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Elbow contracture following operative fixation of fractures about the elbow

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Background: The rates of elbow contracture and contracture release after surgically treated elbow trauma are poorly defined. The purpose of this study was to define the incidence of elbow contracture diagnosis and release after surgical treatment for elbow trauma.

Methods: The Humana insurance database was queried using the PearlDiver Patient Records Database between 2007 and 2017. Subjects were identified using International Classification of Diseases (ICD) codes in combination with Current Procedural Terminology codes and were included if they had a minimum of 1-year follow-up. Qualifying operative elbow trauma patients were queried for development of postoperative elbow contracture. Patient demographic characteristics, risk factors for elbow stiffness, and use of postoperative anticoagulation were recorded. Fracture severity was classified based on ICD-9 and ICD-10 codes. Logistic multivariate analysis was performed to determine independent risk factors for postoperative elbow contracture.

Results: The study population included 10,672 patients who were surgically treated for elbow trauma. In total, 902 patients (8.4%) were diagnosed with a contracture following fracture. Of patients with a diagnosis of elbow contracture, 65 patients (7.2%) underwent contracture release. On average, time to contracture diagnosis was 3.6 months (SD 7 months) and time to contracture release was 8.4 months (SD 3.6 months). The use of postoperative anticoagulation, burn or head injury at the time of fracture, male sex, obesity, opioid use, and moderate or severe fracture severity were significantly associated with progression to elbow contracture.

Conclusion: The development of elbow contracture after surgical treatment of elbow trauma has a relatively high incidence of 8.4%.

Elbow contracture is a known complication after elbow trauma and can result from a range of injuries including fracture, dislocation, soft tissue injury, and burns. Morrey postulated that the elbow is especially vulnerable to development of contracture because of its complex articular anatomy characterized by a high degree of congruency.[13] Although directed occupational therapy and progressive early range of motion after any elbow injury can help minimize risk of contracture, a subset of patients are still plagued by decreased range of motion in spite of these modalities.[2,10]

Post-traumatic contracture leads to decreased elbow range of motion and can result in functional impairment, restricting activities in daily life and ability to participate in preinjury profession.[3,12] It has been demonstrated that functional elbow range of motion requires an arc of motion of roughly 30°-130° for activities of daily living such as hygiene and self-care.[14,18] In spite of the debilitating nature of the deficits associated with decreased elbow range of motion, rates of contracture are still not well established.

Previous literature reports varying rates of elbow contracture after trauma based on studies of small cohorts of patients, which range between rates of roughly 3% and 20%.[7,8,15-17] To address the difficulty of identifying a large numbers of patients within a single center, Schrumpf et al performed an epidemiologic review of the New York SPARCS database to identify patients with elbow trauma. This study demonstrated that 270 of 19,063 patients (1.4%) underwent surgical intervention for postoperative elbow contracture,[19] which represented an incidence lower than previously shown. They also determined that risk factors for contracture release in the New York State population included severity of fracture pattern, male sex, younger age, burn, head injuries, and

This study was approved by the Hospital for Special Surgery Institutional Review Board: Study no. 2019-0278, "Utilization of Pearl Diver Database for Analysis of Outcomes and Postoperative Complications Following Hand and Elbow Surgery."

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increased number of hospital admissions. The study additionally noted a protective effect of diabetes against contracture release.

Other investigations of outcomes after elbow trauma have studied similar risk factors, given their established associations to postoperative elbow stiffness[1,8,12]; however, recent data from other subspecialties have identified additional factors' impacts on postoperative stiffness. Recently, the correlation between anticoagulant usage and postoperative arthrofibrosis in the knee joint after total knee arthroplasty has become a topic of interest.[4,9,21,22] In the arthroplasty literature, patients treated with perioperative anticoagulation had an increased likelihood of developing postoperative stiffness. Additionally, recent studies have demonstrated an association between increased opioid use and poorer functional outcomes after musculoskeletal surgery.[11,24] However, no study has yet specifically examined the relationship between anticoagulant or opioid usage and contracture following surgical treatment of elbow trauma.

