THE OPERATIVE TREATMENT OF SCAPULAR FRACTURES

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Fractures of the scapula occur mainly from direct trauma involving considerable violence and associated injuries of the shoulder and thorax are common. In most cases early functional treatment gives good or excellent results. Operative treatment may, however, be indicated, especially with displaced intra-articular fractures, fractures of the glenoid rim associated with humeral head subluxation, or unstable fractures of the scapular neck.

Between 1967 and 1981, we treated 37 such fractures by open reduction and stable osteosynthesis. We were able to follow up 33 cases (89%), of which 21 (64%) had complete functional recovery. The other 12 had varying degrees of pain, loss of mobility, and weakness. Overall, however, 79% of the patients had good to excellent results.

Scapular fractures are relatively rare, constituting 1% of all fractures and 5% of fractures involving the shoulder. They are usually caused by high-energy vehicular trauma or by falling from a height. Accordingly, there are often associated injuries of the ipsilateral limb, shoulder girdle, and thorax (Rowe 1963; Imatani 1975). In patients with multiple injuries scapular fractures are frequently overlooked or neglected, because other life-threatening problems are the focus of attention.

In most cases early functional treatment of scapular fractures produces good to excellent results (Müller-Färber 1976; DePalma 1983). The bone is embedded in large muscle masses, so that when fractures do occur displacement of the fragments is usually minimal and complete healing is the rule. It is exceptional for a scapular fracture to require open reduction, and operative treatment is justified only when bone and soft-tissue damage are such that with conservative measures alone function will not be restored and post-traumatic osteoarthritis will develop.

Classification
Classification is based on the radiographic appearances, and for a complete evaluation of the scapula several views are needed: these include a "true" anteroposterior view perpendicular to the plane of the scapula, obtained by directing the central ray 30° divergent from the sagittal plane; a lateral view with the central ray 30° posterior to the lateral plane (parallel to the scapular plane); and an axillary view (DePalma 1983). In some cases these views need to be supplemented by others in varying degrees of rotation, or with the arm abducted 90° (Imatani 1975).

Fig. 1

Only after a complete radiological examination can the fracture be accurately classified and the amount of displacement determined (Bernau 1982). Eight distinct varieties of fracture are described (Fig. 1), but combinations also occur. Fractures of the scapular body (Fig. 1, A) can usually be treated conservatively. The thick muscle mantle covering the body prevents significant displacement of the frag-
Fractures (Jeanmaire and Ganz 1982). Slings or splints are used only for the first few days to control pain. However, with a "burst" fracture, the lateral margin of the body may be displaced and a sharp spike may enter the joint capsule (Figs 2 and 3); this would inevitably impair joint function, so that operative reduction and fixation (Figs 4 and 5), or osteotomy of the bony spike would be indicated.

Fractures of the glenoid rim (Fig. 1, B) are usually produced by traumatic dislocation of the humeral head (Hardegger and Kappeler 1980). If the rim fragment is large, then closed reduction of the humeral head may leave the glenohumeral joint still unstable. In such cases, open reduction and fixation of this fragment is indicated in order to prevent recurrent or permanent dislocation of the shoulder (DePalma 1983).

Fractures of the glenoid fossa (Fig. 1, C) without displacement are treated conservatively; but if there is significant displacement (Figs 6 and 7), conservative treatment alone cannot restore congruence. Stiffness and pain may result (Tscherne and Christ 1975) and, for this reason, open reduction and stabilisation is indicated (Figs 8 and 9).

Fractures of the anatomical neck (Fig. 1, D) are relatively rare. The fracture fragment, which contains the glenoid, is usually significantly displaced distally and laterally (Figs 10 and 11) by the pull of the long head of the triceps muscle which inserts into the infraglenoid tubercle. DePalma (1983) has recommended lateral traction through the olecranon for this fracture, and for those through the surgical neck, but if traction is not successful or not desired, then open reduction and internal fixation is indicated (Figs 12 and 13).

