Surgical treatment of post-traumatic stiffness of the elbow

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Surgical release of the elbow was performed in 27 patients with post-traumatic stiffness at a mean of 14.5 months after the initial injury. The outcome was related to whether there had been heterotopic ossification, which had occurred in 18 elbows and to whether, if there had been a fracture, it had involved the articular surface, which had occurred in 13 elbows. The final range of movement and the ratio of desired gain in each group were compared at a mean follow-up period of 22.5 months (12 to 43).

The arc of movement of the elbow improved in all patients after the operation. The mean final arc was 110˚ in those with heterotopic ossification and 86˚ in those without (p = 0.001). The ratios of desired gain were significantly higher in patients with heterotopic ossification (88.2% vs 54.9%; p < 0.001). There was no significant difference in relation to involvement of the articular surface. Careful assessment of the cause of stiffness is important in order to achieve a satisfactory result from surgery for post-traumatic stiffness of the elbow.

Stiffness is a common complication of trauma to the elbow. It may cause severe functional impairment because of the inability to position the hand in space. There are a number of conditions which can lead to loss of movement of the elbow, which can be classified as extrinsic or intrinsic. An intrinsic contracture is caused by intra-articular adhesions, articular malalignment, loss of articular cartilage, or a number of other factors. An extrinsic contracture may arise in the joint capsule, collateral ligaments, or muscles surrounding the joint. It may also be caused by heterotopic ossification which forms around the elbow. The pathogenesis of heterotopic ossification is unknown, but it frequently leads to severe limitation or total loss of movement.

The initial treatment of post-traumatic stiffness of the elbow, particularly when it is extrinsic, should be non-operative. This would include the use of splints, braces, and a supervised exercise programme. When conservative management fails the elbow can be released by a variety of surgical techniques. All studies on the surgical release of post-traumatic stiffness of the elbow have shown an improvement in movement regardless of the surgical approach or specific technique. However, the outcome and post-operative range of movement may vary according to the underlying pathological condition. We have therefore analysed the outcome after surgical treatment according to the pre-operative pathology.

Patients and Methods

Between November 1997 and April 2001, 27 patients with stiffness of the elbow were treated by surgical release. There were 18 men and nine women with a mean age of 32.7 years (16 to 61). The dominant elbow was involved in 12 and the non-dominant in 15. All of the patients were skeletally mature and stiffness of the elbow had developed after injury. The mean interval between injury and surgery was 14.5 months (6 to 70).

Surgery was indicated if the restriction of movement was causing functional impairment, and had not improved despite physiotherapy for at least six months. All patients showed radiological union of the initial fractures and adequate stability of the joint. The cause of loss of movement was considered to be extrinsic in all including those with an intra-articular injury who had adequate healing of the articular surface without major incongruity (less than 2 mm) or loss of articular cartilage (less than 30%). When stiffness was associated with heterotopic ossification, assessment of the maturity of the heterotopic bone was based on plain radiographs and indicated by a smooth, well-demarcated cortical margin and defined trabecular markings. None of the patients had suffered burns of the elbow or an associated injury to the head or spinal cord. All had an adequate soft-tissue envelope around the elbow. Those in whom contractures of the skin...
or surrounding muscles were the major features were excluded from the study.

The primary injury to the elbow was a peri-articular fracture of the olecranon or epicondyle in six elbows, a fracture of the radial head in six, an intra-articular fracture of the distal humerus in four, a Monteggia or proximal ulnar fracture in four, a dislocation or fracture-dislocation of the elbow in three, a supracondylar fracture in two, and local trauma without fracture in two. Previous treatments had included open reduction and internal fixation of the fracture in 17 patients, closed reduction and percutaneous pinning in two, anterior transposition of the ulnar nerve in two, and casting or splintage in seven.