In this study, we aimed to establish the incidence of contracture development following surgical treatment of elbow trauma using a national database. Our secondary aims were (1) to confirm previously published rates of contracture release and (2) to determine whether anticoagulant use following surgical treatment of elbow trauma is associated with an increased risk of contracture and contracture release.

Materials and methods

Data were collected from the Humana insurance database using the PearlDiver Patient Records Database (www.pearldiverinc.com) from 2007 to 2017. The PearlDiver database contains records for more than 22 million patients, further describing hospital and physician billing records, as well as prescription medication information. Subjects were identified using Current Procedural Terminology and International Classification of Diseases (ICD) codes.

Patients were first identified by fracture diagnosis consistent with an elbow trauma using ICD-9 and ICD-10 coding and were subsequently queried to have a concurrent procedure code indicative of surgical treatment of elbow trauma to establish a cohort of patients who experience elbow trauma managed by surgical intervention (Supplementary Appendix S1). Patients were included if they had a minimum of 1-year follow-up and if they were aged ≥18 years. Lastly, a 1-year postoperative time follow-up period was used to identify patients who developed postoperative elbow contracture or had undergone contracture release based on ICD and Current Procedural Terminology coding (Supplementary Appendix S1). Patients who underwent contracture release within 60 days of fracture surgery were excluded to minimize potential billing error. The population was also examined for rates of heterotopic ossification as well as for manipulation under anesthesia.

Patient demographic characteristics including age, sex, and medical comorbidities defined previously by the Deyo modification of the Charlson Comorbidity Index (CCI) were collected.[5,19-21,23] In addition, previously identified risk factors for elbow stiffness were collected, including history of diabetes mellitus, diagnosis of a head injury, or thermal burn at time of contracture.

Fracture severity was determined based on fracture diagnosis codes. Fracture severity was categorized as mild, moderate, or severe based on prior classification conducted by Schrumpf et al[19] (Table I). If a patient had numerous fractures, the fracture was classified as according to the most severe injury pattern. Finally, time from elbow trauma and surgical intervention to elbow contracture was calculated.

Lastly, anticoagulant and opioid use following fracture surgery was taken into consideration for the analysis, given their association to development of postoperative joint contractures.[9,11,24] Opioids that were accounted for in this analysis include oxycodone, hydrocodone, morphine sulfate, codeine, fentanyl, hydromorphone, meperidine, methadone hydrochloride and oxymorphone. History of anticoagulant use was determined by the presence of a filled prescription for an anticoagulant medication within 1 year of the postoperative period following surgical intervention of the elbow trauma. Anticoagulants included in this analysis were warfarin, aspirin, low-molecular-weight heparin, direct factor Xa inhibitors, and fondaparinux. Aspirin use could only be tracked for patients who had fulfilled a prescription to obtain the medication, as aspirin obtained over the counter does not create an insurance record claim and is not contained in this database.

Statistical analysis

Data on patients' demographics, comorbidities, fracture severity, medication history, and postoperative complication were analyzed with univariate and multivariate analyses using software provided by PearlDiver. Analysis was first conducted on development of elbow contracture. Subsequent analysis was conducted on contracture release. Univariate analysis was conducted with chi-square tests or analysis of variance, where appropriate. A logistic multivariate analysis was performed to determine independent associations of risk factors of the postoperative contracture or contracture release. The multivariate analysis results were reported as odds ratios (ORs) and 95% confidence intervals. A P value of $<.05$ was used as the cutoff for significance. Age between 30 and 49 years, CCI of 0, and female sex were considered as controls for multivariate analysis. These groups were chosen as control references in our model, given that they are classically believed to be the lowest risk with regard to the development of elbow contracture.

Results

In total, 10,672 patients were identified with surgically treated elbow trauma. Of those, 902 (8.4%) patients developed subsequent elbow contracture within 1 year from surgery. Among patients who developed an elbow contracture, 65 (7.2%) underwent an elbow contracture release. Of the total population, 0.6% of patients underwent contracture release.

