

# Incidence of Postoperative Elbow Contracture Release in New York State

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**Purpose** To determine the incidence of elbow contracture requiring release after surgically treated elbow trauma and to identify patient, injury, and treatment factors that may predict contracture development.

**Methods** The New York Statewide Planning and Research Cooperative System database identified 32,708 patients who were surgically treated for elbow trauma from 1997 to 2009. The database identified 270 of those patients who underwent subsequent contracture release. The median time from index fracture procedure to contracture release was 31 weeks.

**Results** Patients requiring a contracture release were younger (43 vs 56 y) and more commonly male (57%). Injuries classified as severe were more common in the contracture group (11% vs 5%), as were open fractures (17% vs 11%). A multivariate regression analysis revealed that patients with burns were 16 times more likely to require surgical contracture release, and the use of internal fixation to treat the fracture was protective against contracture development.

**Conclusions** The incidence of elbow contractures treated with release after surgically treated elbow trauma was low but increased with the severity of the initial trauma. (*J Hand Surg* 2013;38A:1746–1752. Copyright © 2013 by the American Society for Surgery of the Hand. All rights reserved.)

**Level of evidence** Prognostic II.

**Key words** Elbow contractures, elbow trauma, post-traumatic contracture.



**D**ESPITE THE CONSIDERABLE disability resulting from a stiff elbow, little is known about the incidence or predisposing factors to the condition,<sup>1</sup> although fractures, dislocations, soft tissue injuries (including burns), and head injuries are known to contribute.<sup>2</sup> The normal arc of elbow flexion-extension is 0° to 145°, and the traditionally accepted minimum

range of motion tolerated for daily activities is 30° to 130°.<sup>3</sup> Many normal activities are difficult to perform with less than 40° to 120° of motion.<sup>4</sup> Some patients who do not have this functional arc desire treatment to improve their elbow motion.<sup>5</sup> A recent study showed that higher flexion is needed for contemporary tasks.<sup>6</sup> These authors found that a range of 27° to 149° of motion was needed for use of a cell phone and typing on a keyboard.<sup>6</sup> Loss of elbow range of motion, especially flexion, is poorly tolerated because of the lack of compensatory motions in other joints.<sup>4,7</sup>

Previous studies describing the rates of elbow contracture development are limited to small patient cohorts with varying injury patterns.<sup>2,8–15</sup> None of these studies were performed at the population level, making it difficult to make generalizations regarding the true

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incidence of contracture development or predisposing factors.

The goal of the study was to identify the incidence of contracture release after surgically treated elbow trauma. We hypothesized that the incidence of elbow contracture would be higher in patients with a more severe injury, including intra-articular patterns and dislocations and greater comorbidities as measured by the Charlson Deyo Comorbidity Index.<sup>16</sup>

## MATERIALS AND METHODS

The Statewide Planning and Research Cooperative System (SPARCS) from the New York State Department of Health is an administrative database reporting all hospital admissions and ambulatory surgery procedures within the state. The database captures discharge data on all patients being cared for in the state and has previously been used in orthopedics for epidemiological studies.<sup>16,17</sup> SPARCS has been operational since 1982, providing over 30 years of hospital discharge data. However, unique patient identifiers were introduced in 1997 allowing individual patients to be followed across multiple hospital admissions and ambulatory procedures. Owing to the administrative nature of the database, no identifiable patient information is available; therefore, the study was institutional review board-exempt per our institutional guidelines.

The database was used to identify all patients with surgically treated elbow trauma. The International Classification of Diseases (ICD) diagnosis codes from the ninth revision with clinical modifications and procedure codes were used to identify patients treated with surgical procedures for elbow trauma from January 1, 1997, to December 31, 2009 (Appendices A and B; available on the *Journal's* Web site at [www.jhandsurg.org](http://www.jhandsurg.org)). To be eligible for inclusion, patients were required to have both a diagnosis code for elbow pathology and a procedure code for surgical treatment. Patients with surgically treated elbow trauma were identified from the SPARCS inpatient and ambulatory surgery databases. Subsequent admissions for contracture release codes for these patients were also identified through December 31, 2010, to allow for a minimum of 1 year of follow-up from initial fracture treatment for all patients in the cohort (Appendix A; available on the *Journal's* Web site at [www.jhandsurg.org](http://www.jhandsurg.org)). All patients considered to have a contracture had both an ICD diagnosis code and either a Current Procedural Terminology or an ICD procedure code for contracture release. We did not track or record patients who underwent a revision contracture release. All of the analyses considered the first contracture release only.

