Between 1996 and 2000, we treated ten patients with severely comminuted fractures of the radial head using low-profile mini-plates. Their mean age was 42 years (24 to 71). Three fractures were Mason type III and seven were Mason-Johnston type IV. At a mean follow-up of 28.5 months (15 to 44), all fractures had united. The plates were removed in nine patients.

No patient had difficulty with daily activities or symptoms of instability of the elbow. The mean range of flexion of the elbow was from 7° to 135°, with 74° of supination and 85° of pronation. According to the Broberg and Morrey functional elbow index, the mean score was 90.7 points (73 to 100), and the outcome was excellent in three patients, good in six and fair in one.

These results compare favourably with those reported previously. The technique is applicable to severely comminuted fractures of the radial head which otherwise would require excision.

Received 2 September 2002; Accepted after revision 28 April 2003

It is generally accepted that displaced or comminuted fractures of the radial head are best treated by excision of the radial head.1-7 Long-term complications, such as distal radioulnar dissociation with proximal translation of the radius, weakness and degenerative changes of the wrist and elbow have been described.8-13 More recently, some authors have reported good results following open reduction and internal fixation using AO mini-plates and screws, Herbert screws and other forms of fixation.14-19 It remains that, if the fracture is severely comminuted, it may not be amenable to internal fixation.

Patients and Methods

Between 1996 and 2000, we treated ten patients with a severely comminuted fracture of the radial head using low-profile mini-plates (Table I). There were six men and four women with a mean age of 42 years (24 to 71). The mechanism of injury was a fall on the outstretched hand in six and a motor vehicle accident in four. Three fractures were Mason type III,1 and seven were Mason-Johnston type IV.2 Mason type III fractures associated with dislocation of the elbow and ligamentous injuries were classified as Mason-Johnston type IV. According to the AO classification system, three were type B2.2 and seven type B2.3 fractures of the radial head. One fracture (case 2) was a type II open fracture according to Gustilo's criteria.20 One patient (case 1) also had a fracture of coronoid process (Regan-Morrey type II21) and one (case 4) also had an avulsion fracture of olecranon.

The mean time interval between injury and operation was ten days (7 to 16). The patient (case 2) with an open fracture was treated initially with debridement and irrigation, and the wound was closed primarily. Internal fixation of all fractures was combined with cancellous bone grafting. Associated fractures were fixed concomitantly. Repair of the medial collateral ligament was also carried out in the seven patients with a Mason-Johnston type IV fracture. There were no associated neurovascular injuries.

At a mean follow-up of 28.5 months (15 to 44), any symptoms related to the elbow were recorded. Physical assessment included measurement of the range of movement and strength of the elbow and forearm, and the stability of the elbow. A standard, long-limb goniometer was used to measure the range of movement. Flexion and extension of the elbow was measured with the forearm in neutral rotation and the range of pronation and supination with the elbow in 90° of flexion. Anteroposterior (AP) and lateral radiographs of the elbow and forearm allowed measurement of the carrying angle, and the assessment of bony union, congruity and post-traumatic osteoarthritis. AP radiographs of the wrist were taken in supination to measure ulnar variance.
and compare it with the contralateral side. The outcome was graded using the elbow functional rating index described by Broberg and Morrey.10

**Operative technique.** With the patient placed in the supine position under general anaesthesia, we used Kocher’s lateral approach to expose the radial head between the anconeus and extensor carpi ulnaris. A longitudinal incision was made through the annular ligament and capsule, along the radial collateral ligament. Once reduced, the fracture fragments were held with small forceps or temporarily fixed with 1 mm Kirschner wires. Bone graft was placed between the radial head and neck.

We used the low-profile T-shaped mini plate (Stryker Leibinger, GmbH & Co, Freiburg, Germany) with a profile height of 0.55 mm. The screw diameters were 1.7 mm, and the heads which were also low-profile, were countersunk into the plate. Two plates were applied as a buttress from the radial shaft to the head. They were bent to conform to the contour of the radial neck. On the radial shaft, the screws of the plate perforated the opposite cortex. On the radial head we inserted the tip of the screws into subchondral bone so as not to perforate the opposite articular cartilage. Associated small fragments were fixed with screws. In this way, the head and shaft were connected by two plates (Fig. 1). After fixation, we examined the alignment and movement of the radial head, both radiologically and by manipulating the forearm manually (Fig. 2). Herbert screws may be used if the fracture fragments are large enough to engage the screw head (Fig. 3).