Elbow contracture in 902 patients was diagnosed at a mean of 3.6 months after initial injury (SD 7 months). Of the 902 identified elbow contracture patients, 65 progressed to surgical contracture release at an average of 7 months after initial injury (SD 3.6 months, range 2-12 months). Of note, 4% (267/6915) of patients with a mild fracture pattern, 14% (455/3307) of patients with a moderate fracture pattern, and 18% (81/450) of patients with a severe fracture pattern progressed to contracture diagnosis.

Demographic associations demonstrated risk factors for the development of elbow contracture after surgically treated elbow fracture. Associations included age, sex, CCI, diabetes mellitus, obesity, head injury at the time of fracture, fracture severity, and postoperative anticoagulation or opioid use (Table II). Independent associations were then modeled with multivariate analysis, and the use of postoperative anticoagulation (OR 1.19), burn at the time of fracture (OR 3.01), head injury at the time of fracture (OR 1.19), male sex (OR 1.17), obesity (OR 1.83), opioid use (OR 1.08), and moderate (OR 2.23) or severe (OR 1.10) fracture severity were significantly associated with progression to elbow contracture (Table III). Diabetes mellitus, CCI greater than 0, and age <30 or >50 years were protective against the development of elbow contracture. Numbers of patients with heterotopic ossification and who underwent manipulation under anesthesia were too low for reporting based on PearlDiver guidelines.

Table I
Classification of fracture severity based on diagnosis

Category	Codes
Elbow trauma diagnosis—mild	Fracture of unspecified part of lower end of humerus closed
	Fracture of lateral condyle of humerus closed
	Fracture of medial condyle of humerus closed
	Other closed fractures of lower end of humerus
	Closed fracture of upper end of forearm unspecified
	Fracture of olecranon process of ulna closed
	Fracture of coronoid process of ulna closed
	Other and unspecified closed fractures of proximal end of ulna
	Fracture of head of radius closed
	Fracture of neck of radius closed
	Other and unspecified closed fractures of proximal end of radius
Elbow trauma diagnosis—moderate	Pathological dislocation of upper arm joint—dislocation or displacement of joint, not recurrent and not current injury; spontaneous dislocation (joint); elbow joint; humerus
	Recurrent dislocation of upper arm joint elbow joint; humerus
	Supracondylar fracture of humerus closed
	Fracture of unspecified condyle(s) of humerus closed
	Fracture of unspecified part of lower end of humerus open
	Monteggia fracture closed
	Fracture of radius with ulna upper end (any part) closed
	Open fracture of upper end of forearm unspecified
	Fracture of olecranon process of ulna open
	Other and unspecified open fractures of proximal end of ulna
	Fracture of head of radius open
	Fracture of neck of radius open
	Other and unspecified open fractures of proximal end of radius
	Closed dislocation of elbow unspecified site
	Closed anterior dislocation of elbow
	Closed posterior dislocation of elbow
	Closed medial dislocation of elbow
	Closed lateral dislocation of elbow
	Closed dislocation of other site of elbow
Elbow trauma diagnosis—severe	Supracondylar fracture of humerus open
	Fracture of lateral condyle of humerus open
	Fracture of medial condyle of humerus open
	Fracture of medial condyle of humerus open
	Other fracture of lower end of humerus open
	Fracture of coronoid process of ulna open
	Monteggia fracture open
	Fracture of radius with ulna upper end (any part) open
	Open anterior dislocation of elbow
	Open posterior dislocation of elbow
	Open medial dislocation of elbow
	Open lateral dislocation of elbow
	Open dislocation of other site of elbow

Discussion

Our study of surgically treated fractures about the elbow revealed an 8.4% incidence of postoperative elbow contracture diagnosed within 1 year postoperatively and an overall rate of contracture release of 7.2% among these patients. These numbers provide important information regarding the epidemiology of post-traumatic elbow contracture development and release after surgical treatment of elbow trauma. Our study design allows follow-up of individual patients within a large insurance database and thus eliminates surgeon bias, allowing for an accurate assessment of the incidence of contracture diagnosis and surgical release.

