Anterior Release of the Elbow for Extension Loss

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Background: There are many causes of elbow contracture. When nonoperative techniques fail to increase the arc of motion of the elbow, surgical intervention may be indicated. The purpose of this study was to report the outcomes of surgical correction, predominantly with an anterior release, of elbow flexion contractures. In addition, we evaluated the efficacy of continuous passive motion in the immediate postoperative period.

Methods: We retrospectively reviewed the outcomes of 106 consecutive patients who had undergone anterior elbow release for the treatment of a flexion contracture between July 1975 and June 2001. Twenty-nine patients were excluded because they had been followed for less than twelve months, leaving a study group of seventy-seven patients. Postoperatively, fifty-four of the seventy-seven patients were treated with continuous passive motion and the other twenty-three patients were treated with extension splinting. The average duration of follow-up was thirty-three months. The average patient age was thirty-four years. The results were evaluated on the basis of both preoperative and postoperative radiographs as well as clinical measurements of elbow motion, all performed by the same examiner using the same large (47-cm-long) goniometer.

Results: The mean preoperative extension in the seventy-seven patients was 52°, which decreased to 20° postoperatively. The mean flexion increased from 111° preoperatively to 117° postoperatively, and the mean total arc of motion increased from 59° to 97°. The total arc of motion in the patients treated with continuous passive motion increased 45°, compared with an increase of 26° in those treated with extension splinting. There were eleven complications in ten patients. The majority were traction neuropathies. There were two infections (one superficial and one deep), both of which resolved following treatment.

Conclusions: Release of a pathologically thickened anterior elbow capsule through a predominantly anterior approach to correct diminished elbow extension is a safe and effective technique. Furthermore, compared with splinting in extension alone, the utilization of continuous passive motion during the postoperative period increases the total arc of motion.

Level of Evidence: Therapeutic study, Level III-2 (retrospective cohort study). See Instructions to Authors for a complete description of levels of evidence.

There are many causes of limited elbow motion, including local trauma, burns, osteoarthrosis, inflammatory arthritis, hemophilia, and infection. These causes have been classified as intrinsic or extrinsic factors[1]. Nonoperative techniques such as active and passive range-of-motion exercises with static and dynamic splinting can improve motion. When these modalities fail, operative intervention may be indicated. Several operative approaches for the release of flexion contractures have been reported[1-22]. The purpose of this study was to determine which factors influenced the outcomes in a series of seventy-seven patients treated predominantly with an anterior elbow release to correct a flexion contracture.

Materials and Methods

We retrospectively reviewed the outcomes of all patients who had undergone surgical release of the elbow for the treatment of diminished elbow motion during the period from July 1975 to June 2001 at our institution. The senior author (J.R.U.) performed all of the surgical procedures. Nonoperative treatment (physical therapy and static and dynamic splinting) had been attempted and had failed to regain elbow motion in all patients. Patients with congenital elbow contracture or elbow spasticity were not included in the study. Of the 106 patients who underwent surgical release of the elbow, twenty-nine were excluded because they had not been followed for twelve months, leaving seventy-seven patients who had been followed clinically for a minimum of twelve months. Fifty-two patients had been followed for two years or more postoperatively, and the remaining twenty-five had been followed for between one and two years postoperatively. The mean duration of follow-up was thirty-three months (range, twelve to 120 months). Follow-up range-of-motion data were included only when the

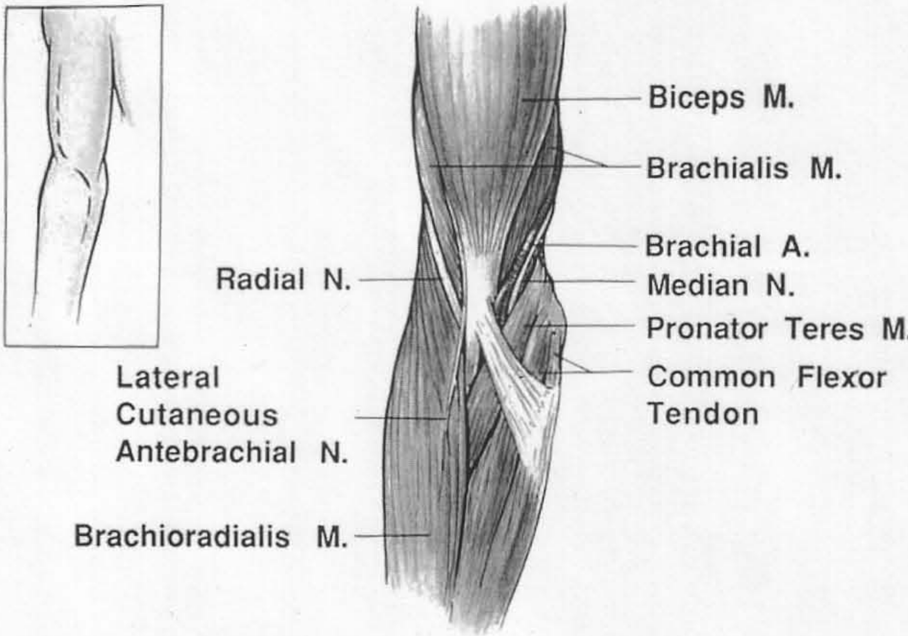

Fig. 1-A
An s-shaped incision crosses the antecubital skin crease. The biceps tendon is identified early in the approach and serves as a landmark for the isolation and protection of the neurovascular structures.