Patients 17 years old or younger, those with cerebral palsy or arthrogryposis, and those who had a procedure defined as a release within the first 60 days from their injury admission were excluded. Exclusion designations were determined by analysis of the ICD-9 codes present in each of the patient's records. We limited inclusion to New York State residents based on zip code because nonresidents were less likely to return to a New York State hospital for follow-up care.

The surgical diagnosis for each patient was determined through the diagnosis codes used for the index admission (Appendix B; available on the *Journal's* Web site at [www.jhandsurg.org](http://www.jhandsurg.org)). Patient age, sex, year of surgery, and comorbid conditions defined by the Deyo modification of the Charlson Comorbidity Index were identified for each patient.<sup>15</sup> We also determined whether a patient had a hospital admission with a diagnosis of a head injury, thermal burn, or diabetes. Finally, we calculated the time to contracture release or end of follow-up for each patient.

Owing to the administrative nature of the database, information was not available about the mechanism of injury or the duration of symptoms. Furthermore, the performance of a contracture release was used as a surrogate for the clinical diagnosis of a contracture. Because individual outpatient medical records were not reviewed as a part of this study, contracture release was the only means we had to identify the presence of a contracture.

We used ICD-9 diagnosis and treatment codes for elbow trauma to determine the nature of the injuries. All elbow trauma ICD-9 diagnosis codes were grouped into 3 categories of severity as defined by the authors (Appendix B; available on the *Journal's* Web site at [www.jhandsurg.org](http://www.jhandsurg.org)). For example, open fractures, dislocations, and involvement of both radius and ulna or both humeral condyles were considered more severe than those injuries involving a single articular surface, an absence of a dislocation, or a closed injury.

The coding for elbow pathology via the ICD-9 system was specific. Thus, for the vast majority of patients, we were able to report on the presence of articular involvement, open injuries, dislocations, fractures with dislocation, and which anatomical sites were injured. In a minority of patients (34%), the injuries were coded with less specific codes, and we were, therefore, unable to report on the articular involvement.

In order to analyze the contribution of different primary treatments on contracture development and the need for subsequent release, we also assigned the surgical procedures used to treat these traumatic elbow

conditions into 3 categories of severity (Appendix C; available on the *Journal's* Web site at [www.jhandsurg.org](http://www.jhandsurg.org)). These assignments were based on the language used to define the codes. Finally, the use of hardware for internal fixation and number of surgical admissions before contracture release were identified for each patient.

Finally, we reviewed the data on the surgical facilities and the surgeons who performed the treatment of the initial trauma as well as the subsequent contracture release. Data were broken into quartiles for reporting purposes to account for surgeons and facilities that handle a larger volume of either trauma or releases. In addition, the distance traveled from a patient's home zip code to the treating facility's zip code was calculated. The distances traveled were calculated using the Google maps algorithm so as to best represent time traveled by the patient seeking care.

### Statistical methods

Descriptive statistics were calculated for all variables of interest. Means, medians, SDs, and ranges were used for continuous variables, and frequencies and percentages were used for categorical variables. Univariate analyses including *t*-tests and chi-square tests were used to determine which predictors would be used to construct a multivariable logistic regression model for risk factors for subsequent contracture release. Significance level was set to  $P = .05$ .

### RESULTS

There were 32,708 patients with an elbow fracture diagnosis initially treated with surgery. Nearly 13,000 were excluded because the patients were 17 years old or younger. Two patients were excluded because they had a contracture release performed at the time of initial fracture fixation. Nearly 800 of the patients were non-New York residents and were thus excluded. Twenty-seven had a diagnosis of cerebral palsy and 1 had a diagnosis of arthrogryposis and were, therefore, excluded. Two patients had had a prior contracture release, and 6 had a contracture release in the first 60 days after index treatment and were, thus, also excluded.

