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RESEARCH ARTICLE

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Short-term adverse event rates and risk factors following total elbow arthroplasty for fracture and arthropathy: a matched analysis of nationally representative data

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Abstract

Background Total elbow arthroplasty (TEA) is a mainstay treatment for elbow arthropathy and elbow fracture that can relieve pain and restore functional motion. The purpose of this study was to determine the role of surgical indication in the incidence of short-term adverse events and risk factors influencing complications in TEA to treat arthropathy compared to TEA for fracture. Matched cohorts were created to better isolate the impact of the surgical indication.

Methods The study identified patients within the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) database that underwent TEA to treat arthropathy or fracture from 2010 to 2020. Matched cohorts were created to analyze the incidence of 30 day adverse events and risk factors for complications.

Results The study included 599 patients for analysis. The overall incidence of any adverse event was 9.7%. In matched cohorts of 218 patients, the fracture group experienced a higher incidence of overall adverse events (13.8% vs. 6.0% in the arthropathy group, $p=0.009$) and postoperative transfusions (9.6% vs. 1.8% in the arthropathy group, $p<0.001$). Logistic regression revealed an increased risk of any adverse event in the combined matched cohort with longer operative times (OR = 1.007, CI: 1.002–1.012, $p=0.006$) and those undergoing fracture treatment (OR = 2.447, CI: 1.047–5.717, $p=0.039$). Outpatient status was associated with a lower risk of adverse events in the combined matched cohort (OR = 0.207, CI: 0.058–0.739, $p=0.015$).

Conclusions Even when controlling for comorbidities, patients undergoing TEA for fracture have a greater likelihood of short-term complications, particularly requiring a blood transfusion. Treatment of a fracture and increased operative time were risk factors for all patients, while outpatient status was protective.

Level of evidence III.

Keywords Total elbow, Arthropathy, Fracture, Arthroplasty, Complications

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Background

Elbow arthropathy is a relatively uncommon musculoskeletal condition that mostly affects individuals who take part in excessive sport, manual work, or as a result of posttraumatic injury to the elbow [1]. Elbow fracture involves a fracture in one or more of the bones that make up the elbow such as the medial epicondyle, radial head, olecranon, and coronoid [2]. In cases where nonsurgical treatment for elbow arthropathy or fracture is ineffective, a surgeon may recommend total elbow arthroplasty (TEA) as the best treatment option [1, 3–5].

For both elbow arthropathy and elbow fracture, TEA is an acceptable option that provides pain relief and functional range of motion [6]. Recently, there have been vast improvements in the technology and techniques used in elbow arthroplasty; however, complication rates, revision rates, and implant survival for TEA lag behind other joint arthroplasties [7].

The purpose of this study was to determine the role of surgical indication in the incidence of short-term adverse events and risk factors influencing complications in TEA to treat arthropathy compared to TEA for fracture. Matched cohorts were created to better isolate the impact of the surgical indication. This allows for more informed risk stratification in identifying patients eligible for TEA and improved counseling on the postoperative course after surgery. We hypothesize that elbow fracture patients are at a greater risk of developing postoperative complications compared to patients undergoing TEA for arthropathy.

Methods

Patient population

The American College of Surgeons National Surgical Quality Improvement Project (ACS-NSQIP) was used to conduct this analysis. NSQIP data was collected by the certified Surgical Clinical Reviewer at each participating site. Participant Use Data Files (PUF) from 2010 to 2020 were used in this analysis, which included patients who underwent surgery from January 2010 to December 2020. NSQIP uses a systematic sampling process to determine which cases are included in the PUF. All patients were followed for 30 days postoperative.

The inclusion criteria for this analysis were any patients that underwent TEA to treat arthropathy or fracture. The NSQIP database excludes cases involving minors (patients less than 18 years of age), trauma cases, and cases that were returned to the operating room due to a complication from a prior procedure. The data was cleaned for this analysis using R Studio version 2023.06.0 (Boston, MA) to exclude cases that had an operative time or body mass index (BMI) less than or equal to zero minutes (R studio). Cases were also excluded if functional status, dyspnea status, sex, or American Society of Anesthesiologists (ASA) class did not have a response. If the principal anesthesia technique was "none", "not reported", or "other" the case was excluded.

Variables

The independent variable for this analysis was the indication for TEA: arthropathy or fracture. The dependent variables were adverse events following surgery. The outcomes of interest were death, wound dehiscence, sepsis, pulmonary embolism, renal complication, myocardial infarction, cardiac arrest, stroke, transfusion, deep vein thrombosis (DVT), urinary tract infection (UTI), pneumonia, intubation issues, surgical site infection (SSI), and return to the operating room. Any adverse event (AAE) included all the above complications.

