Management of recurrent, complex instability of the elbow with a hinged external fixator

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We have treated 16 patients with recurrent complex elbow instability using a hinged external fixator. All patients had instability, dislocation or subluxation of the ulnohumeral joint. The injuries were open in eight patients and were associated with 20 other fractures and five peripheral nerve injuries. Two patients had received initial treatment from us; 14 had previously had a mean of 2.1 unsuccessful surgical procedures (1 to 6). The fixator was applied at a mean of 4.8 weeks (0 to 9) after the injury and remained on the elbow for a mean of 8.5 weeks (6 to 11). After treatment we found the mean range of flexion-extension to be 105° (65 to 140). At a final follow-up of 23 months (14 to 40), the mean Morrey score was 84 (49 to 96): this translated into one poor, three fair, ten good and two excellent results.

Complications included one fractured humeral pin, one temporary palsy of the radial nerve, one recurrent instability, one wound infection, one severe pin-track infection and one patient with reflex sympathetic dystrophy. Although technically demanding, the use of the fixator is an important advance in the management of recurrent complex elbow instability after failure of conventional treatment.

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Traumatic dislocation of the elbow, complicated by associated fractures and/or extensive soft-tissue injuries, is a challenging problem.1-5 Given the propensity of the elbow to develop a contracture after injury, one of the objectives of treatment should be to provide sufficient stability to allow early postoperative mobilisation.1,3,6-8 The nature of the injury often makes this impossible.7,9,10 and this may lead to early arthritis and permanent disability.7,11-13

Any external fixation device must provide stability and allow movement through the anatomical centre of rotation of the elbow.2,7,13 We describe the treatment of 16 patients with injuries of the elbow in whom we used a specific external fixator which met these criteria.

Patients and Methods

We treated ten men and six women at four institutions. All the surgeons who participated had been trained in the reconstruction of the upper limb and were familiar with the use of hinged external fixators. We excluded from the study patients with fractures of the distal humerus that affected the centre of rotation of the elbow and also those who were unable to understand or comply with the requirements of the rehabilitation programme. All the patients had sustained traumatic dislocation of the ulnohumeral joint of previously normal elbows. In ten the injured arm was the dominant limb. Eight had open wounds. Six had multiple associated injuries with a mean Injury Severity score of 23.3 (16 to 41). Twelve patients had associated fractures including injuries to the head of the radius, the olecranon, the capitellum, the coronoid process, the trochlea, the distal radius and the shaft of the radius and ulna. Associated injuries included four palsies of the ulnar nerve (one sensory and motor and three motor) and one of the radial nerve (sensory and motor).
Their occupations included manual labour, truck driving, logging, homemaking, hairdressing and graphic design. Their mean age was 39 years (21 to 68) (Table I).

Concentric stability had not been restored by conventional treatment. Recurrent dislocation had occurred in 11 patients and recurrent subluxation in three. Two were found to be unstable at operation.

The patients had undergone a mean of 2.1 previous procedures (1 to 6) on the elbow (Table I). Many had had a number of attempts at closed reduction before referral. It was possible to measure the range of movement in only six patients. The mean movement was 55° (35 to 80).

None of the patients could work or undertake recreational pursuits; all were taking narcotic analgesics.

In 14 patients we applied the external fixator after primary treatment had failed. The mean time after the first procedure was 4.8 weeks (2 to 9). In two, it was applied at the time of the original treatment. The first of these two patients (case 1) had sustained an open posteromedial dislocation of the elbow and complete rupture of the collateral ligaments, anterior and posterior capsule and the brachialis muscle. The distal humerus protruded through a 12 cm laceration. When the elbow remained unstable after open reduction and soft-tissue reconstruction, the surgeon decided to use the external fixator. The second patient (case 10) had sustained a fracture-dislocation of the elbow with comminuted fractures of the capitellum and radial head. There was residual instability of the elbow after fixation of the fracture and repair of the collateral ligament. The external fixator was applied to provide the stability necessary to allow early movement.

The Compass elbow hinge. This is a circular hinged external fixator constructed of metal and radiolucent plastic (Smith & Nephew Richards Inc, Memphis, Tennessee). It has a valgus alignment of 7°. The hinge mechanism comprises an articulating worm gear which can be disengaged allowing free movement. Engagement gives passive incremental movement. A distraction mechanism allows for concentric distraction of the joint of up to 6 mm. On each side of the hinge is a central hole designed to be concentric with the centre of rotation of the elbow. A Steinmann pin is passed through the hole to align the hinge. Once the latter is fixed proximally to the humerus and distally to the ulna, the pin is removed. Standard fixation pins are used.

