PERCUTANEOUS SCREW FIXATION FOR FRACTURES OF THE SCAPHOID

GERALD E. WOZASEK, KLAUS-DIETMAR MOSER

From University School of Medicine, Vienna

We describe a percutaneous technique for screw fixation of all types of fractures of the scaphoid. During a 15-year period ending in 1984, 280 cases were treated by this method; 198 of them returned for evaluation in 1986 and comprise the material for this report. After a mean postoperative time of 82 months, 89% of the recent fractures had united as well as 81.8% of those with delayed or nonunion and 42.8% of those with sclerotic nonunion.

Most acute fractures of the scaphoid heal with conservative treatment (London 1961; Trojan 1961; Leslie and Dickson 1981) but nonunion is not uncommon in unstable fractures with comminution or displacement (Cooney, Dobyns and Linscheid 1980; Herbert and Fisher 1984; Dias, Brinkel and Finlay 1989). Eddeland et al (1975) reported a pseudarthrosis rate of 63.6% in a series with displacement of less than 1 mm which were treated in plaster. Other disadvantages of conservative treatment are the duration of immobilisation and the loss of ability to work.

The prerequisites for rapid union are anatomical reduction and compression of the fracture surfaces. Stable screw fixation maintains apposition of the fragments, promotes rapid revascularisation, and permits wrist movement throughout the healing period.

The introduction of a screw is not easy, even in the widely exposed scaphoid, but, under fluoroscopy, a guide wire can be inserted into the scaphoid percutaneously without much difficulty. The osteosynthesis can then be performed with cannulated instruments and only minimal operative trauma. In 1970 Streli published details of this technique for the first time; we here report our clinical observations, problems and results with this method.

TECHNIQUE

The following instruments are needed: a guide wire 1.0 × 80 mm; a cannulated drill bit 3.3 mm; a cannulated tap; cannulated screws (shaft 2.9 mm, thread 4.8 mm, length 14 to 32 mm); and a cannulated screwdriver for countersunk cross-slit screws (Fig. 1). In addition, a cannulated reamer is sometimes needed for the resection of a pseudarthrosis (Fig. 2).

The operation is performed under general, brachial plexus or local intravenous anaesthesia. The patient is placed supine on the operating table. His hand is suspended by the thumb in a Japanese finger trap on an extension frame to permit visualisation of the scaphoid with the image intensifier in all positions between full pronation and supination. Ulnar deviation of the wrist causes the scaphoid to slide out from under the radial styloid process.

The guide wire is introduced, in the axis of the scaphoid, into the dorsal surface of the scaphoid tubercle just between the articular surfaces facing the radius and the trapezoid. Depending on the obliquity of the fracture, the point of insertion can be moved to the palmar or the dorsal side to be more nearly at right angles to the fracture and thus achieve more stable fixation. The lateral radiograph does not show the entire proximal outline of the scaphoid. The guide wire is directed towards the middle of the distal articular surface of the radius, that is, into the proximal pole of the scaphoid (Fig. 3a). This is the most critical part of the operation.

At the point where the guide wire enters, a 10 mm skin incision is made and the soft tissues are divided down to bone. The length of screw required is then determined by the difference in length between a correctly placed wire with its tip at the proximal pole and a second

---

G. E. Wozasek, MD, Lecturer and Orthopaedic Surgeon
Second Department of Trauma Surgery, University of Vienna, Medical School, Spitalgasse 23, A-1090 Vienna, Austria.

K.-D. Moser, MD, Orthopaedic Surgeon
Department of Trauma Surgery, LKH Salzburg, Austria.

Correspondence should be sent to Dr. G. E. Wozasek.

© 1991 British Editorial Society of Bone and Joint Surgery
0301-620X/91/1045 S2.00

138 THE JOURNAL OF BONE AND JOINT SURGERY
parallel pin of the same length with its tip at the distal pole (Fig. 3b). A pilot hole is then drilled with a cannulated drill and a thread is cut with a screw tap. The screw is then inserted over the correctly positioned guide wire.

Figure 3a – The lateral view does not show the entire proximal outline of the scaphoid, so the guide is directed towards the middle of the distal articular surface of the radius if it is to enter the proximal pole of the scaphoid. Figure 3b – The screw length is determined by the difference in protruding length between one 8 cm pin with its tip at the proximal pole and a second parallel pin of the same length with its tip at the distal pole.