Of our total population, the rate of contracture release after surgical treatment of elbow trauma was 0.6%. This importantly supports the data obtained from the SPARCS database, demonstrating an overall contracture release incidence of 1.4% after surgical intervention for elbow trauma.[1] Our study also provides insight into the rate of contracture development that does not progress to surgical release. Our data are consistent with rates of post-traumatic contracture development reported in previous data sets, ranging from 3% to 20%.[7,8,15-17] In contrast, that reported by Schrumpf et al is likely low because of identification of contracture patients by Current Procedural Terminology code for progression to contracture release.[19] Taken together, these administrative data sets represent important benchmarks from which orthopedic surgeons may provide anticipatory guidance to their patients prior to surgical treatment for elbow trauma.

Additionally, our data confirm low rates of surgical contracture release established by Schrumpf. We believe that these rates are low even among those who develop an elbow contracture, as these are not commonly performed procedures, and commonly physicians who are comfortable in performing elbow fracture fixation may not have the same comfort to perform contracture release. Additionally, we believe that these procedures may be too high risk in a high comorbidity population. However, our sample size was too small to perform subgroup analysis on the contracture release population.

Most prior studies on the topic of elbow contracture have been performed through the retrospective review of small cohorts of patients who have developed the complication rather than through the prospective study of a population with injuries that place them at risk for contracture. Given the limitations of such retrospective analysis, prior studies have neither been able to reach conclusions about the incidence of this complication nor of risk factors predisposing patients to development of the complication. Here we utilize a prospectively collected administrative database to identify

Table II
Risk factors for the development of elbow contracture

Category	Total fracture patients, n (%) (n = 10,672)	Total contracture patients, n (%) (n = 902)	*P* value*
Anticoagulants	1640 (15.37)	197 (21.84)	**.02**
Age, yr			**<.001**
18-30	525 (4.92)	45 (4.99)	
31-49	1106 (10.36)	125 (13.86)	
50-69	3895 (36.50)	361 (40.02)	
70+	5146 (48.22)	371 (41.13)	
Sex			**<.001**
Male	3796 (35.57)	258 (28.60)	
Female	6876 (64.43)	644 (71.40)	
CCI			**<.001**
0	3907 (36.61)	385 (42.68)	
1	1969 (18.45)	180 (19.96)	
2	1283 (12.02)	111 (12.31)	
3	960 (9.00)	77 (8.54)	
4	683 (6.40)	39 (4.32)	
≥5+	1870 (17.52)	110 (12.20)	
Burn at time of fracture to follow-up	32 (0.30)	<11 (1.00)	.07
Head injury at the time of fracture	312 (2.92)	25 (2.77)	**.034**
Diabetes mellitus	1319 (12.36)	126 (13.97)	**.023**
Obesity	339 (3.18)	52 (5.76)	**<.001**
Opioid usage	4769 (44.69)	666 (73.84)	**<.001**
Fracture severity			**<.001**
Mild	6915 (64.80)	267 (29.60)	
Moderate	3307 (30.99)	455 (50.44)	
Severe	450 (4.22)	81 (8.98)	

* Boldface indicates significance.

a group of patients who have undergone surgery for elbow fracture and, from this group, identified the patients who developed subsequent contracture. In utilizing these prospectively collected data, we can identify both incidence of and risk factors for this complication from a generalizable group of elbow fracture patients. We can then analyze these longitudinally collected data in a retrospective fashion.

Our findings confirm those cited in prior literature, demonstrating an increased risk of contracture development in the setting of burn, head injury, male sex, obesity, and fracture severity as well as the protective effect of diabetes. Additionally, our data further add to the growing body of literature identifying the contribution of anticoagulation and opioids to the development of joint contracture after surgery.[9,11,21,24] Additionally, like Schrumpf et al, we found that burn at the time of injury was the most influential risk factor for contracture development (OR 3.01).

