We have assessed the value of using a simple apparatus, the Carpal Box, in patients with suspected scaphoid fracture, to produce elongated and magnified radiographs of the carpus. The interobserver agreement between 60 observers of standard scaphoid radiographs and longitudinal and transverse Carpal Box radiographs (X-CB) was compared in 11 patients. Three-phase bone scanning was used as a comparative standard. If at least 75% of the observers agreed and the result was confirmed by three-phase bone scanning, the outcome was termed reliable.

Scaphoid radiographs and the longitudinal X-CB films were reliable in four patients and the transverse X-CB films in six patients. The bone scan suggested a scaphoid fracture in five of the 11 patients.

Agreement in the interpretation of the standard scaphoid radiographs was acceptable in only 36% of patients: in interpretation of transverse Carpal Box radiographs this figure increased to 55%.

The scaphoid bridges the proximal and distal rows of the carpus and is vulnerable to fracture and dislocation. Fractures of the scaphoid comprise 70% to 80% of injuries to the carpal bones (Dunn 1972), but may be difficult to demonstrate radiographically. The typical mechanism of injury is an impact to the palm with the wrist extended, usually in a fall on to the outstretched hand. Tenderness in the region of the scaphoid or in the anatomical snuffbox suggests the possibility of a fracture, but symptoms vary and clinical examination of the wrist may do no more than heighten the suspicion of fracture (Waizenegger et al 1994a). Fractures of the scaphoid are not always recognised on the initial radiographs.

The recommended radiological views include postero-anterior (PA) with hand and wrist flat, oblique at 45°, PA supinated in the palm-down position, and lateral and PA in as much ulnar deviation as possible with the central beam angled 15° to 20° towards the elbow (Ruby 1992). The reliability and accuracy of these radiographs are not precisely known.

The radiographs which are traditionally taken on the initial presentation include a PA view with the hand and wrist flat in maximal ulnar deviation, oblique at 45°, PA supinated in the palm-down position, and lateral and PA in 15° of pronation, oblique PA in 15° of supination, and a true lateral. These show a sensitivity of only 64% but have an acceptable interobserver agreement (kappa 0.76). When the radiographs are repeated after two and six weeks, sensitivity decreases to 31% and 30% respectively, while the kappa value also falls below 0.50 (Tiel-van Buul et al 1993a,b).

Dias et al (1988, 1990) reviewed the value of radiographs in diagnosing fractures of the scaphoid and in assessing signs of union. They concluded that they cannot provide conclusive proof that there is not a fracture or that there is evidence of union. Three-phase bone scintigraphy is therefore recommended for patients whose initial negative radiographs do not show a fracture (Ganel et al 1979; Jørgensen et al 1979; Rolfe et al 1981; Stordahl et al 1984; Tiel-van Buul et al 1992a, 1993b; Shewring, Savage and Thomas 1994; Waizenegger et al 1994b). This gives a sensitivity of approaching 100% and a specificity of 98%, with high interobserver agreement (kappa >0.80). The major disadvantages of a bone scan include the lack of anatomical information, the radiation dose, the cost and limited availability.

Use of the Carpal Box may increase the effectiveness of...
plain radiographs in the diagnosis of fractures of the scaphoid. We have used a redesigned prototype (Carpal Box; Orpidem, Zetten, The Netherlands) which was first described by Proubasta et al (1989). Transverse and longitudinal Carpal Box radiographs (X-CB) show elongated and magnified views of the carpus, thereby reducing the overlap and creating better images of the individual bones. The technique has shown promising results in a pilot study (Tiel-van Buul et al 1992b).

We compared the interobserver agreement of 60 doctors in the interpretation of Carpal Box radiographs with that for traditional views using three-phase bone scintigraphy as the standard.

PATIENTS AND METHODS

We studied the routine scaphoid radiographs and the longitudinal and transverse Carpal Box films from 11 consecutive patients with suspected scaphoid fracture. The standard views were PA of the hand in ulnar deviation, oblique with the hand in 10° of supination and maximal ulnar deviation, lateral with the distal arm elevated 15°, and PA with the tube tilted 40° distally (Mamoray MR 3-II, AGFA b.v., Rijswijk, The Netherlands). On the same day, X-CB radiographs were taken with the wrist lying longitudinally and transversely on top of the box with the tube fixed vertically and the cassette positioned at 50° (Fig. 1).