measurements had been done at our institution with use of a large goniometer (47 cm in length, with 5.5 cm from the center axis to the increment markings) by the same surgeon (J.R.U.). Preoperatively, all patients were concerned primarily about the loss of elbow extension. Few patients also desired increased elbow flexion. Follow-up radiographs were not routinely made; they were obtained only for the patients who were experiencing pain or other symptoms, with a deviation from the standard postoperative course.

Our primary indication for surgery was a flexion contracture exceeding 20° that the patient believed affected elbow function or was related to pain. After attainment of a thorough history, performance of a physical examination and recording of the findings, and discussion of the needs and desires of the patient, the final decision to perform an elbow release through an anterior approach was based on the imaging studies of the elbow. If the plain radiographs, tomograms, or computed tomography scan revealed a relatively well-preserved ulno-

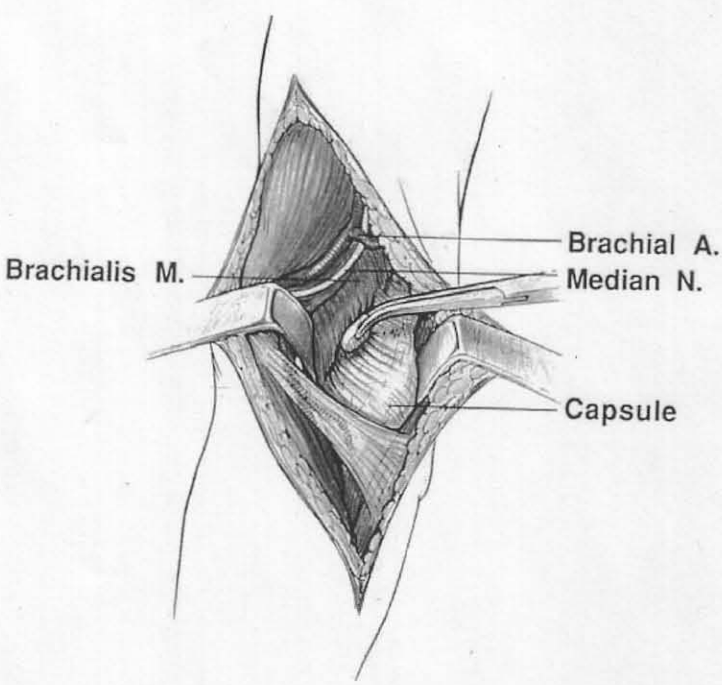

Fig. 1-B
The medial side is approached first because the ulnohumeral joint is more readily identified on this side. The surgeon should be aware of neurovascular structures adherent to the thickened capsule.

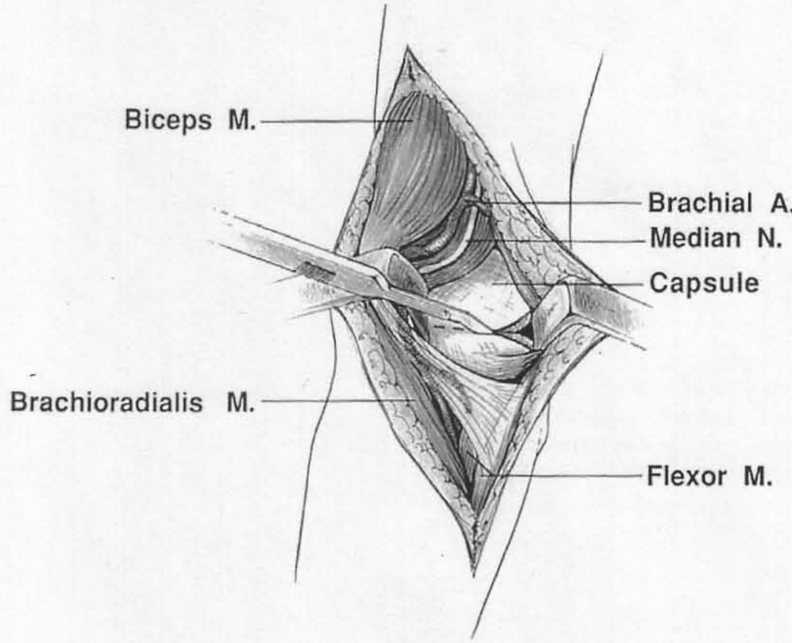

Fig. 1-C
The medial aspect of the capsule is released sharply. An approximately 8-mm-long strip of capsule is excised.

humeral joint and minimal or no osteophytes in the olecranon fossa, the patient was considered a good candidate for this procedure. Twenty-four elbows (31%) showed only mild irregularities of the ulnohumeral articulation, and the remainder were free of ulnohumeral irregularities.