Flexion and extension were measured by a goniometer positioned along the lateral aspect of the arm and forearm and centred on the lateral epicondyle. The mean pre-operative limitation of extension was 40° (10 to 90), and the mean pre-operative flexion was 86° (40 to 130). The mean pre-operative pronation was 58° (0 to 90) and supination 65° (10 to 90). Severe restriction of forearm rotation causing functional limitation was seen in four patients associated with pathology at the proximal radio-ulnar joint or interosseous membrane.

Operative technique. All patients underwent surgery in the supine position, under general anaesthesia, with the involved arm on a hand table and with the use of a tourniquet.

The skin incision was determined by several factors including the site of the heterotopic bone, the location of the previous incision, and whether there was an ulnar neuropathy. A lateral incision was used in seven patients, a medial incision in four, a posterior midline incision in 13, a medial and lateral incision in two, and an anterior and posterior incision in one.

Initially, in those patients with heterotopic bone this was approached and its extent defined. A sufficient amount was resected until there was no residual block to movement of the elbow. Heterotopic bone was frequently excised with part of the capsular structures including the posterior band of the medial collateral ligament, but the anterior band of the medial collateral ligament and the lateral collateral ligament complex were always preserved. No attempt was made to remove heterotopic bone if it was located in an area where it was not affecting movement of the elbow and access was not feasible. Capsular release was then performed if there was a persistent deficit of flexion or extension.

A posterior capsulectomy was performed in all patients while anterior capsulectomy was carried out if the persistent limitation of extension was greater than 20°. The anterior capsule was excised in 18 patients under direct vision through either a lateral or medial approach. The tip of the olecranon was routinely removed while the tip of the coronoïd process was removed only when it was thought to block full flexion. No attempt was made to perform a fenestration of the olecranon fossa.

In one patient, the lateral collateral ligament complex was detached from its humeral origin during capsular release because of severe distortion of the anatomy. It was reattached using a pullout suture through drill holes in the lateral epicondyle. No patient required a tenotomy or lengthening of the biceps, triceps or brachialis muscles. In 18 patients who had pre-operative symptoms in the ulnar nerve, or in whom the nerve was found to be entrapped at operation it was carefully dissected free from compression. It was transposed anteriorly into a subcutaneous or sub-muscular position in 16 elbows. In the remaining two elbows, it was released without transposition.

The elbow was finally passively flexed and extended to assess the gain in movement. A range of ulnohumeral movement of 20° to 130° was achieved in all patients. The pneumatic tourniquet was released and haemostasis obtained. The wound was closed with suction drainage. A long-arm splint was applied with the elbow in extension or flexion depending on the direction in which movement was more resistant to passive manipulation, or in 90° of flexion when there was no major direction of limitation.

Post-operative management. In patients who had pre-operative heterotopic ossification, a single dose of radiation of 700 cGy was given to the elbow on the first post-operative day as prophylaxis against recurrence.

The elbow was immobilised for two to four days until the suction drains had been removed and physiotherapy begun. This consisted of active-assisted and passive flexion and extension exercises of the elbow. Emphasis was placed on slow stretching of the elbow. Aggressive manipulation was not undertaken. Neither continuous passive movement nor continuous brachial plexus block was used. At night the patient wore a splint with the elbow in the position of maximum flexion or extension which could be obtained without excessive pain. The night splint was usually discontinued between two and three weeks after surgery as part of a self-directed programme at home after discharge. Those who were not sufficiently motivated or when progress was slow were supervised by a physiotherapist. A custom-moulded turnbuckle orthosis, which allowed gradual progressive stretching, was used in four patients who had difficulty in retaining movement with routine physiotherapy. Physiotherapy was continued for at least three months after operation.

Assessment. The patients were followed up for a mean of 22.5 months (12 to 43). At the final follow-up the absolute values of the arc of flexion and extension were measured and the ‘ratio of desired gain’, was calculated. This was the percentage of movement gained compared with the desired gain, the goal being 20° to 130° of flexion. Although an arc of movement from 30° to 130° was considered to be functionally adequate,8 we believe that a flexion contracture of less than 20° is needed for cosmetic acceptance by most patients.