The last turns of the screw generate compression and should close the fracture cleft. While this is being done, the traction produced by the weight of the arm is eliminated by resting the patient’s elbow on the table. Screw lengths at 2 mm intervals from 14 to 32 mm, with short and long threads and 1 mm thick washers, are enough to cover all sizes of scaphoid. To achieve compression the threaded portion is always entirely within the proximal fragment and must not cross the fracture line. After removal of the guide wire, two or three skin sutures complete the operation.

When fixation appears absolutely stable, which can be verified by moving the wrist in all directions under the image intensifier, a palmar plaster splint is applied. This is worn until the wound is healed; with comminuted fractures plaster is needed for six weeks. The screw is removed as soon as bone fusion has been confirmed by radiological and clinical examination, though impingement at the radioscaphoid joint or local discomfort occurred in only a few cases. If the screw has to be removed before fracture healing is certain, we place a corticocancellous peg graft into the screw hole.

When the operation is performed for established nonunion the false joint is milled out percutaneously with a specially developed cannulated reamer (see Fig. 2). Care has to be taken not to penetrate the outer wall of the scaphoid which would permit extrusion of spongiosa. The cavity is filled with autogenous cancellous bone through a small funnel and compressed with a punch. The wrist is then immobilised for six weeks in a plaster gauntlet.

In patients with a small necrotic proximal fragment, we do not attempt reconstruction. We use an open approach to excise the fragment and replace it with an autogenous bone graft from the contralateral anterior superior iliac spine (modified Russe II procedure, Russe
A bone screw is used to give rigid fixation but revascularisation requires a long period of immobilisation.

PATIENTS
Between 1970 and 1984, 280 patients were treated by percutaneous screw fixation; in 61 of these additional bone grafting was performed and in six a modified Russe II procedure was necessary. Of these 280 patients, 198 (70.7%) were re-examined in 1986, after a mean postoperative time of 82 months. The average age of the 176 men and 22 women was 29 years at the time of operation (range 16 to 68); 165 of the men (94%) were heavy labourers, farmers or temporary registered workers. Most patients had sustained their fractures during forced dorsiflexion of the wrist caused by falls, crank handle injuries or catching soccer balls; surprisingly, 10 did not remember any acute traumatic episode.

The fractures were classified into four groups, according to the interval between injury and operation: acute fractures; delayed union (a persistent gap at 12 weeks after injury); established nonunion with cavitation; and sclerotic nonunion. The results were assessed subjectively, objectively and radiologically and graded according to the criteria in Table I.

RESULTS
Sound radiological union occurred in 130 patients with fresh fractures (89%) after an average of 4.2 months (Table II and Fig. 4). Radiographically, 30% of the fractures were classified as stable and 70% as unstable (oblique or comminated). Five nonunions were due to technical errors; on two occasions the screw had been placed partly outside the proximal fragment of the scaphoid, twice the thread had engaged both fragments, and once the screw was too long to permit interfragmentary compression. One screw became loose and was replaced, two superficial wound infections occurred but cleared rapidly with antibiotics, and two patients developed Sudeck's atrophy. In addition three patients had superficial radial nerve irritation but this caused only temporary discomfort.

There was no difference in the postoperative treatment between a heavy labourer and an office employee. Patients had returned to work after an average of three weeks (range one week to eight months).

In 25 fractures with delayed union and in eight with established nonunion and cavitation, bony healing was achieved in 27 cases (81.8%) (Table III and Fig. 5). Homologous match-stick grafting was performed after screw removal in fractures with doubtful union to accelerate reossification of the screw hole. Failure to carry out percutaneous bone grafting at the time of initial

Table I. Grading of the results

<table>
<thead>
<tr>
<th>Grade</th>
<th>Subjective</th>
<th>Objective</th>
<th>Radiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>1*</td>
<td>No pain, normal strength</td>
<td>Full function</td>
<td>Sound union, no deformity</td>
</tr>
<tr>
<td>2*</td>
<td>Occasional pain, good strength</td>
<td>20° loss of movement, superficial nerve irritation</td>
<td>Sound union, minor arthritis</td>
</tr>
<tr>
<td>3</td>
<td>Frequent pain</td>
<td>20° to 50° loss of movement</td>
<td>Doubtful union, minor arthritis, normal shape of scaphoid</td>
</tr>
<tr>
<td>4</td>
<td>Continuous pain</td>
<td>50° loss of movement, restricted use</td>
<td>Nonunion, severe arthritis, fragment necrosis</td>
</tr>
</tbody>
</table>

* 1 and 2 = good

Table II. Results of 146 acute fractures

<table>
<thead>
<tr>
<th>Grade</th>
<th>Subjective</th>
<th>Objective</th>
<th>Radiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>87</td>
<td>107</td>
<td>107</td>
</tr>
<tr>
<td>2</td>
<td>50</td>
<td>30</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>7</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

Fig. 4
Radiographs of a comminuted fracture of the waist of the scaphoid: pre-operative; postoperative; five months later, showing slight avascular changes of the proximal fragment; result after nine years.
PERCUTANEOUS SCREW FIXATION FOR FRACTURES OF THE SCAPHOID

Fig. 5

Radiographs of a scaphoid fracture with delayed union: pre-operative; postoperative; after one year; and after six years.