Fractures of the surgical neck (Fig 1, E) may be associated with severe displacement of the lateral scapular angle (Magerl 1974). The amount of displacement is dependent upon whether there is an associated fracture of the clavicle, or coracoclavicular ligamentous disruption, or both. If the clavicle and these ligaments are intact (Fig. 14) the fracture remains stable. If, however, the suspensory and stabilising functions of these structures are lost (Fig. 15) the neck fragment becomes unstable because muscle forces and the weight of the arm pull it distally and anteromedially (Figs 16 and 17; Ganz and Noesberger 1975). The relationship of the glenohumeral joint with the acromion and the nearby muscle origins is altered resulting in functional imbalance. To restore normal function, operative treatment (Figs 18 and 19) with restoration of the anatomical relationship is preferred to conservative management (Judit 1964; Magerl 1974; Tscherne and Christ 1975).

Fractures of the acromion (Fig. 1, F) with minimal dislocation are treated conservatively. However, the pull
Figures 6 to 9—Fracture of the glenoid fossa. Figure 6—Displaced fracture of the glenoid fossa with an associated fracture of the lateral body. Figure 7—Radiographic appearance. Figure 8—Plan for osteosynthesis by means of tension band wiring around anchored screw heads dorsally, and buttress plating dorsolaterally with a semi-tubular plate. Figure 9—Radiograph one year after operation.

Figures 10 to 13—Fracture of the anatomical neck. Figure 10—The fracture fragment is displaced by the pull of the long head of triceps. Figure 11—Radiographic appearance. Figure 12—Plan for reduction and screw fixation. Figure 13—Immediate postoperative radiograph.
of the deltoid muscle can displace and tilt the fragment inferiorly, which compromises the function of the rotator cuff; if there is significant displacement, painful non-union can develop (Russe 1975). To prevent this complication operative reduction may be indicated, followed by fixation with a screw or a tension band.

Fractures of the scapular spine (Fig. 1, G) occur most often in combination with body fractures. The treatment is conservative unless significant displacement is present and there are other associated fractures requiring open reduction. Fixation can be achieved with an interfragmentary screw and dorsal tension band wiring.

Figures 14 and 15—Fractures of the surgical neck. Figure 14—With an intact clavicle and coracoclavicular ligaments, the fracture remains stable. Figure 15—With an associated clavicular fracture and ligamentous disruption the fracture is unstable.

Fractures of the scapular spine (Fig. 1, G) occur most often in combination with body fractures. The treatment is conservative unless significant displacement is present and there are other associated fractures requiring open reduction. Fixation can be achieved with an interfragmentary screw and dorsal tension band wiring.

Figures 16 to 19—Unstable surgical neck fracture. Figure 16—The surgical neck fragment is severely displaced anteromedially. Figure 17—The radiographic appearance. Figure 18—Plan for fixation with a posteriorly applied semi-tubular buttress plate and an additional lag screw through the spine into the dense bone of the anatomical neck. Figure 19—Radiograph four months after operation.
Fractures of the coracoid process (Fig. 1, H) occurring at the base are judged to be stable if the coraco-acromial and coracoclavicular ligaments are intact (DeRosa and Kettelkamp 1977): such fractures can be expected to heal uneventfully. Operative treatment is, however, indicated when ligamentous damage leads to displacement of the coracoid sufficient to cause compression of the neurovascular bundle (Neer 1975). Fractures of the coracoid tip are avulsion fractures produced by the pull of the attached conjoined origin of the short head of biceps and the coracobrachialis. Re-attachment of the tip fragment may be indicated in athletic individuals (DeRosa and Kettelkamp 1977).

Combined fractures with involvement of the glenoid, body, and apophyses are usually seen in patients with multiple injuries. In these patients operation may need to be postponed because of other injuries, but secondary or late operation should at least be considered in patients with significantly displaced glenoid fractures. Secondary surgery is, however, technically very difficult because of callus and scar-tissue formation.

MATERIAL AND METHODS

From 1967 until 1981, 37 patients with scapular fractures requiring operative intervention were treated. These included: 4 apophyseal fractures (coracoid process, acromion process and spine), 11 fractures of the glenoid rim, 12 of the glenoid fossa, 3 of the surgical neck, 2 of the anatomical neck and 5 combined fractures. The sex distribution was unequal, with 31 males and 6 females. The youngest patient was 17, the oldest 85 and the average age 42 years. Ten patients had multiple injuries and were treated by secondary or delayed operation. In eight patients there were additional injuries of the ipsilateral limb or shoulder girdle: 1 brachial plexus injury, 2 proximal humeral fractures, 4 clavicular fractures, and 1 dislocation of the acromioclavicular joint.