After exclusion criteria were applied, 19,063 patients remained in the analyzable cohort of surgically managed traumatic elbow injuries from 1997 to 2009, of which 270 patients underwent a subsequent contracture release. This represents a 1.4% rate of contracture release after surgical treatment for elbow trauma. The median time from index fracture treatment to contracture release was 7 months (range, 2 mo to 10 y). Additional data were available on patients without ob-

serving a contracture release for a median of 7.1 years (range, 1–14 y).

The mean age for patients undergoing contracture release was 43 years versus 56 years for noncontracture patients ( $P < .001$ ) (Table 1). Contracture release patients were more often male (57% [154/270] vs 42% males in the noncontracture group;  $P < .001$ ). Concomitant head injuries were seen in 4.4% (12/270) of the contracture release group and 3.7% (692/18,793) of the noncontracture group ( $P = .59$ ). Burns were noted in a higher proportion of patients with contracture release (4.4% [12/270] vs 0.2% [34/18,793];  $P < .001$ ), and there was a trend toward decreased prevalence of diabetes (6.3% [17/270] vs 9.8% [1851/18,793];  $P = .051$ ).

Contracture release patients were more likely to have had 2 or more admissions for surgical treatment of an elbow injury during the surveillance period before development of a contracture (6% [17/270] vs 2% [304/18,793];  $P < .001$ ) (Table 2). In addition, contracture release patients had a higher proportion of severe injuries as indicated by the diagnosis codes (11% [30/270] vs 5% [967/18,793];  $P < .001$ ). Initial diagnoses of open fractures (17% [46/270] vs 11% [2002/18,793];  $P < .001$ ) were more common in the contracture group.

Using a multivariate logistic regression model, the observation of a burn was the strongest predictor of future contracture release (Table 3). Patients with burns were 16 (95% confidence interval [CI], 7.3–33.6) times more likely to undergo a contracture release compared with those who were not diagnosed with a burn. Multiple admissions for fracture treatment resulted in a 2.9-fold (95% CI, 1.6–5.2) increase in the rate of contracture release. Patients undergoing a procedure classified as severe had a 2.2-fold (95% CI, 1.0–4.7) greater chance of undergoing a contracture release compared with patients undergoing less severe procedures. Patients with an elbow injury classified as severe by diagnosis code had a 1.5-fold (95% CI, 1.0–2.3) greater chance of contracture release.

The use of internal fixation at the time of initial treatment had a protective effect against later contracture release. Patients with internal fixation had a 0.4 odds ratio (OR) for undergoing a later contracture release (95% CI, 0.2–0.7). Age also had a protective effect on against undergoing a later contracture release because patients who were older at the time of injury were less likely to undergo a release (OR, 0.97; 95% CI, 0.97–0.98).

A total of 2230 different surgeons performed the 19,063 surgical cases in 246 separate surgical facilities within New York State over this 12-year

**TABLE 1. Summary of Patient Demographics Requiring a Contracture Release Following Surgically Treated Elbow Trauma**

	Surgically Treated Contracture		No Surgically Treated Contracture		Total	P
	n	%	n	%		
Mean age (at first fracture)	270	1.4	18,793	98.6	19,063	
	43.4 (range, 18–83)		56.1 (range, 18–104)			<b>&lt; .001</b>
Sex						
Male	154	57	7926	42		<b>&lt; .001</b>
Female	116	43	10,867	58		
Charlson-Deyo Comorbidity Score						
0	238	88	14,464	77		<b>&lt; .001</b>
1	23	9	3120	17		
2	5	2	711	4		
3	1	0	198	1		
4+	3	1	300	2		
Diabetes at time of first fracture	17	6.3	1851	9.8		.051
Head injury at time of first fracture	12	4.4	692	3.7		.59
Burn diagnosed at first fracture to end follow-up	12	4.4	34	0.2		<b>&lt; .001</b>
Median time between first fracture procedure and first contracture procedure and diagnosis	7 mo (range, 2 mo to 10 y)					
Median time between first fracture procedure and end of follow-up evaluation for patients without contracture			7.1 y (range, 1–14 y)			

Bold denotes significance or near significance ( $P < .05$ ).

period (Table 4). On average, these surgeons treated fewer than 1 traumatic elbow case surgically each year, with the majority of patients being treated at hospitals near their homes.