The lateral ligament complex, which was usually avulsed from the lateral condyle was reattached with an anchor (Mitek GII Anchor System; Ethicon, Johnson & Johnson Co, Westwood, Massachusetts). If there was associated injury to the ulnar collateral ligament, it was repaired with non-absorbable sutures or an anchor using a medial approach.

***Table I.*** Details of ten patients with a comminuted fracture of the radial head treated by open reduction and internal fixation using low-profile mini-plates

<table>
<thead>
<tr>
<th>Case</th>
<th>Gender</th>
<th>Age (yrs)</th>
<th>Fracture type *</th>
<th>Time from injury to operation (days)</th>
<th>Length of follow-up (mths)</th>
<th>Range of movement (degrees)</th>
<th>Carrying angle increase (degrees)</th>
<th>Ulnar variance increase (mm)</th>
<th>Functional rating index (pts)</th>
<th>Overall result</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>F</td>
<td>26</td>
<td>IV + cor</td>
<td>9</td>
<td>44</td>
<td>-9/135</td>
<td>70/70</td>
<td>1</td>
<td>1</td>
<td>86 Good</td>
</tr>
<tr>
<td>2</td>
<td>M</td>
<td>37</td>
<td>III (O)</td>
<td>15</td>
<td>32</td>
<td>5/143</td>
<td>80/90</td>
<td>3</td>
<td>3</td>
<td>100 Excellent</td>
</tr>
<tr>
<td>3</td>
<td>M</td>
<td>24</td>
<td>III</td>
<td>13</td>
<td>25</td>
<td>0/135</td>
<td>80/85</td>
<td>4</td>
<td>-2</td>
<td>85 Good</td>
</tr>
<tr>
<td>4</td>
<td>F</td>
<td>61</td>
<td>IV + olec</td>
<td>16</td>
<td>27</td>
<td>-3/140</td>
<td>70/90</td>
<td>5</td>
<td>2</td>
<td>85 Good</td>
</tr>
<tr>
<td>5</td>
<td>F</td>
<td>71</td>
<td>IV</td>
<td>11</td>
<td>29</td>
<td>0/140</td>
<td>80/90</td>
<td>0</td>
<td>0</td>
<td>100 Excellent</td>
</tr>
<tr>
<td>6</td>
<td>M</td>
<td>34</td>
<td>IV</td>
<td>8</td>
<td>21</td>
<td>-5/130</td>
<td>80/90</td>
<td>0</td>
<td>0</td>
<td>92 Good</td>
</tr>
<tr>
<td>7</td>
<td>M</td>
<td>58</td>
<td>III</td>
<td>8</td>
<td>31</td>
<td>-8/138</td>
<td>80/87</td>
<td>0</td>
<td>0</td>
<td>93 Good</td>
</tr>
<tr>
<td>8</td>
<td>M</td>
<td>28</td>
<td>IV</td>
<td>10</td>
<td>37</td>
<td>-10/142</td>
<td>72/78</td>
<td>1</td>
<td>0</td>
<td>100 Excellent</td>
</tr>
<tr>
<td>9</td>
<td>M</td>
<td>52</td>
<td>IV</td>
<td>9</td>
<td>15</td>
<td>-20/130</td>
<td>67/85</td>
<td>2</td>
<td>1</td>
<td>93 Good</td>
</tr>
<tr>
<td>10</td>
<td>F</td>
<td>27</td>
<td>IV</td>
<td>7</td>
<td>24</td>
<td>-23/116</td>
<td>65/85</td>
<td>0</td>
<td>0</td>
<td>73 Fair</td>
</tr>
</tbody>
</table>

*cor, fracture of coronoid process (Regan-Morrey type II); (O), Gustilo type II open fracture; olec, avulsion of olecranon
†minus means loss of extension

Intra-operative photographs of case 3 with a) showing a Mason type III fracture, and b) fixation of the fracture with two low-profile mini-plates and screws.
Case 5: a) a preoperative AP radiograph, b) a lateral tomogram and c) a postoperative lateral radiograph. The ulnar collateral ligament which was detached from the medial epicondyle was repaired with an anchor; d) an AP radiograph 29 months after operation and 23 months after removal of the implants.

