Between 1993 and 1999, we treated ten patients with comminuted fractures of the olecranon by multiple tension-band wiring and a graft from the iliac crest. Their mean age was 35 years (19 to 56). The mean follow-up was for 28.5 months (15 to 46) and the mean time to union of the fractures was four months (3 to 7).

No patient reported difficulties with activities of daily living or symptoms of instability of the elbow. The mean flexion was to 135° (125 to 145) with a mean flexion contracture of 15° (10 to 30). The mean pronation was 70° (60 to 80) and mean supination 79° (70 to 90). Only three patients had mild pain and loss of strength. Five patients had excellent and five good results with a mean Broberg and Morrey index score of 94.5 points (84 to 100).

Our results compare favourably with those previously reported and the technique is thought to be a practical alternative to plate fixation in fractures with extreme comminution.

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A comminuted fracture of the olecranon is a difficult injury to treat. Since it is an intra-articular and the olecranon effectively functions as the fulcrum of the lever arm of the elbow, it is necessary to restore precise anatomical alignment with rigid fixation so that early movement can be encouraged. Although tension-band wiring is the standard technique for fixation, it can be difficult to carry out adequately when there is comminution and bone loss. Under these circumstances, the compressive force of the wiring may cause the fragments of bone to collapse, displacing the fracture, and shortening the ulna. Fixation by a plate, in combination with bone grafting, is an alternative method used to maintain reduction of comminuted fractures after reconstruction of the joint surface. It does not, however, consistently provide enough stability to allow early mobilisation, especially when the proximal fragment is small and thin.

We describe the operative technique employed and the results of treatment in ten patients with comminuted fractures of the olecranon using multiple tension-band wiring in combination with a bone graft from the iliac crest.

Patients and Methods

Between 1993 and 1999, we treated ten patients (eight men and two women) with comminuted fractures of the olecranon (Fig. 1 and Table I). Their mean age at the time of operation was 35 years (19 to 56). All fractures had been caused by a high-energy injury, including eight motor-vehicle accidents and two falls from a height. Six of the fractures were open, and were graded according to the criteria of Gustilo and Anderson as type I in four patients and type II in two. All the fractures were classified according to the Mayo classification; six were type IIB and four type IIIB. Three patients (cases 8 to 10) had type-IIIB fractures involving the coronoid as the major fragment (Fig. 1a), and one (case 8) also had a Monteggia fracture associated with a fracture of the distal radius. There were no associated neurovascular injuries.

The mean interval between injury and operation was 9.5 days (2 to 15). The six patients with open fractures were treated by irrigation, debridement and primary wound closure, and delayed internal fixation. The elbow was immobilised in a long-arm splint for a mean of 2.6 days (1 to 5) after operation, after which active exercises were started. Dynamic flexion and extension splints were used after three or four weeks, and strengthening and endurance exercises after three months.

The mean follow-up period was 28.5 months (15 to 46). Evaluation at follow-up consisted of assessment of the stability, muscle strength, the active range of flexion and extension of the elbow, and rotation of the forearm. Antero-posterior and lateral radiographs were taken to assess bony union, articular congruity and post-traumatic degenerative
changes. The overall outcome was determined using the functional rating index described by Broberg and Morrey.12

Operative technique. The patient was placed in the supine position under general anaesthesia. We used a standard posterior approach after inflation of a tourniquet. The goal was to replace the comminuted section of the mid-portion of the olecranon with a bone block from the iliac crest, while preserving the anatomical curvature of the notch of the trochlea. The comminuted posterior section was initially removed, but the length of the ulna was maintained. The bed for the graft was prepared and bone taken from the iliac crest to fill the defect (Fig. 2). The posterior cortex of the fractured olecranon was preserved to provide stability for the graft. Two parallel 1.8 mm Kirschner wires were inserted from the tip of the olecranon through the bone block into the shaft of the ulna (Fig. 3a). After radiological assessment of the length of the ulna and the contour of the trochlear notch two 0.8 mm wires were anchored to the bone block and to the shaft of the ulna separately, passed around the Kirschner wires, and twisted in a figure-of-eight (Fig. 3b). In the patient with a large fragment of the coronoid process a 0.8 mm wire was anchored to this fragment, passed around the Kirschner wires, and twisted in a figure-of-eight fashion over the bone block.