In contrast, 99 surgeons performed the 270 contracture releases. Over half of these patients had their elbow contracture release by a different surgeon than the one who performed their index elbow procedure. Despite this, only about one third of the patients undergoing their release traveled farther than the distance to the institution that treated them initially, indicating that most of the patients remained near their primary treating facility regardless of who performed their second surgery.

## DISCUSSION

The frequency and risk factors for the development of post-traumatic elbow contractures are poorly understood. This study provides information regarding the epidemiology of post-traumatic elbow contractures that were treated with a surgical release. Our results showed

that, from 1997 to 2009, the overall rate of surgically treated elbow contractures was 1.4% after traumas initially managed surgically.

The study design allows follow-up of individual patients treated by any physician in New York State. This study stands out from other reports because there was no surgeon bias. The SPARCS database is funded, administered, and maintained by New York State and participation is compulsory for all hospitals and surgery centers. This allowed for an accurate calculation of the incidence of surgically treated elbow contractures.

From the regression analysis of this large sample of contractures, we were able to confirm that the severity of the initial trauma and of the surgical procedure used to address the injury were influential factors in the development of a surgically treated contracture. However, the occurrence of a burn was the most influential event that could lead to a later contracture release. Severity of the injury and treatment, patient age, and number of admissions all influenced the development of contracture needing release.

**TABLE 2. Independent Factors Affecting the Rate of Elbow Contracture**

	Contracture		No Contracture		P
	n	%	n	%	
Number of fracture admissions (before contracture if patient had contracture)					
1	253	94	18,489	98	< .001
2 or 3	17	6	304	2	
Procedure Characteristics					
Severity level of procedure					
Severe	261	96	18,037	95	.08
Moderate	2	1	466	3	
Mild	7	3	290	2	
Internal fixation	251	93	18,164	97	< .001
Diagnosis characteristics					
Severity level of diagnosis					
Severe	30	11	967	5	< .001
Moderate	63	23	4,874	26	
Mild	177	66	12,952	69	
Diagnosis intra- vs extra-articular					
Intra	121	74	9,377	76	.52
Extra	43	26	2,977	24	
Diagnosis open vs closed					
Open	46	17	2,002	11	< .001
Closed	224	83	16,791	89	
Diagnosis dislocation vs fracture					
Fracture	254	94	17,476	93	.22
Dislocation	8	3	394	2	
Dislocation + fracture	8	3	923	5	
Bold denotes significance or near significance (P < .05).					

Bold denotes significance or near significance ( $P < .05$ ).

**TABLE 3. Multivariate Regression Analysis of Predictors of Elbow Contracture**

Variable	OR	Lower CL	Upper CL	<i>P</i>
Age	0.97	0.97	0.98	<b>&lt; .001</b>
Sex	1.09	0.83	1.42	.55
Burn	15.67	7.31	33.61	<b>&lt; .001</b>
Multiple fracture admissions	2.87	1.58	5.21	<b>&lt; .001</b>
Severe procedure vs moderate/mild	2.21	1.03	4.73	.04
Internal fixation	0.40	0.24	0.69	<b>&lt; .001</b>
Diagnosis severe vs moderate/mild	1.52	1.02	2.27	.04

CL, confidence limit; OR, odds ratio.

Although male sex was associated with subsequent contracture release in the univariate analysis, it was not an independent risk factor in the multivariate regression

analysis. Decreased patient age was identified a risk factor for contracture release in both univariate and multivariate analyses. Although we do not have epi-