Operative technique. All operations were carried out under general anaesthesia with a tourniquet and antibiotic prophylaxis. Nine patients were in the lateral decubitus position. The other seven were supine and image intensification was used. Our choice of approach depended on associated fractures, previous incisions, open wounds and nerve injuries. It was posterior in 12 patients and combined medial and lateral in four. In all patients we identified and protected the ulnar nerve. We dealt first with associated fractures and ligamentous and other soft-tissue injuries, using local tissue for augmentation and bone anchors or transosseous sutures for fixing. Two patients needed primary replacement of the radial head. In three others with clinical evidence of ulnar neuropathy, the nerve was transposed anteriorly into a subcutaneous location at the end of the procedure. One patient (case 4) whose nerve had been transected at the time of injury later had interfascicular grafting using the sural nerve.

In applying the external fixator we first inserted a Steinmann pin through the centre of rotation of the elbow, either under direct vision before wound closure or under the control of an image intensifier. The fixator was positioned over this pin with its proximal and distal arms aligned over the humerus and ulna, respectively. Through a small incision we secured the frame to the bone with two or three Schanz pins. The fixator was then aligned and adjusted and the Steinmann pin removed (Fig. 1). The range of movement was checked and any necessary adjustments made. Radiographs were taken to confirm concentric reduction of the elbow and any associated fractures (Fig. 2).

Physiotherapy continued daily from the morning after the operation. Selected patients received postoperative brachial plexus blocks to enhance their ability to comply. The physiotherapist or patient moved the elbow freely until the limit of flexion or extension was reached. At that point the gear mechanism of the external fixator was engaged and movement was manually increased by a further 5 to 10°. The external fixator thus functioned as a continually readjustable static splint.

Patients were seen weekly after operation.

Follow-up evaluation. The work of Broberg and Mörrey has given us a basis for assessing the quality of elbow function. We measured movement with a hand goniometer. Manual resistance was used to assess strength, with the opposite arm serving as a control. Stability was determined by physical examination, including varus and valgus stress manoeuvres, provocative tests for posterolateral instability, and, when necessary, radiologically. The patients’ own perceptions of stability were also taken into account. Post-traumatic degenerative changes were assessed on the radiographs using the scale of Knirk and Jupiter: grade 0, no degenerative change; grade 1, slight narrowing of the joint space; grade 2, marked narrowing of the joint space with formation of osteophytes; and grade 3, total loss of the joint space with formation of osteophytes and cysts.

Results

Details are given in Table I. None of the patients was lost to follow-up. They were reviewed at a mean of 23 months after surgery (14 to 40). The external fixator was in place for a mean time of 8.5 weeks (6 to 11). The decision to remove it was based on the stability of the elbow, the progression of the range of movement and the condition
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<tr>
<th>Case</th>
<th>Age (yr)</th>
<th>Gender</th>
<th>Mechanism</th>
<th>Associated Fractures</th>
<th>Time to Associated hinge procedures (wk)</th>
<th>Associated hinge treatment</th>
<th>Time in Follow-up</th>
<th>Mayo rating</th>
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<td>Fall (stairs)</td>
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CR, closed reduction under anaesthesia; OR, open reduction; RHR, replacement of the radial head; ORIF, open reduction and internal fixation; STSG, split-thickness skin graft; I+D, irrigation and debridement; UT, ulnar nerve transposition.

† Motor-vehicle accident
‡ Reflex sympathetic dystrophy
of the pin sites. In ten patients it was removed under local anaesthesia and in the remaining six with a range of elbow movement of less than 100°, we manipulated the elbow under general anaesthesia and removed the fixator.

The mean arc of flexion-extension at follow-up was 105° (65 to 150). The patients had a mean flexion contracture of 22° and mean flexion of 127°. The mean pronation was 76° (20 to 90) and the mean supination 75° (15 to 90). In 13 the arc of rotation was within 5° of that of the opposite side. Three patients (one with a fracture of the radial head, one with a severe fracture of the distal radius, and one with a previous varus malunion of the proximal ulna) had marked restriction of rotation.

Concentric stability, as measured clinically and radio-

logically, was achieved in the elbows of 14 patients. One had recurrent instability. Another, who has resumed working and is free from pain, had minor valgus laxity with a definite ‘endpoint’ and only 2 mm of opening evident on a stress radiograph.

At the final follow-up 15 patients had concentric reduction of the elbow (Fig. 2). One (case 16) required a second operation to secure reduction. In terms of degenerative changes, 11 elbows were rated grade 0, four were grade 1 and one was grade 2. According to the elbow scoring system of Broberg and Morrey at the final follow-up there was one poor, three fair, ten good and two excellent results. The mean score was 84 (49 to 96). Eleven patients had no or slight pain requiring no medication and four had moderate pain with some medication required occasionally with activity. Only one patient had moderately severe pain needing frequent medication.