The mean age was thirty-four years (range, thirteen to sixty-six years). There were fifty-four male patients and twenty-three female patients. The etiologies of the elbow contractures included fifty-one isolated fractures (seven intra-articular and forty-four extra-articular), one pure dislocation, eight ulnohumeral and/or radiocapitellar dislocations with associated fractures, one case of primary osteoarthrosis, one case of inflammatory arthritis, one closed head injury, one brachial plexopathy, eight other cases of local trauma (two gunshot wounds and six soft-tissue injuries), one infection, and one case of osteochondrosis; the injury or disease was not specified for three patients. No patient was excluded from the final cohort because of the etiology of the contracture or because of ulnohumeral incongruity. Fifty-eight of the seventy-seven patients had undergone a total of ninety prior procedures

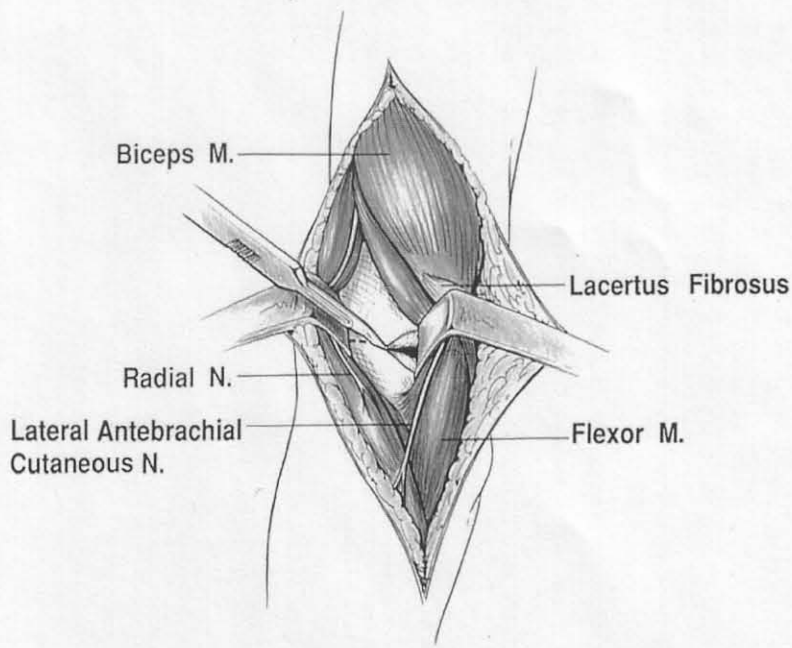

Fig. 1-D
The lateral capsule is released in a similar fashion, with care taken to protect the radial nerve.

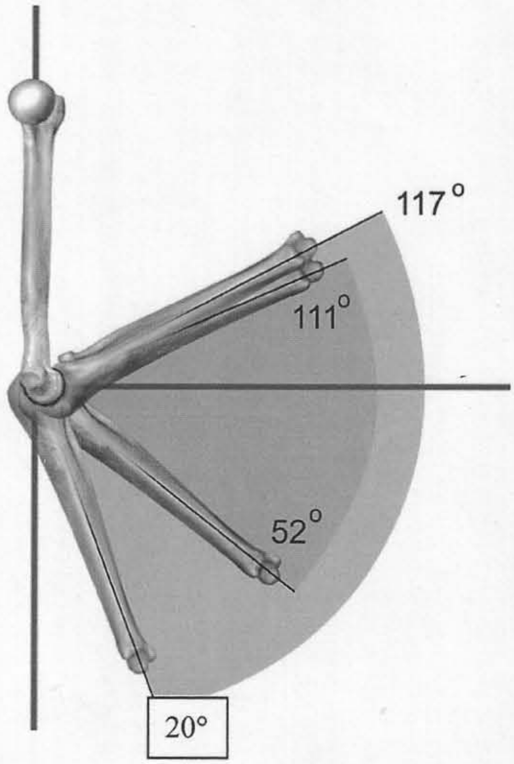

Fig. 2
Preoperative and postoperative range of motion of the elbow in the series as a whole. The total arc of motion improved from 59° to 97°.

(range, one to four procedures), either as the initial treatment of the injury or in an attempt to regain motion. Of these ninety prior procedures, only four involved a contracture release (two anterior capsular releases and two posterior capsular releases). Prior procedures and additional procedures performed at the time of the index operation as well as the preoperative and postoperative ranges of motion are listed in the Appendix. The mean time from the initial injury to the surgery, when a specific date could be identified, was twenty-six months (range, three to 240 months).

