Posttraumatic Elbow Stiffness
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CHAPTER 8

Operative Management

Comparison of Elbow Contracture Release in Elbows with and without Heterotopic Ossification Restricting Motion
Abstract
We compared 16 patients with post-traumatic heterotopic ossification (HO) restricting elbow motion (but not complete bony ankylosis) after elbow trauma with 21 patients with capsular contracture alone to test the hypothesis that HO is associated with diminished motion after release. Patients with burns or head injury were excluded. The preoperative flexion arc averaged 59° in the HO cohort and 52° in the capsular contracture cohort. The mean flexion arc after the index surgery improved by 54° to a mean arc of 113° in the HO cohort and by 35° to a mean of 87° in the capsular contracture cohort (P = 0.02). After all subsequent procedures (including procedures to address residual stiffness in 1 patient in the HO cohort and 4 patients in the capsular contracture cohort), the flexion arc averaged 116° in the HO cohort and 98° in the capsular contracture cohort (P = 0.19). Open release of posttraumatic elbow stiffness is more effective when HO hindering motion is removed than when there is capsular contracture alone.

Background
The elbow is prone to stiffness after trauma. When the stiffness is dysfunctional and does not improve with time and exercise (including static progressive or dynamic splinting), operative treatment is considered. Operative treatment consists of excision of tissues contributing to elbow stiffness, including thickened and contracted capsule and heterotopic bone. Several reports documenting improvement in motion with open excision of contracted elbow capsule have increased enthusiasm for the operative treatment of elbow stiffness.1,6,17,18 Yet stiffness associated with heterotopic ossification (HO) has been approached with greater caution and less optimism.14 In this investigation, we tested the hypothesis that patients with post-traumatic elbow stiffness regain less ulnohumeral motion after open elbow contracture release in the presence of HO.

Materials and Methods
Over the 5-year period between 1998 and 2003, 2 surgeons performed an open elbow contracture release in 47 adult patients satisfying the following inclusion criteria: (1) skeletally mature, (2) prior elbow trauma, (3) an arc of ulnohumeral motion less than 100°, and (4) failure to regain at least 100° of motion with an exercise program including static progressive or dynamic elbow splinting within 4 months of injury or the most recent surgery. Exclusion criteria included (1) severe burn injuries, (2) injury to the central nervous system, (3) complete bony ankylosis, (4) prior elbow contracture release, (5) active infection, (6) primary osteoarthritis, (7) radiographic signs of grade 2 or 3 arthrosis according to the system of Broberg and Morrey3, and (8) associated nonunion, malunion, or advanced articular injury requiring interposition arthroplasty or total joint arthroplasty.
The human research committee at our institution approved a protocol for the retrospective review of medical records and for inviting patients with inadequate follow-up to return for a free examination and radiographs. Of the patients, 10 (21%) had fewer than 6 months of follow-up in their medical records and were excluded: 6 were lost to follow-up, 3 declined participation, and 1 was deceased. Among the remaining 37 patients, 22 returned for a comprehensive examination including outcome questionnaires, and 15 patients, with a mean follow-up of 20 months (range, 7-57 months), were evaluated based on data from the medical record alone. In 16 patients, HO contributed to restriction of ulnohumeral motion, and in 21 patients, the contracture was due to capsular contracture alone.

**HO cohort**

The HO cohort consisted of 8 men and 8 women with a mean age of 43 years (range, 17-73 years). The left arm was involved in 9 patients (3 dominant) and the right in 7 (5 dominant). Nine patients were injured in a fall from a standing height, one in a fall from a greater height, five in a motor vehicle crash, and one in a work-related crush injury. The initial injury was an elbow fracture-dislocation in 7 patients, a distal humeral fracture in 6, and a radial head fracture in 3. In three patients, the fracture was associated with a wound: type 2 in one and type 3 in two according to Gustilo and Anderson. The initial treatment was operative in all patients. One had repair of the brachial artery during the initial operative treatment. No patients in this cohort had an ipsilateral skeletal injury.

