number of active areas
was the same. The visual analogue certainty as to the
precise localisation of disease activity was $93 \pm 7\%$ which
was statistically significant ($p < 0.001$).

Of the six patients who had hindfoot and ankle disease,
two had normal radiographs. Of the remaining four, one
had one radiological site of abnormality which could
account for the symptoms, one had two sites, one three and
one four.

After radiological and clinical assessment the visual
analogue certainty of the site of disease was $71 \pm 3\%$.

After bone scanning, areas of active disease were shown
in a single area in four patients and in two areas in two.
Two new sites of abnormality had been localised and four
sites of possible disease activity had been excluded.

The degree of certainty of localisation after bone scan-
ning was 46 ± 19%. After coregistration the visual analogue certainty of disease localisation was 94 ± 5% which was significant (p < 0.001).

Discussion

A similar ‘coregistration’ technique to ours has been described by Hawkes et al. for use with wrist injuries. Their technique had an error of up to 4 mm compared with an error of less than 1 mm with our method. In addition, their technique required the patient to be moved between radiography and bone scanning which may account for the larger error, and the fact that one investigation out of 23 had to be abandoned.

The isotope bone scan gives useful information on disease activity, but the anatomical resolution is often poor. Before the development of this technique, bone scanning was used to evaluate those patients with severe pain and disability in the foot and ankle with either no localised radiological change or with more than one site of abnormality. Coregistration has improved the accuracy of localisation of disease in both the hind- and midfoot. The bone scan excluded 12 sites of active pathology in ten patients with abnormal radiographs. There were another seven patients with normal films in whom pathology was identified. By adding coregistration, the certainty of active disease was increased from 47% to 93% (p < 0.001) in the midfoot and from 46% to 94% in the hindfoot and ankle (p < 0.001).

Other techniques of identifying disease activity in the foot and ankle are invasive and require injection of local anaesthetic under X-ray screening or CT guidance. Joints within the foot may have interconnections and patients with multiple abnormalities may require multiple injections.

Coregistration is needed only in selected cases in which the reporting physician is unable to localise the disease on the first scan. Indeed, in the forefoot, in which the structures are more easily identified on the bone scan, coregistration was found to contribute little to treatment. The technique is inexpensive and requires only the purchase of a ‘coregistration box’. The only extra radiation to which the patient is exposed is that of the additional radiographs.

Our technique of combining two standard investigations may provide an advance in the investigation and localisation of disease for the more accurate treatment of painful and disabling conditions in the foot and ankle.

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References