Table III
Multivariate analysis of risk factors for elbow contracture following surgical fixation

Category	OR (95% CI)	*P* value*
Anticoagulant	1.191 (1.130, 1.254)	**<.001**
CCI		
1	0.806 (0.766, 0.849)	**<.001**
2	0.781 (0.735, 0.830)	**<.001**
3	0.773 (0.720, 0.830)	**<.001**
4	0.512 (0.464, 0.564)	**<.001**
5+	0.596 (0.558, 0.636)	**<.001**
Age, yr		
<30	0.697 (0.636, 0.765)	**<.001**
50-69	0.927 (0.876, 0.982)	**.009**
>70	0.606 (0.570, 0.644)	**<.001**
Burn at time of fracture	3.012 (2.365, 3.839)	**<.001**
Head injury at time of injury	1.190 (1.075, 1.316)	**<.001**
Male sex	1.173 (1.127, 1.221)	**<.001**
Diabetes mellitus	0.884 (0.837, 0.934)	**<.001**
Obesity	1.826 (1.707, 1.952)	**<.001**
Opioid	1.077 (1.028, 1.128)	**.002**
Moderate fracture severity	2.227 (2.145, 2.313)	**<.001**
Severe fracture severity	1.101 (1.030, 1.175)	**<.001**

CCI, Charlson Comorbidity Index; *OR*, odds ratio; *CI*, confidence interval.
* Boldface indicates significance.

Although multiple fracture patterns are included in this study, we provide a comprehensive view of surgically managed elbow trauma given that prior retrospective studies have identified the propensity of multiple fracture patterns to progress to elbow contracture. Ehsan et al[6] studied 177 patients who underwent elbow contracture release and found a variety of initial injuries, including distal humerus fracture, elbow fracture dislocation, simple dislocation, radial head fracture, olecranon fracture, posterior Monteggia, and proximal bone fracture as well as crush injury to the elbow. Another study of 34 patients who underwent operative intervention for elbow contracture demonstrated that 44% of patients requiring contracture release had simple fracture patterns on review of initial injury imaging.[1] Although this study represents one of a heterogeneous population, the stratification of fracture severity aids in the delineation of how fracture pattern may impact postoperative contracture development.[1] Our data demonstrated that both moderate and severe fracture patterns carried a higher risk of contracture development than did mild fractures. However, the OR was greater for the development of contracture in moderate fractures compared with severe fractures. We suspect that this was likely secondary to our ability to detect or distinguish the diagnosis of heterotopic ossification in this heterogeneous population.

Our data came from an administrative database, which has inherent weaknesses. We are neither able to determine range of motion for patients nor patient-rated outcomes. Second, we are unable to standardize the treatment decision algorithm to perform contracture release. This is potentially subject to heterogeneity in preferences based on surgeon and patient thresholds of stiffness for performing a second surgery. Because of these limitations, we examined both the rate of contracture diagnosis as well as that of contracture release, which allows us to both directly compare our data to that from the Schrumpf study and also understand the rates at which surgeons perform contracture release in patients who develop a complication. An additional limitation is that patients who received over-the-counter aspirin or nonsteroidal anti-inflammatory drugs may not have been captured in our analysis, because medications obtained over the counter are not captured in claims billing. Nonsteroidal anti-inflammatory drug use may have influenced the rate contracture development or progression to contracture release; nevertheless, we believe our study provides a guideline for non-aspirin anticoagulants based on population-level data. The risk profile of nonsteroidal anti-inflammatory drug use warrants further study in this regard. Finally, we are unable to determine duration or compliance of patients taking anti-coagulation medication, and further research may elucidate the importance of duration of thromboprophylaxis treatment with regard to contracture development.

Conclusion

In conclusion, among our population of 10,672 patients who underwent surgical treatment for elbow trauma, we identified a rate of elbow contracture development of 8.4%. Additionally, in those patients diagnosed with contracture, we identified a rate of progression to contracture release of 7.2%, representing 0.6% of the overall population. Additionally, our study confirms previously identified risk factors for the development of elbow contracture and is the first study to identify the association between post-operative use of thromboprophylaxis and opioids with the development of elbow contracture.

Disclosure

The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article.

Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jses.2019.09.004.

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