**TABLE 4. Hospital and Surgeon Data for Initial Trauma Treatment and Contracture Release**

Fracture Treatment	Count of Unique Providers	Mean Number of Cases Treated	Minimum Number of Cases Treated	25th % Quartile	Median Number of Cases Treated	75th % Quartile	Maximum Number of Cases Treated
Hospital/facilities	246	77.5	1	14	44	98	527
Treating surgeon	2,230	8.5	1	1	3	10	230
		Mean	Minimum	25th % Quartile	Median	75th % Quartile	Maximum
Distance traveled to facility, km (mi)	n = 17,635	15.9 (9.9)	0	3.2 (2)	9.7 (6)	19.3 (12)	491 (305)
Contracture Treatment	Count of Unique Providers	Mean Number of Cases Treated	Minimum Number of Cases Treated	25th % Quartile	Median Number of Cases Treated	75th % Quartile	Maximum Number of Cases Treated
Hospital/facilities	63	4.3	1	1	1	3	66
Treating surgeon	99	2.7	1	1	1	2	41
		Mean	Minimum	25th % Quartile	Median	75th % Quartile	Maximum
Distance from patient zip code to hospital zip code, km (mi) (n = 242)		31.7 (19.7)	0	8 (5)	21 (13)	40 (25)	238 (148)
Change in distance traveled (n = 229)		8.9 (5.5)	-27 (-17)	0	0	10 (6)	208 (129)
Number of patients traveling farther for contracture admission (n = 77)		34%					
Patients who changed treating facility (n = 243)	112	46%					
Patients who changed surgeon for treatment of contracture (n = 243)	133	55%					



miological data on contracture development to explain the difference, it is possible that younger patients were more frequently offered surgical management or that they were less tolerant of functional limitations. It is unknown why internal fixation was protective against subsequent contracture release. One possible explanation is that internal fixation allowed for earlier range of motion and more aggressive therapy, but the database used did not provide access to that information.

The incidence of contractures needing surgical release was low compared with our personal experience and that which has been published previously.<sup>2,8-14</sup> These previous reports have shown an incidence of elbow contracture between 3% and 20% following elbow trauma.<sup>2,8-14</sup> This could be for several reasons. The data in the set identified patients with surgically treated elbow trauma and subsequent contracture release and not all clinically observed contractures. Patients who left the state during the study period or sought treatment outside the state may not have been accurately captured as having a contracture. Patients who developed a contracture and did not want or were not offered a contracture release were not captured.

There is a degree of geographic variability in access to this procedure. Nearly one quarter of all of the contracture releases performed in this cohort were treated in a single institution. Further, only one fourth of the hospitals at which the initial surgery was performed also performed the follow-up contracture release. Because patients stayed within a radius of 20 miles of their home for their elbow care, many patients may not live within a region where the procedure is performed and, therefore, may not have access to it. This regional heterogeneity may be the best explanation of the relatively low observed rate of contracture release. Patients in some areas simply might not have access to care and, thus, did not get the treatment that could result in better outcomes after elbow trauma.

The data came from an administrative database, which was an inherent weakness. We did not have access to any clinical data available for these patients, such as the mechanism of injury for trauma cases or the range of motion of the patients at any stage of their treatment. Because the ability to function with a stiff elbow is dependent on many patient-specific factors, only one of them being range of motion, we feel that the choice to have a subsequent operation for stiffness was a suitable surrogate for severe disabling contracture.<sup>18</sup> The incidence of mild post-traumatic stiffness is clearly much higher. In addition, our methodology limited our accuracy of appropriately identifying diagnoses and

treatments to the accuracy of the diagnosis and treatment codes used.

We have shown that burns, the severity of the injury, the need to have more invasive procedures, and multiple admissions were the strongest predictors of developing a contracture requiring surgical release. High-grade loss of elbow motion after trauma is a complex problem that occurs with relative infrequency, making it difficult to be studied by any single surgeon or institution without a large upper extremity referral base. Our results may be useful in preoperative discussions with patients undergoing initial surgical treatment for elbow trauma.