On the fifth day, three-phase bone scanning using $^{99m}$Tc diphosphonate was performed with imaging carried out immediately (the first phase) and after five minutes (the second phase) and at three hours (the third phase). The scan was classified as positive if a focal increase in uptake could be recognised in the scaphoid region and negative if normal uptake was seen or a diffuse or focally increased uptake was found elsewhere.

The scaphoid and Carpal Box radiographs were assessed blind and independently by 60 observers in the presence of an investigator. They were told that the films were of wrists injured in a fall and that, clinically, fracture of the scaphoid was suggested. They were asked whether there was radiological evidence of a fracture of the scaphoid. They could give four answers; definitely not, probably not, definitely yes and probably yes. The observers were from four departments: radiodiagnosis, surgery, orthopaedic surgery and plastic reconstructive and hand surgery (PR&H).

Statistical analysis. We analysed and expressed the data in terms of interobserver agreement. If agreement was reached by at least 75% of the observers and the result was similar to that of the bone scan, the outcome was termed reliable. Individual scores were calculated as percentages ‘correctly’ diagnosed. The observers were divided into three groups according to specialty, namely, radiologists, surgeons and a combination of PR&H surgeons and orthopaedic surgeons, and into another two groups, consultants and residents, defining experience. For the kappa statistics we used the measurement of agreement for the whole group and for each of the groups mentioned (Fleiss 1981). We also tested the agreement between the interpretation of the scaphoid radiographs and the Carpal Box radiographs for the whole group, as well as for consultants and residents, using the McNemar test for symmetry (McNemar 1947).

RESULTS

Of the 60 observers, there were 14 radiologists, 27 surgeons (including 3 traumatologists), 5 PR&H surgeons, and 14 orthopaedic surgeons, of whom 26 were consultants and 34 were residents (Table I).
Table II. Percentage agreement between the 60 observers for the scaphoid radiographs and Carpal Box radiographs compared with the bone scan

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Sex</th>
<th>Bone scan</th>
<th>Scaphoid radiographs</th>
<th>Carpal Box longitudinal</th>
<th>Carpal Box transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>24</td>
<td>M</td>
<td>Positive</td>
<td>25</td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td>2</td>
<td>43</td>
<td>M</td>
<td>Negative</td>
<td>47</td>
<td>58</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>54</td>
<td>F</td>
<td>Negative</td>
<td>78</td>
<td>88</td>
<td>78</td>
</tr>
<tr>
<td>4</td>
<td>39</td>
<td>F</td>
<td>Negative</td>
<td>78</td>
<td>85</td>
<td>78</td>
</tr>
<tr>
<td>5</td>
<td>31</td>
<td>F</td>
<td>Positive</td>
<td>75</td>
<td>77</td>
<td>90</td>
</tr>
<tr>
<td>6</td>
<td>28</td>
<td>F</td>
<td>Negative</td>
<td>60</td>
<td>48</td>
<td>43</td>
</tr>
<tr>
<td>7</td>
<td>29</td>
<td>M</td>
<td>Positive</td>
<td>55</td>
<td>60</td>
<td>85</td>
</tr>
<tr>
<td>8</td>
<td>46</td>
<td>F</td>
<td>Negative</td>
<td>45</td>
<td>65</td>
<td>78</td>
</tr>
<tr>
<td>9</td>
<td>25</td>
<td>F</td>
<td>Negative</td>
<td>65</td>
<td>58</td>
<td>63</td>
</tr>
<tr>
<td>10</td>
<td>26</td>
<td>M</td>
<td>Positive</td>
<td>15</td>
<td>3</td>
<td>25</td>
</tr>
<tr>
<td>11</td>
<td>44</td>
<td>M</td>
<td>Positive</td>
<td>88</td>
<td>77</td>
<td>85</td>
</tr>
</tbody>
</table>

Table III. Judgement of traditional radiographs and X-CB for the whole group

<table>
<thead>
<tr>
<th>Kappa value 95% CI</th>
<th>Radiographs and longitudinal X-CB</th>
<th>Radiographs and transverse X-CB</th>
<th>Longitudinal and transverse X-CB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.56 (0.50 to 0.63)</td>
<td>0.51 (0.45 to 0.58)</td>
<td>0.66 (0.61 to 0.72)</td>
</tr>
</tbody>
</table>