One patient had serial debridement for a deep infection, but none of the others had additional surgery before the index surgery for elbow contracture release. The interval between the initial injury and the index surgery for elbow contracture release averaged 10 months (range, 4-25 months).

The mean flexion arc before the index procedure was $59^\circ$ (range, $5^\circ$-$95^\circ$) with mean flexion of $98^\circ$ (range, $65^\circ$-$125^\circ$) and a mean flexion contracture of $39^\circ$ (range, $5^\circ$-$6^\circ$). The mean arc of forearm rotation was $151^\circ$ (range, $0^\circ$-$180^\circ$), with mean pronation of $74^\circ$ (range, $0^\circ$-$90^\circ$) and mean supination of $77^\circ$ (range, $0^\circ$-$90^\circ$).

The contracture release was performed by use of a lateral muscle interval in 4 patients, a medial interval in 3, and a combined medial and lateral interval in 9. The patients were discharged the day after surgery, and none had postoperative pain control with regional analgesia. Two patients received preoperative radiation and one received postoperative radiation (with a single 7-Gy dose) as prophylaxis against recurrence of heterotopic bone, and three were prescribed 25 mg indomethacin 3 times a day by mouth for 2 weeks postoperatively.
Capsular contracture cohort

The capsular contracture cohort comprised 13 men and 8 women with a mean age of 51 years (range, 30-80 years). The left arm was involved in 6 patients (2 dominant) and the right in 15 (15 dominant). Fifteen patients were injured in a fall from a standing height, five in a fall from a greater height, and one in a sports accident. The original injury was an elbow fracture-dislocation in 9 patients, a distal humeral fracture in 8, and a radial head fracture in 4. The original injury was associated with a wound in 1 patient, type 1 according to the system of Gustilo and Anderson. The initial injury was treated operatively in 17 patients (81%). Three had ipsilateral arm injuries, including a fracture of both forearm bones in one, a fracture of the styloid in another, and a fracture-dislocation of the wrist in a third.

In the capsular contracture cohort, 6 patients underwent 9 operations (mean, 1.5 surgeries; range, 1-3 surgeries) subsequent to the initial surgery for acute trauma and before the index surgery for elbow contracture release. One patient had serial debridement of a postoperative infection. The index procedure (capsular release) was performed a mean of 9 months (range, 5-26 months) after the initial injury.

Immediately before the index procedure for elbow contracture release, the flexion arc averaged 52° (range, 10°-85°) with a mean of 94° of flexion (range, 40°-130°) and a mean 42° flexion contracture (range, 10°-70°). The mean arc of forearm rotation was 132° (range, 0°-180°), with mean pronation of 70° (range, 0°-90°) and mean supination of 63° (range, 0°-90°).

A lateral muscle interval was used in 7 patients5,17, a medial interval was used in 720, and a combined medial and lateral interval was used in 7. Patients were discharged the day after surgery with the exception of one, who had an indwelling brachial plexus catheter and was discharged the second day after surgery.

Operative technique

A lateral skin incision was used in 8 patients, a medial incision in 3, separate medial and lateral incisions in 3, and a single posterior skin incision in 23. A medial interval was used for release when there was preoperative ulnar neuropathy, fewer than 90° of flexion, or any medial implants or HO. Otherwise, a lateral interval was used. A combination of medial and lateral intervals was used for complex or severe contractures that could not be addressed with a single operative interval. The ulnar nerve was released and transposed anteriorly into the subcutaneous tissues as a routine part of a medial-sided release and was not addressed if only a lateral interval was used. Fifteen patients underwent simultaneous hardware removal at the time of their contracture release.
### Statistical comparison of cohorts

There were no significant differences between the cohorts in terms of age ($p = 0.09$), gender ($p = 0.52$), open injuries ($p = 0.30$), distal humeral fractures ($p = 0.99$), ipsilateral upper extremity injuries ($p = 0.24$), surgeries subsequent to the initial treatment and before the index release ($p = 0.11$), preoperative ulnar nerve dysfunction ($p = 0.72$), and intra-articular fracture ($p = 0.33$).