The technique of anterior release has been described previously[2]. A curvilinear s-shaped incision spanning the antecubital skin crease was used to approach the anterior capsule. Early in the series, a capsulotomy was performed. In 1995, this was changed to a capsulectomy, in which approximately 8 mm of the capsule was resected. This was done in an attempt to decrease the amount of scar recurrence, although there are no published data to support the efficacy of this approach. Except for the change from the capsulotomy to the capsulectomy, the procedure remained the same over the study period (twenty-six years). If full extension was not achieved after the capsulotomy or capsulectomy and the brachialis appeared to be taut with extension, sharp release of the brachialis fascia was performed. This was done in four patients. Key features of the procedure are illustrated in Figures 1-A through 1-D.

Sixteen patients had an additional posterior incision, which we believed to be indicated when radiographs demonstrated a posterior bone block (i.e., an olecranon osteophyte) causing impingement, a loose body, or retained posterior hardware. All elbows with an additional posterior release were approached through a direct posterior incision with a triceps-splitting technique, with care taken to minimize local dissection. Ten patients with preoperative evidence of ulnar neuropathy underwent ulnar nerve decompression (four patients) or transposition (six patients) at the time of the index procedure. Twenty-three patients had excision of osteophytes from the coronoid (ten patients), coronoid fossa (three), olecranon tip (nine), or radial head (one). The majority (sixty-one) of the seventy-seven patients had the surgery with regional anesthesia. An indwelling catheter placed adjacent to the brachial plexus was used in twelve patients for forty-eight hours of postoperative pain management. This treatment was initiated late in the series. Although we prefer to use it, it is not always feasible as some patients refuse a block and, occasionally, the anesthesia staff cannot obtain an effective block.

Following surgical release, the upper extremity was either placed in an anterior splint (twenty-three patients) in maximum extension or treated immediately in a continuous passive motion machine (Kinetic, Charleville-Mezieres, France) (fifty-four patients). The typical postoperative course consisted of inpatient hospitalization for two to three days for instruction regarding use of the continuous passive motion machine and adjustment of the machine. We recommend that patients use the continuous passive motion machine for one to four weeks, depending on the severity of the preoperative contracture and on our presumption of patient compliance. The patients who had the most severe contracture and who seemed most likely to neglect self-driven postoperative physical therapy were told to use the continuous passive motion machine for four weeks or more, whereas highly motivated patients with a less severe contracture utilized the continuous passive motion machine for only one or two weeks. At the time of discharge, supervised physical therapy, which was to last three to six weeks, was arranged for all patients regardless of whether they were to use the continuous passive motion machine.

A Student t test, performed with Microsoft Excel X statistical software (Redmond, Washington), was utilized to compare data between two groups (those treated with and those not treated with the continuous passive motion machine, those with and those without ulnohumeral arthrosis, and different age groups). Results were considered significant when the p value was ≤ 0.05.

Results

The mean flexion contracture of 52° preoperatively decreased to 20° postoperatively. The mean flexion increased from 111° preoperatively to 117° postoperatively, and the mean total arc of motion increased from 59° preoperatively to 97° postoperatively, an improvement of 38°. Range-of-motion data are summarized in Figure 2.

The mean preoperative arc of motion (and standard deviation) had been 52° ± 28° (range, 0° to 100°) in the fifty-four patients treated with continuous passive motion during the early postoperative period and 73° ± 29° (range, 20° to 150°) in the twenty-three treated with extension splinting. Postoperatively, these values improved to 96° ± 25° (mean increase, 45° ± 3°) and 99° ± 25° (mean increase, 26° ± 5°), respectively ($p = 0.0076$).

We found no significant difference, with the numbers available, between age groups with regard to the corrected arc of elbow motion or the amount of correction of the flexion contracture. The mean gain in the arc of elbow motion was 38.8° ± 34.1° for patients between the ages of thirteen and nineteen years, 34.2° ± 24.9° for those between the ages of twenty and thirty-nine years, and 46.1° ± 22.1° for those forty years of age or older ($p = 0.6$). The mean amount of correction of the flexion contracture was 35.7° ± 22.0°, 28.3° ± 13.9°, and 33.7° ± 20.6°, respectively ($p = 0.27$).

The mean improvement in the range of motion was 37.5° ± 3.5° in the twenty-four patients with radiographic evidence of ulnohumeral osteoarthrosis and 36.9° ± 4.1° in the fifty-three without evidence of osteoarthrosis ($p = 0.8$).

There were eleven complications in ten patients. New symptoms of ulnar neuropathy and/or neuritis developed during the postoperative course of four patients. Three of these patients were treated with ulnar nerve transposition. The other two patients had improvement with nonoperative treatment (vitamin B_6 [50 mg three times a day], elbow pads, and nonsteroidal anti-inflammatory medications). Transient radial nerve palsy developed in two patients. One of them had had an external rotation humeral osteotomy at the time of the index procedure. Paresthesias in the distribution of the superficial radial nerve developed in one patient. One patient had a posterior interosseous nerve palsy. Three months after the elbow release, this patient had a surgical exploration that revealed a neuroma in continuity with the posterior interosseous nerve. Nerve-grafting was performed, but there was an incomplete return of digital extension. One patient had an avulsion of the lateral antebrachial cutaneous nerve. This patient had had a flexion contracture of 80° for seventeen years.