The ratio of desired gain was defined as follows (flexion contracture, FC; further flexion, FF):

\[
\text{Ratio of desired gain (\%) = } \frac{[\text{pre-op FC-20} + (130-\text{pre-op FF}) – (\text{post-op FC-20} – (130-\text{post-op FF})] \times 100}{(\text{pre-op FC-20} + (130-\text{pre-op FF})}
\]
We assessed separately the gain in movement in flexion and extension. Any gain beyond 20° of extension or 130° of flexion was not included in our calculations.

The clinical results were analysed according to the pre-operative condition. Patients were divided into two groups based on the presence (18 elbows) or absence (nine elbows) of heterotopic ossification (Table I). If heterotopic bone was only found in an area unrelated to the limitation of movement intra-operatively the patient was included in the non-heterotopic ossification group. The patients were also divided into two groups based upon whether there was involvement of the articular surface (13 elbows) or not (14) (Table I). The overall functional evaluation was assessed using the Mayo elbow performance score.\(^9\)

### Statistical analysis

The total arc of movement, the ratio of desired gain, and the Mayo elbow performance score at the final follow-up were compared between the patients with and without heterotopic bone, and between those with and without intra-articular involvement. A Mann-Whitney U test was performed using the SPSS package (version 11.0; SPSS Inc, Chicago, Illinois) to compare the two groups. A p value of <0.05 was considered significant.

### Results

#### Movement

The mean pre-operative limitation of extension of 40° was reduced by the final follow-up to a mean of 19° (5 to 35), and the mean flexion increased from 86° to 121° (100 to 140). The total arc of ulnohumeral movement improved from a mean of 46° to 102° (65 to 135), a mean increase of 56°. The mean post-operative pronation was 65° (15 to 90) and the mean post-operative supination was 71° (20 to 90). The arc of ulnohumeral movement improved in all patients, but the goal of 20° to 130° of flexion was only obtained in ten of 27 elbows.

The mean arc of ulnohumeral movement was 110° in elbows in which heterotopic ossification was present and 86° when it was absent. The final arc was significantly greater in elbows in which heterotopic ossification had been present and resected (p = 0.001). The mean final arc of movement was slightly greater in the patients without intra-articular injury (108°) than in those with intra-articular injury (95°), but the difference was not statistically significant (p = 0.051) (Table II).

The mean ratio of desired gain at the final follow-up examination was 77.1% (27% to 100%). It was 88.2% in the elbows in which heterotopic ossification had been present and resected and 54.9% in those in which it had been absent (p < 0.001). There was no significant difference in the ratio of desired gain between the patients who had sustained an intra-articular injury (mean 69.4%) and those who had not (mean 84.2%; p = 0.111, Table II).

#### Function

The mean Mayo elbow performance score was 81 points (71 to 100). The results were excellent in 11 elbows, good in 11, and fair in five. Those with heterotopic ossification showed a significantly higher score than those without (88 points compared with 78 points, p = 0.028). However, there were no significant differences between the patients who had an intra-articular injury and those who had not (84 points compared with 86 points, p = 0.541). All were free from pain or had only mild pain except for one who had moderate pain over the medial aspect of the elbow. One patient had minor lateral laxity during stress testing but this was not a functional problem.

#### Complications

Heterotopic ossification developed in one patient who had sustained an intra-articular injury after release of the capsular contracture. A repeat operation including resection of the heterotopic bone was performed seven months later. Ulnohumeral movement of 20° to 115° and 77% of the desired gain were obtained by the final follow-up. Two patients in the group with heterotopic ossification had radiological recurrence of ossification. One achieved 100% of the desired gain in ulnohumeral movement but had persistent pain. The other had the least satisfactory result in the study, with movement of only 35° to 105° and 28% of the desired gain.