### Postoperative management

Active-assisted and gravity-assisted elbow motion exercises were initiated the morning after surgery. Continuous passive motion was used in 6 patients, 3 in the HO cohort and 3 in the capsular contracture cohort. Thirteen patients who had difficulty regaining the motion that was obtained in the operating room despite active exercises began using static progressive splints between 3 and 6 weeks after surgery. Passive manipulation of the elbow by the therapist was not permitted.

### Complications and subsequent surgery

Of the 16 patients in the HO cohort, 2 had surgery subsequent to the index surgery. One had removal of a radial head prosthesis that was suspected of being too large. The other had two subsequent surgeries for repeat contracture release and revision of a radial head prosthesis. Of the 21 patients in the capsular contracture cohort, 7 had one or more surgeries subsequent to the index contracture release. Three had one subsequent surgery to address elbow stiffness, and one had three repeat releases. One of these four patients had HO contributing to elbow stiffness, and two had concomitant ulnar nerve transposition. One patient had a radial head resection, one had an ulnar nerve transposition, and one had removal of implants used to repair an olecranon osteotomy.

### Evaluation

An investigator who was not involved in the patients’ care evaluated 22 of them in a research-specific follow-up visit. These 22 patients were evaluated according to 3 physician-based elbow scoring systems (Mayo Elbow Performance Index [MEPI]$^{23}$, Broberg and Morrey rating system$^{3}$, and American Shoulder and Elbow Surgeons [ASES] elbow evaluation$^{16}$) and one upper extremity–specific health status questionnaire (Disabilities of the Arm, Shoulder and Hand [DASH]$^{12}$). Arthrosis was rated by an independent observer according to the system of Broberg and Morrey$^{4}$. As a quantitative measure of pain for use in all analyses, we used the pain subscales of the ASES elbow evaluation instrument$^{16}$, adding the scores of these 5 scales for a summary pain score ranging from 0 to 50 points, with 0 points indicating no pain.
Statistical analysis
The 2 cohorts were compared via univariate analyses by use of the Student \( t \) test for continuous variables and Fisher exact test for dichotomous variables (SPSS software, version 10.0; SPSS, Chicago, IL). \( P < .05 \) was considered statistically significant. The following variables were evaluated: age, gender, open injuries, distal humeral fractures, surgeries subsequent to the initial treatment and before the index release, preoperative ulnar nerve dysfunction, and intraarticular fractures. Our plan was to include any factor with \( p < .08 \) in a multivariate statistical analysis; however, none was below this threshold, so no multivariate analysis was performed.

Results
Results after index procedure
The results of the index procedure for contracture release are reported as either the final follow-up motion in patients who did not have subsequent surgery or the motion immediately before a subsequent surgery for contracture release. The result of the index procedure was recorded at a mean of 24 months (range, 3-63 months) after the index procedure in the HO cohort and a mean of 24 months (range, 4-50 months) after the index procedure in the capsular contracture cohort.

In the HO cohort, the mean flexion arc was 113° (range, 60°-145°), with mean flexion of 130° (range, 100°-145°) and a mean flexion contracture of 17° (range, 0°-40°). The mean forearm rotation was 157° (range, 90°-180°), with mean pronation of 79° (range, 0°-90°) and mean supination of 78° (range, 20°-90°). There were no significant differences between patients who had simultaneous hardware removal during the index contracture release and those who had hardware left in place for gains in motion after the index surgery (\( p = .14 \)).