## REFERENCES

1. Lindenhovius AL, Jupiter JB. The posttraumatic stiff elbow: a review of the literature. *J Hand Surg Am.* 2007;32(10):1605-1623.
2. Evans PJ, Nandi S, Maschke S, Hoyer HA, Lawton JN. Prevention and treatment of elbow stiffness. *J Hand Surg Am.* 2009;34(4):769-778.
3. Morrey BF, Askew LJ, Chao EY. A biomechanical study of normal functional elbow motion. *J Bone Joint Surg Am.* 1981;63(6):872-877.
4. Morrey BF. *The elbow and its disorders.* 3rd ed. Philadelphia: WB Saunders; 2000.
5. King GJ, Faber KJ. Posttraumatic elbow stiffness. *Orthop Clin North Am.* 2000;31:129-143.
6. Sardelli M, Tashjian RZ, MacWilliams BA. Functional elbow range of motion for contemporary tasks. *J Bone Joint Surg Am.* 2011;93(5):471-477.
7. Tan V, Daluiski A, Simic P, Hotchkiss RN. Outcome of open release for post-traumatic elbow stiffness. *J Trauma.* 2006;61(3):673-678.
8. Myden C, Hildebrand K. Elbow joint contracture after traumatic injury. *J Shoulder Elbow Surg.* 2011;20(1):39-44.
9. Forthman C, Henket M, Ring DC. Elbow dislocation with intra-articular fracture: the results of operative treatment without repair of the medial collateral ligament. *J Hand Surg Am.* 2007;32(8):1200-1209.
10. Doornberg JN, Parisien R, van Duijn PJ, Ring D. Radial head arthroplasty with a modular metal spacer to treat acute traumatic elbow instability. *J Bone Joint Surg Am.* 2007;89(5):1075-1080.
11. Mohan K. Myositis ossificans traumatica of the elbow. *Int Surg.* 1972;57(6):475-478.
12. Mehlhoff TL, Noble PC, Bennett JB, Tullos HS. Simple dislocation of the elbow in the adult. Results after closed treatment. *J Bone Joint Surg Am.* 1988;70(2):244-249.
13. Thompson HC III, Garcia A. Myositis ossificans: aftermath of elbow injuries. *Clin Orthop Relat Res.* 1967;50:129-134.
14. Roberts PH. Dislocation of the elbow. *Br J Surg.* 1969;56(11):806-815.
15. Ghali WA, Hall RE, Rosen AK, Ash AS, Moskowitz MA. Searching for an improved clinical comorbidity index for use with ICD-9-CM administrative data. *J Clin Epidemiol.* 1996;49(3):273-278.
16. Lyman S, Jones EC, Bach PB, Peterson MG, Marx RG. The association between hospital volume and total shoulder arthroplasty outcomes. *Clin Orthop Relat Res.* 2005;432:132-137.
17. Lyman S, Koulouvaris P, Sherman S, Do H, Mandl LA, Marx RG. Epidemiology of anterior cruciate ligament reconstruction: trends, readmissions, and subsequent knee surgery. *J Bone Joint Surg Am.* 2009;91(10):2321-2328.
18. Lindenhovius AL, Doornberg JN, Ring D, Jupiter JB. Health status after open elbow contracture release. *J Bone Joint Surg Am.* 2010;92(12):2187-2195.

**APPENDIX A. ICD-9 and CPT Procedure Codes for Contracture Release With ICD-9 Diagnosis Codes for Defining Presence of Contracture**

ICD-9 Code	Description
80.42	Division of joint capsule, ligament, or cartilage of elbow
CPT Code	Description
29835	Arthroscopy, elbow, surgical; synovectomy, partial
29836	Arthroscopy, elbow, surgical; synovectomy, complete
29837	Arthroscopy, elbow, surgical; debridement, limited
29838	Arthroscopy, elbow, surgical; debridement, extensive
24149	Radical resection of capsule, soft tissue, and heterotopic bone, elbow, with contracture release (separate procedure)
24006	Arthrotomy of the elbow, with capsular excision for capsular release (separate procedure)
ICD-9 Diagnosis Code	Description
718.42	Contracture of upper arm joint
718.43	Contracture of forearm joint
718.52	Ankylosis of upper arm joint
718.53	Ankylosis of forearm joint
719.52	Stiffness of joint not elsewhere classified, upper arm
719.53	Stiffness of joint not elsewhere classified, forearm

CPT, Current Procedural Code; ICD-9, International Classification of Diseases, 9th edition.