Eight patients were able to resume their former occupations and recreational activities. Six returned to lighter work and less strenuous recreational activities but in two of these this was due to associated injuries and not to the state of their elbows. Two of the patients remained unemployed mainly because of associated injuries.

Complications. Six patients (38%) developed a complication, but only three (19%) required reoperation. One (case 16) had posterior subluxation of his elbow in the external fixator. There were a number of contributory factors, including incorrect placement of the centre-of-rotation pin, lack of compliance and early loosening of the humeral pins, which allowed excessive movement of the hinge. The subluxation was treated by closed reduction and transarticular fixation of the pin. Later, he had an elbow release and achieved an arc of movement of 90°. Another developed reflex sympathetic dystrophy, but subsequently improved to achieve an arc of movement of 65° with minimal pain. Two developed pin-track infections in the humerus which required irrigation, debridement and removal of the pin. The fifth patient developed
a superficial wound infection which responded to antibiotics and the sixth had a transient palsy of the radial nerve which recovered after ten weeks of conservative treatment.

Discussion

The bony and ligamentous anatomy of the ulnohumeral joint allows for 3 to 4° of varus-valgus laxity.\textsuperscript{2,5,10} The centre of rotation of the elbow lies on an axis which is internally rotated between 3 and 8° relative to the plane of the epicondyles. The usual carrying angle is between 10 and 15° of valgus. When using an external fixator to restore congruent stability and yet allow early movement, these factors must be considered.\textsuperscript{6,7}

Elbow stability depends both on bony congruity and the soft-tissue structures, especially the medial and lateral collateral ligaments.\textsuperscript{2,17} Clinical instability usually results only after a number of structures have been damaged. Valgus stress, for instance, is restricted by the medial collateral ligament, the radial head and the geometry of the proximal aspect of the sigmoid notch. The restoration of elbow stability after injury depends on the repair or reconstruction of these damaged structures.\textsuperscript{10}

In this study, we have defined elbow instability as non-concentric articulation of the ulnohumeral joint. Previous authors have obtained poor results from conventional treatment of this condition. Josefsson et al\textsuperscript{12} reported four cases of recurrent dislocation associated with fractures of the radial head. Regan and Morrey\textsuperscript{9} found a satisfactory outcome in only 20% of a large number of patients with type-III coronoid fractures. Adler and Shaftan\textsuperscript{18} reported that although fractures of the radial head associated with elbow dislocations comprise only 10% of all fractures of the head in a large series, they were responsible for over half the poor results. Bennett et al\textsuperscript{6} reported a failure rate of 50% in the treatment of unstable fracture-dislocations by conventional techniques. Broberg and Morrey\textsuperscript{11} described how prolonged casting, undertaken in an attempt to maintain reduction following fracture-dislocation of the elbow, led to a high incidence of stiffness.

In the only directly comparable series reported, Cobb and Morrey\textsuperscript{7} successfully treated six of seven patients with unstable fracture-dislocations of the elbow by applying the Mayo hinged external fixator. In their patients the mean arc of flexion after surgery was 88°. The external fixator gave stability and mobility so that the joint could be subjected to immediate postoperative continuous passive movement without disturbing the healing fractures and ligaments.

With the Morrey fixator, a pin remains inserted through the centre of rotation of the elbow for the duration of the treatment. By contrast, all the pins used with the Compass external fixator are remote from the joint itself. We believe that this helps to reduce the rate of pin loosening. It also decreases the risk of pin-track infection which can lead to the potentially devastating complication of septic arthritis. Loss of the centre-of-rotation pin because of infection or drainage necessitates removal of the Morrey frame.\textsuperscript{13} With the fixator which we used, sepsis can be dealt with simply by removing and replacing the pin.

Using the same device as ours, Wyrsh et al\textsuperscript{19} reported having restored stability in seven of nine unstable fracture-dislocations, although the complication rate was 50%. Others have described preliminary good results with similar dynamic external fixators.\textsuperscript{6} In our series, in which the difficulties of restoring stability were compounded by the failure of previous operations, 12 patients (75%) achieved a Morrey elbow score of good or excellent. There was only one poor result (6%).

We do not recommend the use of the hinged external fixator for the treatment of complex fractures of the distal humerus. The nature of the fracture makes it difficult to insert the Steinmann pin at the centre of rotation. The clinical problems seen with complex proximal fractures of the ulna and radius do not often arise: accurate reduction and rigid fixation of the fracture of the distal humerus usually restore stability.

In spite of the high complication rates, which have been noted by other authors,\textsuperscript{6,7,19} our findings prompt us to advocate the use of a hinged elbow external fixator in the treatment of recurrent, complex elbow instability, especially when conventional techniques have failed. By providing adequate stability, it allows early movement after fixation and repair of soft tissues and this advance improves the ultimate 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