A deep infection developed in one patient; it resolved with administration of intravenous antibiotics and surgical irrigation and débridement. A superficial wound infection developed in another patient, and it responded to oral antibiotics. This patient had persistent pain and limitation of motion after the anterior release and later underwent interposition arthroplasty.

Thirteen patients had inferior results. Eleven of them had 0° to 10° of improvement in elbow motion, and the other two had a decrease in the overall arc of motion. No pattern with regard to age, gender, medical comorbidities, or degree or duration of contracture could be identified among these sixteen patients to predict who is at risk for inferior results.

Discussion

Prior to the 1985 report by one of us (J.R.U.) and colleagues[2], there were few reports in the literature on operative release of elbow contracture. In 1944, Wilson described his results following complete anterior capsulectomy and lengthening of the biceps tendon[3]. Willner described a modified technique that included osteotomy of the medial epicondyle and reflection of the common flexor origin to allow a complete anterior capsulectomy[4]. More recently, there have been several reports on operative release through a lateral approach[1,5-10], a medial approach[11,12], or a posterior approach[13] and on arthroscopic release[14-17].

In an earlier report on anterior elbow release, fifteen patients who had been treated without a continuous passive motion machine postoperatively had an increase in the mean arc of motion from 69° (range, 48° to 117°) preoperatively to 94° (range, 19° to 114°) at the time of follow-up[2]. In another study, eighteen patients treated with anterior release and postoperative continuous passive motion had an increase in the mean arc from 48° (range, 55° to 103°) to 96° (range, 23° to 119°)[18]. This represented a larger overall improvement in flexion and the total arc of motion with the use of a continuous passive motion machine. Breen et al. reported on the use of anterior release and continuous passive motion in three patients[19]. The mean preoperative flexion contracture of 41° decreased to 5°. Richards et al. also reported on anterior release followed by use of a continuous passive motion machine, in a group of twenty-two patients[20]. There was a mean increase in extension of 36°. Our experience with the adjunctive use of a continuous passive motion machine in the immediate postoperative period parallels that in those reports. The improvement in the total arc of motion was 45° ± 3° in our patients treated with a continuous passive motion machine, whereas it was 26° ± 5° in those not treated with a continuous passive motion machine; this was a significant difference of 19° ($p = 0.0076$).

Mansat and Morrey reported on the use of a lateral approach, between the extensor carpi radialis longus and the brachioradialis, in thirty-eight patients with a contracture secondary to extrinsic causes[21]. This so-called column procedure involved anterior capsulectomy and capsulotomy, with posterior capsulectomy as necessary. The mean arc of elbow motion increased from 49° preoperatively to 92° postoperatively.

Husband and Hastings described their lateral approach[10], and Cohen and Hastings later modified it to a lateral collateral ligament-sparing technique[9]. They performed an anterior and posterior capsulectomy through a lateral approach in twenty-two patients. The mean arc of motion of the elbow increased from 74° to 129°.

Arthroscopic elbow release was reported in 1992. Proponents of this technique consider it to be safe and associated with less morbidity when compared with an open release[14,16,17,22]. In 1994, Timmerman and Andrews[22] reported on nineteen patients with posttraumatic arthrofibrosis who underwent arthroscopic treatment. Mean extension improved from 29° to 11°, and mean flexion improved from 123° to 134°. Phillips and Strasburger[14] reported on twenty-five patients with arthrofibrosis treated with arthroscopic release. The average improvement in the total arc of motion was 41°. In three elbows that were approached through an anterior incision, we found the median nerve to be imbedded in the anterior capsule as a result of severe trauma (fracture-dislocation) and subsequent scarring. In these patients, the median nerve would be at risk during arthroscopic capsular release. Furthermore, it should be noted that the patients in the arthroscopic studies had less severe elbow contractures.

One weakness of our study is the lack of a two-year follow-up for twenty-five patients. Fearing that the presence of ulnohumeral arthrosis was a risk factor for a late decline in the results, we were initially concerned about this lack of a two-year follow-up. To address this concern, we compared the results between patients examined at a minimum of twelve months but less than two years and patients examined at a minimum of two years. We found no difference between the two groups with respect to the postoperative total arc of motion of the elbow. The mean improvement in the arc of motion was 42° ± 26° in the one-year follow group and 38° ± 24° in the two-year follow-up group ($p = 0.25$).

Another concern with this study is the degree of heterogeneity of our cohort. Patients with congenital elbow contracture and spasticity were excluded from the study, but fractures, dislocations, osteoarthrosis, inflammatory arthropathies, closed head injury, brachial plexopathy, and other local trauma were are all etiologies in our patient population. However, we believe that this degree of variability is representative of most orthopaedic practices that treat elbow disorders and thus these conclusions are generally applicable.