## APPENDIX B. Severity of Diagnoses (at Index Procedure)

Code	Description	Severity	Dislocation	Open/ Closed	Intra-articular/ Extra-articular
812.51	Supracondylar fracture of humerus open	Severe	N	Open	Extra-articular
812.52	Fracture of lateral condyle of humerus open	Severe	N	Open	Intra-articular
812.53	Fracture of medial condyle of humerus open	Severe	N	Open	Intra-articular
812.54	Fracture of medial condyle of humerus open	Severe	N	Open	Intra-articular
812.59	Other fracture of lower end of humerus open	Severe	N	Open	
813.12	Fracture of coronoid process of ulna open	Severe	N	Open	Intra-articular
813.13	Monteggia fracture open	Severe	Y	Open	Extra-articular
813.18	Fracture of radius with ulna upper end (any part) open	Severe	N	Open	
832.11	Open anterior dislocation of elbow	Severe	Y	Open	
832.12	Open posterior dislocation of elbow	Severe	Y	Open	
832.13	Open medial dislocation of elbow	Severe	Y	Open	
832.14	Open lateral dislocation of elbow	Severe	Y	Open	
832.19	Open dislocation of other site of elbow	Severe	Y	Open	
718.22	Pathological dislocation of upper arm joint—dislocation or displacement of joint, not recurrent and not current injury; spontaneous dislocation (joint); elbow joint; humerus	Moderate	Y	Closed	
718.32	Recurrent dislocation of upper arm joint elbow joint; humerus	Moderate	Y	Closed	
812.41	Supracondylar fracture of humerus closed	Moderate	N	Closed	Extra-articular
812.44	Fracture of unspecified condyle(s) of humerus closed	Moderate	N	Closed	Intra-articular
812.50	Fracture of unspecified part of lower end of humerus open	Moderate	N	Open	
813.03	Monteggia fracture closed	Moderate	Y	Closed	Extra-articular
813.08	Fracture of radius with ulna upper end (any part) closed	Moderate	N	Closed	
813.10	Open fracture of upper end of forearm unspecified	Moderate	N	Open	
813.11	Fracture of olecranon process of ulna open	Moderate	N	Open	Intra-articular
813.14	Other and unspecified open fractures of proximal end of ulna	Moderate	N	Closed	
813.15	Fracture of head of radius open	Moderate	N	Open	Intra-articular
813.16	Fracture of neck of radius open	Moderate	N	Open	Extra-articular
813.17	Other and unspecified open fractures of proximal end of radius	Moderate	N	Open	
832.00	Closed dislocation of elbow unspecified site	Moderate	Y	Closed	
832.01	Closed anterior dislocation of elbow	Moderate	Y	Closed	
832.02	Closed posterior dislocation of elbow	Moderate	Y	Closed	
832.03	Closed medial dislocation of elbow	Moderate	Y	Closed	
832.04	Closed lateral dislocation of elbow	Moderate	Y	Closed	
832.09	Closed dislocation of other site of elbow	Moderate	Y	Closed	
812.40	Fracture of unspecified part of lower end of humerus closed	Mild	N	Closed	
812.42	Fracture of lateral condyle of humerus closed	Mild	N	Closed	Intra-articular
812.43	Fracture of medial condyle of humerus closed	Mild	N	Closed	Intra-articular
812.49	Other closed fractures of lower end of humerus	Mild	N	Closed	
813.00	Closed fracture of upper end of forearm unspecified	Mild	N	Closed	
813.01	Fracture of olecranon process of ulna closed	Mild	N	Closed	Intra-articular
813.02	Fracture of coronoid process of ulna closed	Mild	N	Closed	Intra-articular
813.04	Other and unspecified closed fractures of proximal end of ulna	Mild	N	Closed	
813.05	Fracture of head of radius closed	Mild	N	Closed	Intra-articular
813.06	Fracture of neck of radius closed	Mild	N	Closed	Extra-articular
813.07	Other and unspecified closed fractures of proximal end of radius	Mild	N	Closed	

**APPENDIX C. ICD-9 Treatment Codes for Elbow Trauma (at Index Procedure) and Authors' Associated Severity Rating**

Code	Description	Severity Level	Internal Fixation
79.11	Closed reduction of fracture with internal fixation of humerus	Moderate	Y
79.12	Closed reduction of fracture with internal fixation of radius-ulna	Moderate	Y
79.21	Open reduction of fracture without internal fixation of humerus	Mild	N
79.22	Open reduction of fracture without internal fixation of radius-ulna	Mild	N
79.31	Open reduction of fracture with internal fixation of humerus	Severe	Y
79.32	Open reduction of fracture with internal fixation of radius-ulna	Severe	Y
79.81	Open reduction of dislocation of humerus	Moderate	N
79.82	Open reduction of dislocation of humerus radius-ulna	Severe	N

ICD-9, International Classification of Diseases, 9th edition.