RADIOGRAPHY AND SCINTIGRAPHY OF SUSPECTED SCAPHOID FRACTURE

A LONG-TERM STUDY IN 160 PATIENTS

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Radiographs of the scaphoid after injury are difficult to interpret, and bone scintigraphy is widely used to increase the accuracy of diagnosis, though many fractures suspected on scintigraphy cannot be confirmed radiologically. We have reviewed the clinical consequences, after one year, of managing suspected scaphoid fractures according to the bone-scan results.

We studied 160 patients, 35 of whom had initially positive radiographs and were treated in a cast for 12 weeks. The other 125 had bone scintigraphy and were managed according to the result. After a minimum of one year 119 patients were reviewed. Scintigraphically suspected scaphoid fracture could not be confirmed radiologically in 25%. There were no cases of nonunion. The long period of immobilisation in patients with positive radiographs or positive bone scans did not influence the frequency or severity of late symptoms compared with those with a normal bone scan.

It is important to make an early diagnosis in patients with scaphoid fractures because the frequency of non-union increases if treatment is delayed or if the fracture is untreated (Langhoff and Andersen 1988). Even after prompt and adequate treatment, nonunion occurs in 5% to 12% of cases (Eddeland et al 1975; Leslie and Dickson 1981; Dias, Brinkel and Finlay 1989), as assessed by scaphoid radiographs. Fractures of the scaphoid cannot always be seen on the initial radiographs (Duncan and Thurston 1985; Schmidt and Deininger 1985), and there is a high interobserver variability (Tiel-van Buul et al 1992).

Early bone scintigraphy is said to increase the accuracy of diagnosis of fractures of the scaphoid and other carpal bones (Ganel et al 1979; Jørgensen et al 1979; Matin 1979; Rolfe et al 1981; Stordahl et al 1984; Brismar 1988; Young et al 1988), but up to 60% of scintigraphically suspected fractures cannot be confirmed on the radiographs (Van Beek, Van Buul and Broekhuizen 1990), so that using the bone scan as the standard for management may lead to overdiagnosis and overtreatment.

We have evaluated the clinical consequences of basing management and treatment on the results of bone scans.

PATIENTS AND METHODS

We studied consecutive patients with clinically suspected fracture of the scaphoid, basing the diagnosis on a history of recent trauma, sustained by falling on the outstretched arm, and typical clinical symptoms (Verdan 1960; Weber and Chao 1978). We obtained informed consent from all patients and the study was approved by the local medical ethical committee.

Scaphoid radiographs. Four views were taken: posteroanterior in ulnar deviation, oblique (15° pronation and 15° supination) and lateral. These were judged initially by the attending junior surgeon, and reviewed by the consultant traumatologist. Later, for the purposes of the
study, all radiographs were judged blindly by a panel consisting of a bone radiologist, a general radiologist and a senior traumatologist.

**Radionuclide bone scintigraphy.** Bone scintigraphy was performed at least 72 hours after injury and the initial plaster was removed before the examination. After the administration of 200 MBq $^{99m}$Tc-methylidiphosphonate, images were recorded immediately, after 2 to 5 minutes (dynamic phase), and after 2 to 3 hours (static phase). Anterior and lateral static views were obtained in a preset time of 5 minutes.

All bone scans were initially examined by an experienced nuclear physician, and were considered positive if there was focally increased activity (a hotspot) in the scaphoid region in both the dynamic and the static images. A hotspot in both images in another part of the carpus was recorded as a fracture of another bone. All other results were regarded as not caused by a fracture, the criteria for a normal scintgram being symmetrical activity in both wrists, with the same level of activity in the distal ends of the radius and ulna, and diffuse activity in the area of the palm of the hand (Sy, Bay and Camera 1977).

**Diagnostic procedure.** The protocol for management used in this study is shown in Figure 1. All patients seen within 24 hours after a fall on the outstretched hand and with typical symptoms of pain in the anatomical snuffbox, entered the study. If a fracture of the scaphoid was recognised on the initial radiographs (positive), a below-elbow plaster was worn for 12 weeks, with the wrist in slight dorsiflexion and the thumb in a position of opposition. This plaster was changed after five days and again at six weeks. If the first radiographs did not show a scaphoid fracture a plaster was applied and the patient was referred for radionuclide scintigraphy.