In the capsular contracture cohort, the mean flexion arc was 87° (range, 0°-125°), with a mean 118° of flexion (range, 90°-145°) and a mean flexion contracture of 30° (range, 10°-100°). Forearm rotation averaged 164° (range, 80°-180°), with mean pronation of 84° (range, 50°-90°) and mean supination of 80° (range, 30°-90°). The mean improvement in flexion arc was 54° in the HO cohort (ranging from a loss of 20° to a gain of 107°) and 35° in the capsular contracture cohort (ranging from a loss of 15° to a gain of 75°) (\( p = 0.02 \) (Figure 1). There were no significant differences between patients who had simultaneous hardware removal during the index release and those who had not in terms of improvement of motion after the index surgery (\( p = 0.48 \)).

Results after all subsequent procedures
In the HO cohort, the final evaluation occurred at a mean of 26 months (range, 7-63 months) after the index procedure. The final mean flexion arc was 116° (range, 70°-140°), with mean
flexion of 132° (range, 110°-145°) and a mean flexion contracture of 16° (range, 0°-40°). The mean arc of forearm rotation was 161° (range, 90°-180°), with mean pronation of 85° (range, 60°-90°) and mean supination of 76° (range, 20°-90°). There were no significant differences between patients who returned for a research-specific follow-up and those evaluated from the medical record alone in terms of mean flexion arc (p = 0.42) and forearm rotation arc (p = 0.79). Two patients had persistent ulnar nerve dysfunction despite a release of the ulnar nerve during the index surgery. New symptoms of ulnar neuropathy developed in one patient without pre-existing signs of ulnar nerve dysfunction but in whom the ulnar nerve was freed up during the index surgery.

In the capsular contracture cohort, the final evaluation was performed at a mean of 30 months (range, 8-57 months) after the index procedure. The final arc of flexion averaged 98° (range, 60°-140°), with mean flexion of 123° (range, 100°-145°) and a mean flexion contracture of 25° (range, 0°-40°).(Figure 1) The mean final arc of forearm rotation was 163° (range, 80°-180°), with mean pronation of 84° (range, 50°-90°) and mean supination of 79° (range, 30°-90°). There were no significant differences between patients who returned for a research-specific follow-up and those evaluated from the medical record alone in terms of mean flexion arc (p = 0.20) and forearm rotation arc (p = 0.41). Three patients had residual symptoms and signs of ulnar nerve dysfunction despite one or more procedures before, during, or after the index surgery to release or transpose the ulnar nerve.

Figure 1. Flexion and extension arc. FU = follow-up
The mean improvement in the flexion arc from before the index procedure to the final evaluation was 57° (ranging from a loss of 10° to a gain of 107°) in the HO cohort and 46° (range, 10°-100°) in the capsular contracture cohort (p = 0.19) (Figure 1). The mean Broberg and Morrey score was 89 points (range, 60-100 points) in the HO cohort and 82 points (range, 53-98 points) in the capsular contracture cohort (p = 0.09). The categoric ratings were 4 excellent, 11 good, and 1 fair in the HO cohort and 2 excellent, 13 good, 5 fair, and 1 poor in the capsular contracture cohort.

Questionnaires
Twenty-two patients were evaluated according to the MEPI, ASES, and DASH questionnaires: ten in the HO cohort and twelve in the capsular contracture cohort. The mean score on the MEPI was 81 points (range, 50-100 points) in the HO cohort and 82 points (range, 55-95 points) in the capsular contracture cohort (p = 0.93). The categoric ratings were 4 excellent, 3 good, 1 fair, and 2 poor in the HO cohort and 5 excellent, 4 good, 1 fair, and 2 poor in the capsular contracture cohort. The mean score on the ASES elbow evaluation instrument was 84 points (range, 61-100 points) in the HO cohort and 82 points (range, 61-95 points) in the capsular contracture cohort (p = 0.62). The mean pain score was 10 points (range, 0-28 points) in the HO cohort and 12 points (range, 1-38 points) in the capsular contracture cohort (p = 0.79) on a scale from 0 to 50 points, with 0 points indicating no pain. The mean DASH score was 20 points (range, 0-57 points) in the HO cohort and 16 points (range, 0-47 points) in the capsular contracture cohort (p = 0.51).