We believe that release of an elbow flexion contracture through an anterior incision is a safe and effective technique and that the use of continuous passive motion during the postoperative period significantly increases the total arc of motion compared with that associated with splinting alone.

Appendix

eA A table showing patient demographics and elbow range-of-motion data for each of the patients is available with the electronic versions of this article, on our web site at jbjs.org (go to the article citation and click on "Supplementary Material") and on our quarterly CD-ROM (call our subscription department, at 781-449-9780, to order the CD-ROM). ■

NOTE: The authors thank Ricardo Pietrobon, MD, PhD, for his assistance with the statistical analysis.

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The authors did not receive grants or outside funding in support of their research or preparation of this manuscript. They did not receive payments or other benefits or a commitment or agreement to provide such benefits from a commercial entity. No commercial entity paid or directed, or agreed to pay or direct, any benefits to any research fund, foundation, educational institution, or other charitable or nonprofit organization with which the authors are affiliated or associated.

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TABLE E-1. Patient Demographics and Elbow Range of Motion Data*

Age	Sex	Injury	Post Incis	OA	Pre Ext	Pre Flex	Post Ext	Post Flex	Pre Arc	Post Arc	Arc Change	Continuous Passive Motion Machine	Complications	Additional Procedures	Prior Procedures	F/U Interval *(mo)*	Time to Surg *(mo)*	Continuous Axillary Block
15	M	Lateral Condyle Fracture		Yes	42	80	17	102	38	85	47	Yes	None	Coronoid Osteophyte Excision	ORIF Lateral Condyle; Arthroscopic Débridement	24	12	
36	M	Elbow Dislocation, Radial Head Fracture		No	23	123	0	150	100	150	50	Yes	None	Radial Head Excision and Implant	Partial Radial Head Resection	16	8	
33	M	Elbow Dislocation, Radial Head Fracture		No	45	130	20	135	85	115	30	No	None	Ulnar Nerve Decompression	None	20	10	
27	M	No Specific Injuries	Yes	No	58	135	20	122	77	102	25	Yes	None	Olecranon and Coronoid Osteophyte Excision	None	22	X	
29	M	Weight-lifter	Yes	No	30	102	20	120	72	100	28	Yes	Ulnar Nerve Palsy, Resolved after Transposition	Coronoid Osteotomy	None	37	X	
37	M	Primary Osteoarthrosis	Yes	No	40	95	15	130	55	115	60	Yes	None	Osteophyte Excision	None	33	X	Yes
46	M	Radial Head, Olecranon Fracture		Yes	62	112	44	124	50	80	30	Yes	None	ROH ORIF Olecranon Nonunion with ICBG	ORIF ×2	26	16	
29	F	Radial Head Fracture		No	55	150	35	135	95	100	5	Yes	None	Ulnar Nerve Transposition	Excision Radial Head and Coronoid Fragment; Manipulation	60	12	Yes
22	M	Open Intra-articular Distal Humerus Fracture		No	45	112	5	110	67	105	38	Yes	Transient Radial Nerve Palsy	Ext Rotation Humeral Osteotomy	I&D, Traction; ORIF + ICBG	12	10	
66	F	Intra-articular Distal Humerus Fracture		Yes	66	110	5	140	44	135	91	Yes	None	Removal of Loose Body	ORIF	17	11	
44	M	Elbow Dislocation with Coronoid Fracture		No	63	113	15	110	50	95	45	Yes	None	Resection of Heterotopic Bone	None	18	18	
13	F	Elbow Dislocation with Radial Head Fracture		No	70	108	60	100	38	40	2	Yes	None	None	ORIF	12	8	Yes
22	M	Radial Head Fracture, Proximal Ulna Fracture	Yes	Yes	42	95	12	125	53	113	60	Yes	None	Removal of Loose Bodies, Olecranon and Coronoid Osteophyte Excision, Ulnar Nerve Decompression	ORIF; Removal of Loose Body; Manipulation	13	11	