If the bone scan was normal no treatment was given. If it was positive (or if any other fracture was suspected) the plaster cast was reapplied and scaphoid radiographs were repeated after 10 to 14 days. If a fracture was seen then, cast treatment continued until 12 weeks after injury. If the radiographs were still negative, cast treatment was continued and the patient was X-rayed again after six weeks. Subsequently, all the radiographs were retrospectively reviewed by the same panel of experienced observers.

**Follow-up.** Patients were reviewed after a minimum period of one year. They were asked about pain, rated as mild, moderate or severe, and stiffness of the wrist. The carpus was examined for tenderness, and its site and severity recorded. The grip strength of both hands was measured with a Jamar dynamometer (Clifton, New Jersey) in a standard position (shoulder adducted, elbow 90° flexed, forearm in neutral rotation, and the wrist in neutral position: Bechtol 1954). The mean of three measurements for each hand was recorded, and a reduction by more than 10% in a dominant hand or of more than 20% in a non-dominant hand as compared with the uninjured hand, was considered to be significant (Schmidt and Toews 1970; Czitrom and Lister 1988). The ranges of dorsiflexion, palmar flexion, and radial and ulnar deviation at the wrist were measured with a protractor. The sum of these four movement ranges was expressed as a percentage of the total for the opposite uninjured wrist (Dias et al 1987), and a loss of more than 25% of wrist movement was recorded as significant. Tenderness was assessed by pressure on the scaphoid with the hand in ulnar deviation. This normally evokes some tenderness, but the test was considered to be positive if there was more pain on the uninjured side.

Scaphoid radiographs were repeated and assessed blindly by the same panel. If the patients were unable or refused to visit the department, a standard questionnaire was completed by telephone. Chi-squared tests were used for statistical evaluation.

**RESULTS**

Between September 1987 and September 1990 we recruited a total of 160 patients. There were 82 men and 78 women, with a mean age of 38.6 years (12 to 84; Fig. 2), almost half of them being between 20 and 40 years of age. The cause of injury was a traffic accident in 58% (Fig. 3).

In 35 patients (population A), the initial radiographs showed evidence of a scaphoid fracture, although only one was displaced. These patients had a below-elbow plaster for 12 weeks.

In the other 125 patients (population B), the initial
radiographs were judged to show no scaphoid fracture. Bone scintigraphy was performed in these patients at 3 to 34 days (mean 12.3) after injury. The results of the bone scans and of the radiographs at six weeks after injury as judged by the panel are shown in Table I. In 41 patients (32.8%) the bone scan was normal and the later radiographs also showed no carpal fracture. In 84 patients

**Late review.** We contacted a total of 119 patients (74.4%) for follow-up between 13 and 50 months after injury (mean 26.8). Two patients had died, and 39 could not be contacted. One hundred patients were reviewed in our department and 19 were questioned by telephone. Radiographs were obtained of 97 patients (two were pregnant and one refused).

![Age distribution of 160 patients with clinically suspected scaphoid fracture.](image)

**Table I.** Scintigraphic and final radiographic results in 125 patients with clinically suspected scaphoid fractures and negative initial radiographs

<table>
<thead>
<tr>
<th>Result</th>
<th>Bone scan</th>
<th>Radiograph</th>
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<tbody>
<tr>
<td>Negative</td>
<td>41</td>
<td>80</td>
</tr>
<tr>
<td>Positive</td>
<td>35</td>
<td>21</td>
</tr>
<tr>
<td>For scaphoid</td>
<td>49*</td>
<td>24*</td>
</tr>
<tr>
<td>For other fractures</td>
<td>31 radius</td>
<td>16 radius</td>
</tr>
<tr>
<td>22 t/p†</td>
<td>14 t/p†</td>
<td></td>
</tr>
<tr>
<td>20 other</td>
<td>6 other</td>
<td></td>
</tr>
</tbody>
</table>