Results

The mean time to union of the fractures was four months (3 to 7). There were no operative complications. No patient reported difficulty with activities of daily living or symptoms of instability of the elbow.

The mean range of flexion was 135° (125 to 145), with a mean flexion contracture of 15° (10 to 30). The mean pronation was 70° (60 to 80), and the mean supination was 79° (70 to 90). Seven patients had no pain and three (cases 1, 8 and 10) had mild pain during heavy manual labour. There was mild loss of the strength of flexion and extension in three patients (cases 1, 5 and 9). The strength of pronation and supination was almost normal in all patients. None

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Table I. Details of ten patients with comminuted fracture of the olecranon treated by multiple tension-band wiring with a graft from the iliac crest

<table>
<thead>
<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Fracture type (Mayo class)</th>
<th>Wound†</th>
<th>Time from injury to operation (days)</th>
<th>Time to initiation of movement (days)</th>
<th>Duration of follow-up (mths)</th>
<th>Range of movement (degrees)</th>
<th>Elbow rating (points)</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>36</td>
<td>M</td>
<td>IIB</td>
<td>O(I)</td>
<td>15</td>
<td>1</td>
<td>34</td>
<td>-15/125</td>
<td>80/80</td>
<td>84</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>M</td>
<td>IIB</td>
<td>O(I)</td>
<td>13</td>
<td>3</td>
<td>46</td>
<td>-10/130</td>
<td>80/90</td>
<td>97</td>
</tr>
<tr>
<td>3</td>
<td>20</td>
<td>M</td>
<td>IIB</td>
<td>C</td>
<td>8</td>
<td>4</td>
<td>31</td>
<td>-15/135</td>
<td>80/80</td>
<td>97</td>
</tr>
<tr>
<td>4</td>
<td>29</td>
<td>M</td>
<td>IIB</td>
<td>C</td>
<td>9</td>
<td>1</td>
<td>34</td>
<td>-10/130</td>
<td>60/70</td>
<td>97</td>
</tr>
<tr>
<td>5</td>
<td>47</td>
<td>M</td>
<td>IIB</td>
<td>C</td>
<td>2</td>
<td>3</td>
<td>30</td>
<td>-30/125</td>
<td>60/70</td>
<td>91</td>
</tr>
<tr>
<td>6</td>
<td>23</td>
<td>M</td>
<td>IIB</td>
<td>C</td>
<td>4</td>
<td>2</td>
<td>21</td>
<td>-10/145</td>
<td>80/90</td>
<td>100</td>
</tr>
<tr>
<td>7</td>
<td>52</td>
<td>F</td>
<td>IIIB</td>
<td>O(I)</td>
<td>10</td>
<td>1</td>
<td>36</td>
<td>-10/145</td>
<td>70/80</td>
<td>100</td>
</tr>
<tr>
<td>8</td>
<td>37</td>
<td>F</td>
<td>IIIB+cor*</td>
<td>O(I)</td>
<td>7</td>
<td>5</td>
<td>26</td>
<td>-15/145</td>
<td>60/80</td>
<td>93</td>
</tr>
<tr>
<td>9</td>
<td>32</td>
<td>M</td>
<td>IIIB+cor</td>
<td>O(II)</td>
<td>13</td>
<td>3</td>
<td>15</td>
<td>-15/135</td>
<td>70/80</td>
<td>93</td>
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<tr>
<td>10</td>
<td>56</td>
<td>M</td>
<td>IIIB+cor</td>
<td>O(II)</td>
<td>14</td>
<td>3</td>
<td>16</td>
<td>-20/135</td>
<td>60/70</td>
<td>93</td>
</tr>
</tbody>
</table>

* fracture of coronoid process
† O, open; C, closed; I, II, III, grade
had objective evidence of instability of the elbow. The radiographs at the final follow-up showed no steps in the articular surface or gaps in the trochlear notch (Fig. 1c), despite the fact that five patients had a gap in the articular surface of less than 2 mm on the final films taken at operation (Fig. 1b). According to the functional index of Broberg and Morrey,\textsuperscript{12} there were five excellent and five good results with a mean score of 94.5 points (84 to 100) (Table I).