Table IV. Judgement of traditional radiographs and X-CB in the consultants

<table>
<thead>
<tr>
<th>Kappa value 95% CI</th>
<th>Radiographs and longitudinal X-CB</th>
<th>Radiographs and transverse X-CB</th>
<th>Longitudinal and transverse X-CB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.55 (0.45 to 0.65)</td>
<td>0.54 (0.44 to 0.63)</td>
<td>0.68 (0.54 to 0.76)</td>
</tr>
</tbody>
</table>

Table V. Judgement of traditional radiographs and X-CB in the residents

<table>
<thead>
<tr>
<th>Kappa value 95% CI</th>
<th>Radiographs and longitudinal X-CB</th>
<th>Radiographs and transverse X-CB</th>
<th>Longitudinal and transverse X-CB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.57 (0.48 to 0.65)</td>
<td>0.48 (0.40 to 0.57)</td>
<td>0.66 (0.58 to 0.73)</td>
</tr>
</tbody>
</table>

Table II shows the results for the routine scaphoid and the Carpal Box radiographs compared with the bone scan. The latter was positive in five patients (cases 1, 5, 7 (see Fig. 4) 10 and 11) and normal in the other six. Scaphoid radiographs were reliable in four patients, being negative in two (cases 3 and 4) and positive in two (cases 5 and 11). The longitudinal Carpal Box radiographs gave results similar to those of the routine scaphoid radiographs, but transverse Carpal Box radiographs were reliable in six patients, being positive in three (cases 5, 7 and 11; Figs 2 and 3) and negative in three (cases 3, 4 and 8).

There was no significant difference between the judgement of the traditional scaphoid radiographs and the longitudinal Carpal Box views for the whole group, but there was a significant difference between these two views and the transverse Carpal Box films (p < 0.01, respectively). These findings and the appropriate kappa values are shown in Table III.

The consultants showed a significant difference in judgement between the traditional radiographs and the transverse Carpal Box views (p < 0.01), but not between the traditional radiographs and longitudinal Carpal Box films or between transverse and longitudinal Carpal Box views.
The agreement between groups of specialists for the X-CB was acceptable. For consultants, the kappa value was 0.55 for the radiologists, 0.54 for the surgeons and 0.67 for the PR&H.

Case 7. Standard scaphoid views which were judged not to show a fracture: a) PA view; b) oblique view; c) lateral view; and d) PA view with the tube tilted 40° distally.

Case 7. Transverse Carpal Box radiograph showing a fracture of the waist of the scaphoid (arrow).

Case 7. Bone scan showing increased activity in the scaphoid.

separately. For individual members, this ranged from 0.19 to 0.54, from 0.13 to 0.46 for the consultants and from 0.14 to 0.39 for the residents (Fleiss 1981).
and orthopaedic surgeons. For residents, the agreement within specialties was 0.57, 0.49 and 0.65, respectively.

The results for the 60 observers reflect daily practice, since residents usually assess radiographs in the emergency department, and an experienced radiologist will review them later.

DISCUSSION

Inadequate treatment of a scaphoid fracture may lead to nonunion; this may result in severe disability. Early recognition of the fracture in the emergency department is more likely to result in prompt and adequate treatment.

We found that the use of transverse Carpal Box radiographs led to a significant increase in correct diagnoses in the whole group of observers and in the consultant group, confirming the results of a previous investigation on five cadavers (Tiel-van Buul 1992b).

Agreement among the 60 assessors on the interpretation of traditional scaphoid radiographs was acceptable for only four of the 11 patients (36%), but increased to six of 11 (55%) for transverse Carpal Box radiographs. For a clinically suspicious scaphoid fracture we use routine four-view plain radiographs. If no fracture is seen we take transverse and longitudinal Carpal Box views. If these are negative and clinical suspicion persists a bone scan is arranged.

Carpal Box radiography is simple and cheap; it improves the visualisation of non-displaced fractures of the scaphoid.

We wish to thank the 60 observers who took part in this study. No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


McNemar Q. Note on the sampling error of the difference between correlated proportions or percentages. Psychometrika 1947;12:153-7.