* many had multiple fractures
† triquetral/pisiform

(67.2%), a total of 108 hotspots were recognised (35 scaphoid, 31 radius, 22 triquetral/pisiform bone, 20 other carpal bones). There was a single hotspot in 67 patients, two in ten patients and three in seven patients. The radiographs remained negative in 80 patients, but in 45 (36%), the panel diagnosed 57 fractures (21 scaphoid, 16 radius, 14 triquetral/pisiform bone, 6 other). There was a single fracture in 36 patients, two fractures in six patients and three in each of three patients, and all 57 fractures were recognisable as a hotspot on the scan. At this stage, 21 of the 35 patients with hotspots in the scaphoid (60%) had the fracture radiologically confirmed. In retrospect, six of these fractures could be seen on the initial radiographs, nine more on the two-week radiographs and a further six at six weeks after injury.

**Symptoms.** Fifty-one patients (43%) had complaints: they were mild in 30, moderate in 18 and severe in 3 (Table II), and 49 had pain only on exercise. There were no significant differences in the number and severity of complaints between populations A (first radiograph negative) and B. Within population B, we could show no relationship between complaints, scintigraphic diagnosis and subsequent period of immobilisation.
Examination. We examined 100 patients. Grip strength was significantly reduced in 21 (Table III), and 17 of these (81%) had complaints. Twenty of these patients came from population B, and had had scintigraphy (negative 8, scaphoid hotspot 3, other hotspot 9). Of the 79 patients with no significant reduction of grip strength 36 (45%) had complaints. There was no patient with significant loss of wrist movements in population A, but in population B, eight had over 25% loss of range. Of these, three had no scintigraphic or radiologically proven fracture. Follow-up radiographs in the remaining five patients showed osteoporosis in two, nonunion of the styloid process of the ulna in one, and no radiological abnormality in two.

Table II. Symptoms at one-year review of 119 patients after clinically suspected scaphoid fractures

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Population B*</th>
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<tbody>
<tr>
<td></td>
<td>Total (n = 119)</td>
<td>Population A* (n = 21)</td>
<td>Positive scaphoid (n = 30)</td>
<td>Other fracture (n = 48)</td>
</tr>
<tr>
<td>No symptoms</td>
<td>68</td>
<td>11</td>
<td>14</td>
<td>26</td>
</tr>
<tr>
<td>Symptoms</td>
<td>51</td>
<td>10</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td>Mild</td>
<td>30</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Moderate</td>
<td>18</td>
<td>1</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td>Severe</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

* see text

Table III. Grip strength in 100 patients after clinically suspected scaphoid fractures. Number with symptoms are in parentheses

<table>
<thead>
<tr>
<th>Grip strength</th>
<th>Population B*</th>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>79 (36)</td>
<td>17 (9)</td>
<td>24 (13)</td>
<td>24 (5)</td>
</tr>
<tr>
<td>Significant loss*</td>
<td>21 (17)</td>
<td>1 (1)</td>
<td>3 (2)</td>
<td>9 (8)</td>
</tr>
</tbody>
</table>

* reduction in grip strength >10% in the dominant hand or >20% in the non-dominant hand (see text)

Table IV. Radiographic results in 97 patients after clinically suspected scaphoid fractures. Number of patients with symptoms are in parentheses

<table>
<thead>
<tr>
<th>Population B*</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (n = 97)</td>
<td>Population A (n = 18)</td>
<td>Positive scaphoid (n = 27)</td>
<td>Other fracture (n = 32)</td>
<td>Negative (n = 20)</td>
</tr>
<tr>
<td>No abnormalities</td>
<td>44 (24)</td>
<td>6 (5)</td>
<td>10 (7)</td>
<td>15 (3)</td>
</tr>
<tr>
<td>United fracture</td>
<td>30 (13)</td>
<td>10 (4)</td>
<td>10 (5)</td>
<td>10 (4)</td>
</tr>
<tr>
<td>Other abnormalities</td>
<td>23 (11)</td>
<td>2 (1)</td>
<td>7 (4)</td>
<td>7 (5)</td>
</tr>
</tbody>
</table>

Only one of the eight had been immobilised for the whole 12 weeks, the other seven for from one to six weeks (mean 3.4).

The scaphoid stress test was positive in 34 of the 100 patients, with no significant difference between populations A and B. Within population B there was no significant difference between patients with a positive or a negative bone scan.