<p>| Table III. Results of 33 cases of delayed or established nonunion |
|---------------------|---------------------|---------------------|</p>
<table>
<thead>
<tr>
<th>Grade</th>
<th>Subjective</th>
<th>Objective</th>
<th>Radiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>11</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>15</td>
<td>10</td>
<td>12 (+1)</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

<p>| Table IV. Results of 14 cases with sclerotic nonunion |
|---------------------|---------------------|---------------------|</p>
<table>
<thead>
<tr>
<th>Grade</th>
<th>Subjective</th>
<th>Objective</th>
<th>Radiological</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>8</td>
<td>7</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

surgery appeared to have been the prime mistake in 17 cases.

Only six of the 14 sclerotic nonunions (42.8%) treated by bone grafting and screw fixation healed uneventfully (Table IV); two were subsequently treated by a Matti-Russe procedure (Matti 1937; Russe 1960) and two were clinically asymptomatic with the screw remaining in place. Bone graft resorption or partial graft extrusion resulted in persistent nonunion. Our radiological results were much worse than those reported by Herbert and Fisher (1984), although subjective grading was satisfactory in 85.7% of our patients.

Bony union was achieved in only three of the five patients treated by the open modified Russe II procedure (Table V and Fig. 6). One patient required an intercarpal arthrodesis because of carpal collapse.

DISCUSSION

The scaphoid, like the talus, has an almost complete cartilaginous surface except for small bands on its dorsal and palmar aspects. Consequently it does not have the capacity for periosteal healing, but depends on an intrasosseous process. Moreover, the circulation in the proxi-

Fig. 6

Radiographs showing a small proximal fragment: pre-operative; postoperative; after one year; and after seven years.

VOL. 73-B, No. 1, JANUARY 1991
mal third of the bone depends on intra-osseous vessels (Talesnik and Kelly 1966; Gelberman and Menon 1980; Gelberman and Gross 1986). Therefore the more proximal the fracture, the greater the probability of a prolonged healing period or of nonunion.

The basic principles of management of the fractured scaphoid are early diagnosis, anatomical reduction and adequate immobilisation. Displacement or comminution increases the risk of nonunion and requires closed reduction or, if this is not possible, open reduction. Garcia-Elias et al (1988) compared the carpal alignment after different surgical approaches to the scaphoid; they found that a significant increase in the scapholunate and lunocapitate angles resulted from using the palmar approach which divides the radiocapitate and radiolunate ligaments. Since the stability of the carpus depends largely on the integrity of these palmar structures (Fisk 1970), they need to be carefully repaired and protected in plaster if carpal collapse is to be prevented. Accordingly, a dorsoradial incision is advocated when inlay bone grafting is indicated. Internal fixation has an important role in the treatment of unstable nonunion.

Herbert and Fisher (1984) reported union in 100% of acute unstable fractures, in 84.6% of those with delayed union, in 88.2% of those with fibrous nonunion and in 76% of those with sclerotic nonunion. Another multicentre study of 50 scaphoid fractures treated with Herbert’s differential pitch screw showed very similar results (Bunker, McNamee and Scott 1987). In our study, 89% of the acute fractures and 81.9% of the delayed and established nonunions united (grade 1 and 2); 85.7% of the patients with sclerotic nonunion graded their result subjectively good although only 42.9% showed radiological union. In this sclerotic nonunion group there was a high incidence of scaphoid shortening. Although the false joint can be resected percutaneously with the canulated reamer, normal scaphoid length can only be restored by an open graft.

Conclusion. An extensive open exposure of a fractured scaphoid damages the blood vessels and the radiocarpal ligaments. By contrast, percutaneous fixation requires minimal operative trauma. Good results can be anticipated if the fracture is anatomically reduced and the screw correctly placed. Cannulated implants and instruments permit precise drilling, tapping and screw insertion. In fresh fractures without comminution no plaster cast support is necessary and early return to full function can be allowed. In cases with carpal collapse, sclerotic nonunion, or a very small proximal fragment, an open method of fixation should be performed.

The authors wish to thank Dr J. Schatzker for his critical advice in the preparation of this paper.

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