50	M	Radial Head Fracture		No	66	82	55	75	16	20	4	Yes	None	Post. Release, Ulnar Nerve Transposition	Closed Reduction; Arthroscopic Débridement	12	8	
62	F	Tumor Excision		No	40	111	20	130	71	110	39	No	None	Removal Loose Bodies, Coronoid Osteophyte and Radial Head Resection	Radial Head Resection	65	X	
31	F	Capitellum Fracture		No	40	140	5	135	100	130	30	Yes	None	Neurolysis of LABCN	Excision of capitellum	84	6	Yes
44	M	Gunshot Wound, Elbow		No	59	87	0	125	28	125	97	Yes	Transient Ulnar Neuritis	Excision of Heterotopic Bone	None	74	36	
49	M	Open Distal Humerus Fracture	Yes	No	43	122	20	125	79	105	26	Yes	None	Removal of Hardware	ORIF; Ulnar Nerve Decompression	25	21	Yes
18	M	Brachial Plexopathy		No	80	148	5	125	68	120	52	Yes	Avulsion LABCN	Z-Lengthening of Brachialis and Biceps	None	43	221	Yes
24	M	Elbow Dislocation, Radial Head and Coronoid Fracture	Yes	Yes	66	82	40	110	16	70	54	Yes	Superficial Wound Infection; Pain/Decreased Motion; Interposition Arthroplasty, 7/8/96	Excision of Radial Head and Olecranon Osteophytes; Removal Loose Bodies	ORIF; Capsular Release	36	13	
52	F	Intercondylar Humerus Fracture		No	65	107	45	120	42	75	33'	No	None	Radial N Exploration; Sural Nerve Graft	ORIF, ROH, Radial N Exploration	62	5	
13	M	Infection	Yes	Yes	62	150	35	133	88	98	10	No	None	Pronator and Brachialis Release; Olecranon Osteophyte Excision	Drainage of Elbow Infection	18	12	
52	M	Supracondylar Humerus and Olecranon Fracture	Yes	No	70	90	5	100	20	95	75	Yes	None	Ulnar N Decomp.; Olecranon Osteophyte Excision	ORIF	29	10	
35	M	Osteochondrosis		Yes	30	90	25	118	60	93	33	Yes	None	Ulnar and Humeral Osteophyte Excision; Removal of Loose Body	None	29	240	
21	M	Open Lateral Condylar Fracture		Yes	35	130	20	145	95	125	30	No	None	None	ORIF; ROH	12	22	
32	M	Radial Head Fracture		Yes	41	131	11	124	90	113	23	Yes	None	Excision Radial Head Remnant; Insertion Radial Head Implant	Radial Head Excision	18	14	
33	M	Radial Head Fracture		No	62	109	13	136	47	123	76	Yes	None	None	None	13	7	
17	F	Olecranon Open Fracture	Yes	No	90	90	0	130	0	130	130	Yes	Pin Palsy -Explored 7/29/94, Neuroma in Continuity, Grafted with LABCN, Incomplete Digital Ext Recovery	ROH; Resection of Heterotopic Bone	ORIF	12	6	Yes
51	M	Throwing Athlete	Yes	No	25	125	5	130	100	125	25	Yes	None	Carpal Tunnel Release	Posterior Release; Removal Loose Body	74	X	
20	F	MCL Tear		No	25	120	3	125	95	122	27	Yes	None	None	Arthroscopic Débridement	12	7	Yes
56	F	Soft Tissue Injury		No	77	154	10	135	77	125	48	No	Dysesthesia, Paresthesia Superficial Radial Nerve	None	Extensor Origin Release; Manipulation	18	23	
35	M	Seronegative Spondylo-arthropathy		Yes	25	110	5	123	85	118	33	Yes	None	Removal Loose Body; Excision Coronoid and Humeral Osteophyte	None	12	X	Yes
38	M	Radial Head Fracture		No	42	125	5	120	83	115	32	Yes	None	Removal Loose Bodies	None	77	9	
17	M	Intra-articular Distal Humerus Fracture	Yes	Yes	47	110	7	112	63	105	42	Yes	None	ROH, Excision of Olecranon and Coronoid Spurs	ORIF	35	7	Yes
40	F	Supracondylar Humerus Fracture		Yes	30	88	25	115	58	90	32	Yes	None	Brachialis Release	ORIF	20	7	
43	M	Capitellum Fracture	Yes	No	55	126	10	130	71	120	49	Yes	Required Ulnar Nerve Transposition 12/15/00	ROH	ORIF	15	14	Yes
55	F	Capitellum, Distal Ulna, Radius Fracture		No	85	102	10	110	17	100	83	Yes	Required Ulnar Nerve Transposition	Ulnar Neurolysis; Excision of Capitellum	Excision of Capitellum	16	24	