Radiography. Review radiographs showed no abnormalities in 44 patients, of whom 24 had complaints. In 30 patients (13 with complaints) a united fracture was seen, and in 23 (11 with complaints) other abnormalities were found (Table IV); these included degenerative arthritis and widening of the scapholunate joint. None of the patients with a negative bone scan showed any radiographic evidence of old healed fractures. There were no significant differences in radiological abnormalities between populations A and B. Eight out of the 80 patients with a carpal hotspot (10%), in whom the six-week radiographs had shown no fracture, now had signs of a united fracture (scaphoid 4, other carpal bone 3, ulna 1). There were no radiological signs of nonunion in population A or B.

DISCUSSION

In the absence of radiological confirmation, the exact meaning of a hotspot on bone scintigraphy of the scaphoid is difficult to define; but radiography of the scaphoid and wrist cannot provide a reference standard for the diagnosis of scaphoid fracture (Tiel-van Buul et al 1992).

We found a 67% incidence of hotspots in the carpus or wrist of patients judged to have negative initial radiographs. This high incidence suggests that bone scintigraphy overdiagnoses and may lead to overtreatment. The later radiographs at two and six weeks, however, showed an additional 15 scaphoid fractures and 24 other fractures. This reduces the incidence of unconfirmed hotspots to 36%, and the retrospective review of all radiographs by the panel showed six more scaphoid fractures, reducing it further to 31%. This also implies that more experienced examination of initial radiographs would reduce the need for bone scintigraphy by 5%. It is of interest that 28% of all radiologically confirmed scaphoid fractures were detected solely by the panel, emphasising the need for interpretation by an experienced radiologist. In another eight patients a hotspot in the scaphoid, or elsewhere, was confirmed as having been due to a fracture, reducing the incidence of scintigraphically suspected fracture without radiological confirmation to 25%. It is likely that these were minor chip fractures which healed without treatment, leaving no radiographic evidence.

We have shown that patients with clinically suspected scaphoid fracture and initially negative radiographs, managed according to the results of a bone scan,
had long-term outcomes which did not differ from those with initially positive radiographs. The patients with a negative bone scan who were allowed early function after a short period of immobilisation, had a similar incidence of subjective symptoms, and it seems therefore that immobilisation (possibly unnecessary) does not increase the complication rate. Lengthy immobilisation did not lead to a high incidence of reflex sympathetic dystrophy. One patient developed this within five weeks of injury and one showed evidence at late review. Both had been immobilised for short periods (two and six weeks respectively), and the 1.7% incidence accords with other reports (Böh m 1985; de Bruijn 1987).

Grip strength was significantly reduced in 21% of our patients, more in the group with negative initial radiographs, who underwent bone scintigraphy. Loss of grip strength, however, was not related to bone-scan results or subsequent treatment, and it seems likely that this is caused by injuries to the soft tissues. We found no correlation between the incidence and severity of complaints and either grip strength reduction or radiographic abnormalities at follow-up. This strongly supports the idea that injury to the soft tissues is important in generating symptoms.

The incidence of nonunion may be reduced by using the results of the bone scan to guide the management of patients with suspected scaphoid fracture. We had no cases of nonunion at follow-up; the reported incidence is 5% to 12% (Eddeland et al 1975; Leslie and Dickson 1981; Dias et al 1989). This difference could be due to a number of factors. First, in our consecutive series, there was only one severely displaced scaphoid fracture. Secondly, the bone scan may have recorded chip fractures of the scaphoid which would not have any clinical sequelae, but we had expected at least some cases of nonunion in those with initially positive scaphoid radiographs. Thirdly, we used strict conservative immobilisation for 12 weeks. Unfortunately, we have no record of the frequency of nonunion at our hospital before this series and the introduction of bone scanning.

Loss of wrist movement, in only 5% of patients, was not related to the presence or absence of a scaphoid fracture, or to the period of immobilisation.

Conclusions. We advise scaphoid radiography using at least four views. Confirmed fractures should be treated in a below-elbow plaster, including the interphalangeal joint of the thumb, for 12 weeks. Those with negative initial radiographs are treated in plaster until a bone scan is performed after at least 72 hours, and then managed according to the result of the bone scan.

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REFERENCES


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