Operative technique

Depending on the fracture type, the anterior or posterior approach is chosen. Correct positioning is absolutely essential; it should permit the surgeon and his assistants to work efficiently and comfortably, and must allow all the necessary anatomical structures to be displayed. The semi-sitting position fulfils these criteria for approaches to the superior, anterior, and inferior portions of the scapula. The patient lies on the table with the upper part of his body elevated 45° to 60° from the horizontal, with his knees flexed to ensure stability. The injured limb is free for manipulation, with a sandbag under the shoulder and the table tilted slightly away from the surgeon. For posterior approaches, the patient lies in the prone position with a sandbag under the chest wall of the affected side. His head is turned away from that side and the outstretched arm is supported on a table.

Anterior approach. Fractures of the anterior rim, or of the inferior rim of the glenoid, and fractures of the coracoid process are approached anteriorly. The incision is through the deltopectoral sulcus, dividing the subscapularis tendon near its insertion. In fresh rim fractures capsular disruption usually allows full inspection of the joint. The reduction of inferior rim fragments can be difficult, and for better exposure the coracoid tip is osteotomised and the conjoined tendon mobilised. Depending on the size of the rim fragments, fixation is performed with either 3.5 mm or 4.5 mm lag screws.

Posterior approach. Fractures of the scapular neck and fractures of the glenoid fossa are visualised best through the posterior approach. The skin incision curves from the acromion over the spine to the inferior angle (Crenshaw 1980). Dissection is continued through the interval between infraspinatus and teres minor muscles. To provide better exposure the infraspinatus muscle may be detached from its origin; the suprascapular nerve and vessels entering its superior portion must be protected during reflection of the muscle.

Fractures of the glenoid fossa are reduced, provisionally fixed with Kirschner wires, and then secured with lag screws. When lag-screw fixation cannot be done because of the fracture orientation, tension band wiring can provide interfragmentary compression (Figs 6 to 9). If there is a tendency for the fragment to displace inferiorly, it can be supported by a buttress plate applied to the lateral margin.

Fractures of the anatomical neck are usually stabilised with two or three lag screws (Figs 10 to 13). The superior screw is directed obliquely, from the spine proximally to the infraglenoid tubercle distally. The distal tip of the fragment is secured to the body with the second lag screw. Sometimes, however, there is a strong tendency for this fragment to displace inferiorly and stronger fixation is required; this is achieved by the use of an additional lag screw or by dorsal plate fixation, or both.

Unstable fractures of the surgical neck (Fig. 15) are stabilised with a semi-tubular buttress plate and an additional lag screw (Figs 16 to 19). This screw penetrates through the spine and obtains purchase in the dense bone of the anatomical neck; the direction of the screw counteracts the tendency to displacement. For buttressing this large neck fragment, a semi-tubular plate is anchored to the lateral scapular margin. If, however, the scapular neck fragment is only minimally displaced, together with a clavicular fracture, then fixation of the clavicle alone can convert this unstable neck fracture into a stable one.

Severely displaced spine and acromion fractures are treated with combinations of lag screw and tension band fixation.

Combined fractures, which include unstable fractures of the neck and fractures of the glenoid fossa, present a challenge to the surgeon. Certainly most of these fractures should be treated conservatively (DePalma 1983). When the patient's condition permits, however, restoring a congruent joint surface by fixation
of the glenoid fragments and stabilisation of the unstable neck fragment in the manner described, reduces the incidence of post-traumatic osteoarthritis and joint stiffness (Judet 1964; Magerl 1974; Ganz and Noesberger 1975; Russe 1975; Tscherne and Christ 1975).

**Aftercare**

A sling and swathe, or a splint which immobilises the shoulder is applied for 3 to 5 days. After this time functional rehabilitation is begun. Pendulum exercises and then active movements are performed under the supervision of a physiotherapist. As a rule complete healing of the fracture is achieved at 6 to 8 weeks after operation, and maximal movement and function after 10 to 12 weeks.