36	M	Supracondylar Humerus Fracture	Yes	No	80	85	30	110	5	80	75	Yes	None	Resection of Heterotopic Bone; Ulnar N Transposition	ORIF, Radial Head Excision	28	6	
53	M	Closed Head Injury	Yes	No	90	90	10	95	0	85	85	Yes	None	MCL Reconstruction (Plantaris Graft); Ulnar N Transposition; Flexor Pronator Slide; Excision Heterotopic Bone	None	42	29	
43	F	Distal Humerus Fracture		Yes	50	125	20	116	75	96	21	Yes	None	Ulnar N Transposition; Excision Capitellum Osteophyte, Brachialis Release	None	12	23	
35	M	Open Comminuted Intra-articular Distal Humerus Fracture	Yes	No	70	75	25	115	5	90	85	Yes	Deep Wound Infection Requiring I&D	Excision of Heterotopic Bone	I&D, ORIF	19	13	
40	M	Hyperextension Injury	Yes	No	60	90	30	95	30	65	35	Yes	None	Removal of Loose Bodies; Excision of Olecranon Osteophyte	None	14	36	
25	F	Radial Head Fracture		No	26	120	20	120	94	100	6	No	None	Ulnar N Transposition; Radial Head Implant	Radial Head Excision	14	14	
14	M	Lateral Condyle Fracture		Yes	52	134	33	130	82	97	15	Yes	None	None	None	12	11	
32	M	Humerus, Ulna, and Radius Fracture		No	55	130	25	105	75	80	5	No	None	None	ORIF	40	72	
32	F	Olecranon Fracture		No	45	160	15	140	115	125	10	No	None	None	Excision of Fragment	60	8	
17	F	Lateral Condyle Fracture		No	60	120	5	135	60	130	70	No	None	None	None	120	48	Yes
25	F	Trochlea Fracture		Yes	45	95	5	120	50	115	65	No	None	None	ORIF	78	3	
22	F	Supracondylar Humerus Fracture		No	60	95	30	65	35	35	0	No	None	None	ORIF	29	12	
22	M	Hyperextension Injury		No	10	160	5	135	150	130	-20	No	None	None	None	46	48	
18	M	Intercondylar Humerus Fracture		Yes	20	130	10	120	110	110	0	No	None	None	ORIF	41	156	
51	M	Radial Head Fracture		No	70	90	20	110	20	90	70	No	None	None	Excision of Heterotopic Bone	53	8	
42	M	Intra-articular Distal Humerus Fracture		Yes	35	75	30	90	40	60	20	No	None	None	ORIF; Ulnar N Transposition	37	24	
31	M	Intra-articular Distal Humerus Fracture		No	65	115	25	130	50	105	55	No	None	None	ORIF; Tendon Transfer; Posterior Release	26	96	
18	F	Intercondylar Humerus Fracture		No	70	105	30	90	35	60	25	No	None	None	ORIF	41	7	
35	M	Radial Head Fracture, Elbow Dislocation		No	40	115	20	105	75	85	10	No	None	None	Radial Head Replacement	28	17	
34	M	Radial Head Fracture		No	50	125	35	105	75	70	-5	No	None	None	Manipulation	24	24	
32	F	Capitellum Fracture		Yes	45	120	10	125	75	115	40	No	None	None	Excision of Capitellum	25	12	
31	M	Lateral Condyle Fracture		No	50	120	15	130	70	115	45	No	None	None	ORIF	30	12	
30	F	Intercondylar Humerus Fracture		No	80	80	40	105	0	65	65	Yes	None	None	ORIF	48	11	
20	M	Elbow Degloving		No	35	130	15	120	95	105	10	No	None	None	Free Tissue Transfer	72	27	
25	M	Open Humeral Condyle Fracture		Yes	55	80	25	78	25	53	28	Yes	None	None	I&D × 3	24	9	
54	M	Open Humerus, Ulna, Radius Fracture		No	60	90	30	90	30	60	30	Yes	None	None	ORIF	27	67	
49	M	Elbow Fracture/Dislocation		No	75	95	25	95	20	70	50	Yes	None	None	Arthroscopic Débridement	32	6	
54	M	Supracondylar Humerus Fracture		No	65	135	30	115	70	85	15	Yes	None	None	ORIF	40	9	
19	F	Gunshot Wound, Elbow		No	45	95	18	110	50	92	42	Yes	None	None	None	41	24	
31	M	Radial Head Fracture, Elbow Dislocation		Yes	70	105	25	110	35	85	50	Yes	None	None	ORIF × 2	31	39	
43	M	Humeral Osteochondral Fracture		Yes	45	85	15	115	40	100	60	Yes	None	None	ORIF	30	14	
18	M	Radial Head Fracture		No	55	115	15	125	60	110	50	Yes	None	None	None	63	12	
33	M	Supracondylar Humerus Fracture		Yes	65	90	35	85	25	50	25	Yes	None	None	ORIF	30	17	
52	M	Radial Head Fracture		Yes	45	80	25	110	35	85	50	Yes	None	None	Radial Head Replacement	35	14	
15	M	Supracondylar Humerus Fracture		No	45	120	20	115	75	95	20	Yes	None	None	ORIF	27	15	
43	F	Dislocation		Yes	55	125	50	125	70	75	40	Yes	None	None	Closed Reduction; Arthroscopic Débridement	24	23	
27	M	Olecranon Fracture		No	58	95	20	105	37	85	48	Yes	None	None	ORIF	24	6	
43	M	Intercondylar Humerus Fracture		No	65	120	20	120	55	100	45	Yes	None	None	ORIF; Osteotomy for Malunion	32	7	
35	M	Open Intra-articular Humerus Fracture		No	40	120	35	130	80	95	15	Yes	None	None	ORIF × 2	27	10	
23	F	Radial Head Fracture		No	30	90	15	130	60	115	55	Yes	None	None	Excision of Fragment	28	12	

*ROH = removal of hardware; ICBG = iliac crest bone graft; I&D = irrigation and débridement; and LABCN = lateral antebrachial cutaneous nerve.