Radiographic assessment
In the HO cohort, 5 patients (31%) showed signs of arthrosis: grade 1 in 4 and grade 2 in 1. Recurrent HO developed in 2 patients (13%) in the HO cohort. In the cohort undergoing capsular release without HO, 4 patients (19%) had arthrosis: Broberg and Morrey grade 1 in 3 and grade 2 in 1. New heterotopic bone was found in 1 patient (5%).

Discussion
Several case series document the ability to improve motion in stiff elbows using an open capsulectomy. Patients with heterotopic bone restricting motion are often excluded and considered separately. HO has been considered a poor prognostic factor in surgeries to regain elbow motion. Our data suggest that the opposite is true: HO blocking elbow motion is actually a positive prognostic factor for better improvement after the index release, fewer reoperations, and a greater final flexion arc (though not significant with the numbers available). Although Gates et al found no differences between patients with and without HO restricting motion, our results do correspond with those reported by other authors. Park et al
in a retrospective study of 27 patients with post-traumatic elbow stiffness, reported a mean 60° improvement in the flexion arc in patients with HO (final flexion arc of 110°) compared with a mean improvement of 39° in patients with capsular contracture (final flexion arc of 96°). Itoh et al. and Mansat and Morrey stated that patients with stiffness from HO unrelated to elbow trauma (central nervous system injury or severe burns) did better than patients with injured joints and stiffness related primarily to capsular contracture, although these statements were based on small subsets of patients. The case of complete bony ankylosis is distinct. Not only is there much more extensive bone formation, but when there is no elbow motion for a prolonged period, there may be alteration of hyaline cartilage. Our results with total bony ankylosis, though rewarding in some patients, have not been as predictable overall.

We can only speculate as to why heterotopic bone is associated with improved motion and fewer repeat surgeries after operative release of post-traumatic elbow stiffness. When there is a discrete block to motion, the capsule is often less thick and the problem more easily defined and addressed. Patients with pure capsular contracture may have articular incongruity or malalignment, a tendency to excessive scarring, ulnar nerve compression, maladaptive psychosocial factors that limit the effectiveness of their exercise program, or some combination of these factors.

We have only used prophylactic radiation therapy and nonsteroidal anti-inflammatory medication in select cases. Although concerns regarding the risk for causing a malignancy have been tempered recently, our data suggest that prophylactic radiation therapy is not routinely necessary when resecting heterotopic bone that blocks motion but does not cause complete ankylosis. In our opinion, the finding in 1 patient with HO after capsular release was unusual and likely spurious. We do not recommend routine radiation treatment of either sub- total HO blocking motion or pure capsular contracture, although it might be considered in select cases. We also have limited experience with postoperative brachial plexus anesthesia and continuous passive motion and cannot comment on their effectiveness. The insurance companies in our region will only approve an overnight admission for most patients.

It has been reported that surgical removal of heterotopic bone should be delayed for at least 1 year, because early intervention would predispose patients to recurrence. However, in more recent studies, good results were reported when the intervention was performed 3 to 6 months after injury. Radiographic maturity and a mobile non-edematous wound are usually achieved within 4 months of injury and are useful indicators of the appropriate time to intervene. Serum alkaline phosphatase levels and activity on technetium bone scans are no longer believed to be helpful.

Weaknesses of our study are the relatively limited follow-up period and the fact that some patients were evaluated from the medical record alone. Patients with HO blocking elbow
motion, but not causing ankylosis, can expect to have better motion on average after 1 open surgery to address elbow stiffness than patients with capsular contracture and no heterotopic bone. Consequently, additional surgery is less frequent, and the final flexion arc may be better, although our study did not have sufficient power to show a difference.

References