**RESULTS**

Long-term follow-up was possible in 33 of the 37 patients operated upon (89%). These patients were interviewed, examined clinically and their radiographs reviewed. The shortest follow-up was 18 months, the longest 15 years, and the average 6.5 years.

**Table I. Functional clinical results**

<table>
<thead>
<tr>
<th>Range of movement</th>
<th>Number of patients</th>
</tr>
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<tbody>
<tr>
<td>Full</td>
<td>21</td>
</tr>
<tr>
<td>Minimal limitation (abduction deficit &lt; 30°)</td>
<td>5</td>
</tr>
<tr>
<td>Moderate limitation (abduction deficit 30°-40°)</td>
<td>5</td>
</tr>
<tr>
<td>Severe limitation (abduction deficit &gt; 40°)</td>
<td>2</td>
</tr>
<tr>
<td>Pain</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>25</td>
</tr>
<tr>
<td>Minimal (occasional with heavy activity)</td>
<td>3</td>
</tr>
<tr>
<td>Moderate (occasional with routine activity)</td>
<td>4</td>
</tr>
<tr>
<td>Severe (constant)</td>
<td>1</td>
</tr>
<tr>
<td>Muscle power</td>
<td></td>
</tr>
<tr>
<td>Grade 5</td>
<td>22</td>
</tr>
<tr>
<td>Grade 4</td>
<td>5</td>
</tr>
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<td>Grade 3</td>
<td>5</td>
</tr>
<tr>
<td>Grade 2</td>
<td>1</td>
</tr>
</tbody>
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**Functional results.** The range of movement, degree of pain, and strength of the 33 patients are summarised in Table I. The result in 21 patients was judged as excellent with near-normal function. Five patients had slight limitation of movement and Grade 4 strength of abduction; three of these had occasional pain with heavy activity. These five were judged to have good results. Patients in these two categories (good or excellent) were able to do their usual work with no disability.

In five patients, however, there was some disability and loss of activity. These patients had a moderate restriction of movement (less than 30° loss of abduction), measurable muscle wasting and diminished muscle power (Grade 3 to 4). Four of these five complained of pain with routine or heavy activities. All five were assessed as having fair results.

Two patients had poor results. One developed severe glenohumeral osteoarthritis with disabling, intense pain and restriction of movement necessitating arthrodesis at a later date. The other poor result was in a patient who had also injured his brachial plexus which resulted in severe wasting and loss of movement.

**Complications.** Two patients developed superficial infections with *Staphylococcus aureus* after operation; both healed after being drained. Two other patients each developed a haematoma which required evacuation. One patient, with postoperative instability, needed a further fixation operation, after which the fracture healed uneventfully. In eight cases, shoulder mobilisation under general anaesthesia was performed 4 to 6 weeks after operation; none of these patients required a second mobilisation procedure.

**DISCUSSION**

Two groups of scapular fractures can be distinguished: those which will probably heal without long-term complications, and those liable to cause significant disability. The first group includes most fractures of the scapular body, and also those fractures of the scapular neck and apophyses (coracoïd, acromion, scapular spine) which have minimal displacement. The second group is composed of glenoid fracture-dislocations, unstable fractures of the scapular neck and significantly displaced apophyseal fractures.

In the first group conservative treatment is sufficient to restore normal or near normal function. By contrast, fractures in the second group may need anatomical reposition if late disability is to be avoided. Consequently operative treatment with stable osteosynthesis may be indicated; this also permits early functional aftercare. With these fractures other methods of treatment, including early mobilisation or initial traction followed by functional aftercare, have sometimes been successful (Imatani 1975; Neer 1975; DePalma 1983). But it has been our experience, as well as that of other surgeons (Judet 1964; Magerl 1974; Ganz and Noesberger 1975; Tscherne and Christ 1975), that with these displaced intra-articular fractures and unstable neck fractures, better results are achieved with operative than with conservative treatment.

The operative treatment of scapular fractures demands experience of the techniques of osteosynthesis, a thorough knowledge of anatomical approaches and, of course, adequate operative conditions with strict asepsis. The operative indications, therefore, are not dependent only on the pattern of the fracture.
REFERENCES