Case 8: a) a preoperative lateral radiograph; b) a lateral tomogram and c) a postoperative lateral radiograph. Large fragments were fixed with Herbert screws, and the radial head and shaft with two low-profile mini-plates.
A long-arm plaster splint was applied with the elbow in 90° of flexion, and two days after the operation, this was changed to a long-arm cylinder to allow supination and pronation of the forearm with the elbow in 90° of flexion. Two or three weeks after surgery, the cast was changed to a diallock hinge brace, which allowed flexion and extension of the elbow. The patients wore the braces for six weeks. The plates were usually removed between five and seven months later.

Results

All fractures united without evidence of avascular necrosis. When removed, the plates were covered with synovial tissue, but this did not seem to interfere with the function of the proximal radioulnar joint. One patient (case 1) refused to have the plates removed.

Eight patients were pain-free. One (case 7) had occasional pain and one (case 10) had discomfort after manual labour. None had limitation of activities of daily living or symptoms of instability of the elbow.

The mean flexion of the elbow was 135° (116 to 143), and the mean loss of extension was 7° (-23 to 5 hyperextension). The mean pronation and supination of the forearm were 74° (65 to 80) and 85° (70 to 90), respectively. No patient had significant muscle weakness compared with the uninjured side and none had objective evidence of instability of the elbow.

Complete radiological follow-up was available for all patients. The mean increase in the carrying angle was 1.6 mm and in the ulnar variance 0.5 mm, compared with the uninjured side. There were no post-traumatic degenerative changes in seven patients. Three (cases 1, 2 and 10) had minor changes of the radial head without narrowing of the proximal radioulnar joint. According to the functional index of Broberg and Morrey,10 the outcome was excellent in three, good in six and fair in one patient, with a mean score of 90.7 points (Table I).

Discussion

Excision of the radial head has been an accepted form of treatment for a comminuted fracture, such as Mason type III, when anatomical reduction and fixation are not possible. This treatment has yielded good, long-term results, particularly when compared with conservative treatment or open reduction and internal fixation.1,3,7,22,23 Complications of excision of the radial head have also been reported, however, including pain in the wrist, forearm and elbow caused by proximal radial migration.5,9-13 Instability and an increased valgus deformity of the elbow are also common.9,13 Some patients have reported weakness after excision of the radial head, and severe osteoarthritis of the elbow has been recorded on long-term follow-up.9-13

The importance of maintaining congruity of the proximal radioulnar joint has been established clinically and experimentally and several authors have, therefore, advocated preserving the radial head by internal fixation using AO mini-plates or Herbert screws, even when the fracture is severely displaced or comminuted.14-19,24-26 As these series included not only Mason type III fractures, but also type II and AO type B1 to B3, the outcomes are not comparable. Geel et al16 reported a mean functional index of 93.2 points in 19 patients (7 AO type B1, 5 type B2, 4 type B3 and 3 type C3) using AO mini-plates. King et al17 reported a mean score of 86.5 points in 14 patients (8 Mason type II, and 6 type III), using AO mini-plates and a mean range of movement of 11.2° to 135.4° at the elbow, with a mean of 62.9° of pronation and 77.5° of supination. Esser et al18 described nine Mason type III and six type IV fractures. Following fixation with Herbert screws or AO mini-plates, they recorded mean ranges of movement of 3° to 138° and 13° to 131° at the elbow, mean pronation of 86° and 85°, mean supination of 87° and 70° and mean functional indexes of 97 and 82 points, respectively.

Our series included ten patients, three of whom had a Mason type III fracture and seven a Mason-Johnston type IV. The mean functional index was 90.7 points, and the mean range of movement was 7° to 135° at the elbow, with a mean of 74° of pronation and 85° of supination. These results compare favourably with previous reports. Many authors have reported proximal radial migration and valgus angulation after excision of the radial head.4-6,11,13,24 In our series, the mean increase in ulnar variance and carrying angle were 0.5 mm and 1.6°, respectively, suggesting minimal proximal radial migration and valgus angulation.

Herbert screws are only indicated when the fracture fragments are large enough to accept the screw heads. When using them, it is not always possible to join the comminuted radial head firmly to the shaft, particularly when the fracture extends into the neck and the fragments are small. AO mini-plates are required under these circumstances. When placing the plates and screws on the surface of the radial head and neck, they should be placed in the ‘safe zone’, where they will not impinge on the proximal radioulnar joint on rotation of the forearm.27

Another form of treatment for these fractures is replacement arthroplasty.28-30 Although the short-term results seem satisfactory, the long-term results are not known and the indications for prosthetic replacement uncertain.31

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


VOL. 85-B, No. 7, SEPTEMBER 2003