One patient developed a post-operative infection. Drainage and debridement were performed one week after surgery. Ultimately, 100% of the desired gain in the ulnohumeral movement was obtained. Complete palsy of

### Table I. Distribution of patients based on the presence or absence of heterotopic ossification

<table>
<thead>
<tr>
<th>Groups</th>
<th>Intra-articular involvement</th>
<th>No intra-articular involvement</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heterotopic ossification</td>
<td>5</td>
<td>13</td>
<td>18</td>
</tr>
<tr>
<td>Non-heterotopic ossification</td>
<td>8</td>
<td>1</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>13</td>
<td>14</td>
<td>27</td>
</tr>
</tbody>
</table>

### Table II. Range of elbow movement (°) pre-operatively and at final follow-up

<table>
<thead>
<tr>
<th>Group</th>
<th>Pre-operative arc°</th>
<th>Final arc°</th>
<th>Ratio of desired gain</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>Range</td>
<td>Mean</td>
</tr>
<tr>
<td>Heterotopic ossification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (n = 18)</td>
<td>49.8</td>
<td>10 to 100</td>
<td>110</td>
</tr>
<tr>
<td>No (n = 9)</td>
<td>46.7</td>
<td>30 to 60</td>
<td>96</td>
</tr>
<tr>
<td>Intra-articular lesion</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes (n = 13)</td>
<td>39.3</td>
<td>10 to 100</td>
<td>95</td>
</tr>
<tr>
<td>No (n = 14)</td>
<td>53.4</td>
<td>15 to 100</td>
<td>108</td>
</tr>
</tbody>
</table>

*p < 0.05 was considered significant*
the ulnar nerve, apparent immediately after surgery, occurred in one patient. The nerve was explored on the same day and was entrapped in the cubital tunnel, which had been narrowed by fibrous thickening of the surrounding tissues. The nerve was thought to have been stretched during manipulation of the elbow, particularly into flexion at the time of surgery. This was successfully treated by anterior transposition of the nerve, with complete recovery within one week. Two patients reported mild paraesthesiae of the ulnar nerve associated with pre-operative ulnar neuritis, but none had a measurable motor or sensory deficit.

Discussion
Surgical release is indicated in patients with stiffness of the elbow after trauma when conservative methods have failed and function is severely impaired. Previous reports of the results of surgical release have shown an overall improvement in movement of the elbow.2-7 Our results compare favourably with these reports. The main concern of patients is the restoration of movement rather than relief from pain. The functional results are not related to the increase in movement but to whether the final arc of movement is sufficient to perform the level of activities which patients desire.

In order to assess the functional results, we therefore used an index called ‘the ratio of desired gain’ as well as the final arc of ulnohumeral movement. Our aim was an arc of movement from 20˚ of extension to 130˚ of flexion. We calculated the percentage of movement gained by the operation with respect to the desired gain. In this index, the improvement in flexion and extension was considered separately, and the movement gained was expressed as a percentage. This index correlated closely with satisfaction. It is generally agreed that an arc of movement of the elbow from 30˚ to 130˚ is adequate for the performance of most activities of daily living.8 However, in this study, we used an arc from 20˚ to 130˚ in view of the patients’ cosmetic requirements.

The surgical treatment of an intrinsic contracture requires an alteration of the articular anatomy by, for example, interposition or total joint arthroplasty. Morrey, Adams and Bryan10 suggested that arthroplasty was indicated if more than half of the articular surface had been damaged and was not covered by hyaline cartilage, or if malunion caused deformation of the articular surface. In our study, patients with an initial articular injury showed acceptable healing of the articular surface and required only extra-articular release. The overall results were comparable for those patients who had sustained an articular injury and those who had not.

The surgical approach is based on many factors including the site of the previous incision, the location of heterotopic ossification, the planes of elbow stiffness, and the presence of an associated neuropathy. The lateral approach has been described by several authors for the release of post-traumatic contractures of the elbow.5,11,12 The advantages are the ability to see and treat both the anterior and posterior ulnohumeral and radiocapitellar joints through one incision while preserving the collateral ligaments and the origins of the extensor complex.11 However, in patients with ulnar neuropathy, a separate medial exposure is needed to release or transfer the ulnar nerve.