Discussion

Open reduction and rigid internal fixation has become the generally accepted method of treatment for displaced fractures of the olecranon in order to allow early mobilisation, and the prevention of contracture of the elbow. The goals of fixation are realignment of the longitudinal axis of the olecranon, the provision of sufficient stability to allow early mobilisation, preservation of the coronoid process, and anatomical restoration of the articular surface of the trochlear notch.\textsuperscript{4} Tension-band wiring is a widely used technique for stabilising this fracture.\textsuperscript{1-5,7,13-15} This particular construct counteracts the tensile forces from the triceps muscle and converts them to a compressive force at the site of the fracture. Where there is marked comminution with bone loss, tension-band wiring may lead to collapse of the fragments with shortening of the articular surface of the olecranon, dyscongruity of the joint, impingement, loss of movement and degenerative osteoarthritis.\textsuperscript{4}

In the presence of comminution, plate fixation has been used with supplementary Kirschner wires, screws or bone grafting.\textsuperscript{6-9,16,17} In some circumstances, the proximal bone fragment may be small and thin, making fixation with a plate difficult. Severe comminution of the mid portion of the olecranon may occasionally make satisfactory reconstruction impossible, and excision of the comminuted section with shortening of the olecranon may be the only option.\textsuperscript{1}
Several classification systems have been used for comminuted fractures of the olecranon, but there have been few outcome studies. Teasdall et al. reported that 69% (11 of 16) of patients with comminuted fractures treated by fixation using a plate and wires had an excellent or good result, with a mean range of movement of 25° to 110°. Ring et al. found that 88% (15 of 17) of patients with transolecranon fracture-dislocations treated by plate fixation had an excellent or good result, with a mean range of movement of 14° to 127°. Excision of the proximal fragment with reinsertion of the triceps tendon into the proximal ulna is an alternative technique. 4,5,18 There are very few indications for this procedure since it is contraindicated in the presence of damage to the anterior soft tissue, 5 fractures involving the coronoid process and with anterior dislocation of the radial head or ulnar shaft. 4,5 A single intramedullary screw may be combined with tension-band wiring. 4,13-15 This does not function as well as parallel Kirschner wires when fixing a small proximal fragment.

Our series of ten patients included four who had a Mayo type-IIIB unstable comminuted transolecranon fracture-dislocation and three also with considerable involvement of the coronoid process. All patients had an excellent or good result, with a mean range of movement between 15° and 135°. These results compare favourably with others previously described.

The early active movement allowed by rigid fixation is an essential factor in postoperative management, and we believe that the rigid stability obtained with this technique is related to the replacement of the comminuted section with a tricortical bone block from the iliac crest and multiple tension-band wiring. The aggressive resection of the comminuted position may leave a defect requiring a substantial bone graft. Impaction of the graft between the tip of the olecranon and the shaft gives some inherent stability, allowing immediate active mobilisation. Realignment of the longitudinal axis of the ulna and preservation of its length ensures a normal anatomical relationship to the head of the radius.

A further advantage of this technique is that a large fracture fragment of the coronoid process can be fixed securely to the shaft of the ulna by figure-of-eight wiring. The stability of the fracture is tested during the operation through a full range of passive movement of the elbow. In one case a small residual gap in the articular surface of the trochlear notch which was seen at operation was not apparent on the radiographs at the final follow-up.

The indications for multiple tension-band wiring with a graft from the iliac crest to treat fractures of the olecranon are comminution, especially affecting the mid-portion of the olecranon process, with or without transolecranon dislocation (Mayo type IIB and IIIB), and fractures with or without a large fracture fragment of the coronoid process. This technique is an alternative to plate fixation in fractures with extreme comminution. It allows anatomical alignment of the fragments and the bone graft and re-establishment of the normal relationship between the olecranon and coronoid process with early postoperative mobilisation and a good functional outcome.

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