Cohen and Hastings5 reported transient paraesthesiae in the distribution of the ulnar nerve as the most common complication of this approach. It is well known that the ulnar nerve is often trapped by scarring and fibrosis if there is prolonged immobilisation or stiffness of the elbow after trauma. We performed release and transposition of the ulnar nerve in 18 of 27 patients. Sometimes, a patient may not appreciate the subtle changes of ulnar neuritis before operation. In our series, one patient who had not showed definite pre-operative symptoms developed an immediate palsy of the ulnar nerve after release by the lateral approach. This was attributed to traction neuritis caused by the abrupt increase in elbow flexion during the operation. Even in the absence of pre-operative neurological symptoms, the nerve may be compromised subclinically and become symptomatic as elbow flexion increases after surgery.13 Exploration and release of the ulnar nerve are generally recommended not only in patients with symptoms but also in those who show only a Tinel’s sign or positive provocative tests for impingement.

The medial approach has been advocated when there is an ulnar neuropathy or ossification of the medial collateral ligament. Several authors have reported that a fibrous contracture of the posterior band of the medial collateral ligament with or without heterotopic ossification is one of the most important pathological changes in a stiff elbow.4,14 They recommend resection of the posterior oblique bundle followed by posterior and anterior capsulectomies through a single medial approach.

Urbaniaik et al15 described an anterior capsulotomy to release flexion contractures of the elbow using an anterior approach. However, this does not allow any posterior pathology to be addressed and this technique is rarely used. We used it for one patient who had a large volume of heterotopic bone in the antecubital fossa although we also used a posterior incision.

It is evident that the surgical approach chosen must allow all relevant pathology to be addressed. For uncomplicated extrinsic contractures, a lateral ligament-sparing approach can be used. However, in patients requiring a combined medial and lateral approach, our current preference is a posterior midline skin incision. Through this incision, both medial and lateral approaches can be performed after the skin flaps have been elevated.16

We are not aware of any previous study in which the pathological conditions causing stiffness were considered when analysing the results. In our study the outcome was influenced mainly by whether or not heterotopic ossification had been present. Both the mean arc of ulnohumeral movement and the ratio of desired gain were significantly
greater for the elbows in which heterotopic ossification had been present compared with those in which it had not. Heterotopic ossification is poorly understood and characterised by the formation of bone in periarticular regions. Once mature heterotopic bone has limited movement of the elbow, restoration can only be achieved by its excision.

In elbows without heterotopic ossification, stiffness is attributed to fibrous thickening and scarring of the capsuloligamentous structures. On rare occasions, stiffness can result from contracture of the skin or muscles but such patients were not included in this study. Soft-tissue contractures tend to be diffuse and less easily localised than heterotopic bone and excision of heterotopic bone is technically easier than release of soft-tissue contractures.

In the past, it has been suggested that surgical removal of heterotopic bone should be delayed for at least one year as earlier intervention was thought to predispose to recurrence. However, recent studies have reported good results when intervention was performed three to six months after injury. Early excision has substantial benefits. The single greatest advantage is early restoration of movement which may prevent secondary soft-tissue contracture and atrophy and improve function. We advocate early excision but it is important to wait until the radiological margins of the heterotopic bone are clearly defined and signs of bone formation such as pain, local tenderness, swelling, and hyperaemia, have resolved.

Although all patients showed improvement in their active range of movement by their final follow-up, all still lost some movement after surgery. All achieved at least 20° to 130° of ulnohumeral movement intra-operatively. However, the loss of movement during the post-operative period was greater in the non-heterotopic ossification group. We believe that physiotherapy during the post-operative period is very important in minimising the loss of movement gained at operation, particularly in patients with a capsuloligamentous contracture as their main pathological condition.

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