Intervention

Current Procedural Terminology (CPT) code 24,363 was used to define patients that underwent TEA. ICD-9 and ICD-10 codes were used to define patients that underwent TEA to treat arthropathy or fracture (Table 1). All patients were followed for at least 30 days following surgery.

Statistical plan

Matched cohorts were created using propensity score matching according to age, BMI, sex, race, diabetes, smoking status, ASA class, hypertension requiring medication, congestive heart failure, chronic obstructive pulmonary disease (COPD), and bleeding disorders. SPSS version 28.0.1.1 (Armonk, NY) was used for statistical analyses (SPSS). Independent sample *t* tests were used to determine if there was a difference between the arthropathy and fracture groups for continuous variables. Fischer exact tests were used where possible to determine if there was a difference between indication for surgery for categorical variables. If a Fischer exact test was unable to be performed, a chi-square test was used. A binary logistic regression was performed to determine the odds ratio and 95% confidence intervals (CI) with any adverse event as the dependent variable and patient demographics, and comorbidities as covariates for the combined matched group. Results were statistically significant if $p \leq 0.05$.

Results

From 2010 to 2020, 599 patients falling within our inclusion and exclusion criteria underwent TEA for arthropathy or fracture in the NSQIP database, as defined by the ICD codes shown in Table 1. A total of 381 patients underwent TEA for arthropathy and 218 patients were treated for fracture. Prior to matching, arthropathy patients were 64 ± 13.1 years of age, 29.7 ± 7.7 kg/m^2 BMI,

Table 1 ICD codes used in identifying fracture and arthropathy patients

Group	ICD code	Description
Arthropathy	714	Rheumatoid arthritis
	714.3	Chronic or unspecified polyarticular juvenile rheumatoid arthritis
	715.09	Osteoarthrosis generalized involving multiple sites
	715.12	Osteoarthrosis localized primary involving upper arm
	715.22	Osteoarthrosis localized secondary involving upper arm
	715.32	Osteoarthrosis localized not specified whether primary or secondary involving upper arm
	715.92	Osteoarthrosis unspecified whether generalized or localized involving upper arm
	716.12	Traumatic arthropathy involving upper arm
	716.92	Unspecified arthropathy involving upper arm
	719.42	Pain in joint involving upper arm
	M05.622	Rheumatoid arthritis of left elbow with involvement of other organs and systems
	M05.721	Rheumatoid arthritis with rheumatoid factor of right elbow without organ or systems involvement
	M05.722	Rheumatoid arthritis with rheumatoid factor of left elbow without organ or systems involvement
	M06.021	Rheumatoid arthritis without rheumatoid factor, right elbow
	M06.022	Rheumatoid arthritis without rheumatoid factor, left elbow
	M06.821	Other specified rheumatoid arthritis, right elbow
	M06.822	Other specified rheumatoid arthritis, left elbow
	M06.9	Rheumatoid arthritis, unspecified
	M12.521	Traumatic arthropathy, right elbow
	M12.522	Traumatic arthropathy, left elbow
	M12.529	Traumatic arthropathy, unspecified elbow
	M19.02	Primary osteoarthritis, elbow
	M19.021	Primary osteoarthritis, right elbow
	M19.022	Primary osteoarthritis, left elbow
	M19.121	Post-traumatic osteoarthritis, right elbow
	M19.122	Post-traumatic osteoarthritis, left elbow
Fracture	733.11	Pathological fracture of humerus
	733.81	Malunion of fracture
	733.82	Nonunion of fracture
	812	Fracture of unspecified part of upper end of humerus closed
	812.2	Fracture of unspecified part of humerus closed
	812.4	Fracture of unspecified part of lower end of humerus closed
	812.41	Supracondylar fracture of humerus closed
	812.42	Fracture of lateral condyle of humerus closed
	812.43	Fracture of medical condyle of humerus closed
	812.44	Fracture of unspecified condyle(s) of humerus closed
	812.49	Other closed fractures of lower end of humerus
	812.51	Supracondylar fracture of humerus open
	812.59	Other fracture of lower end of humerus open
	813	Fracture of upper end of radius and ulna closed
	813.01	Fracture of olecranon process of ulna closed
	813.05	Fracture of head of radius closed

Table 1 (continued)

Group	ICD code	Description
	813.08	Fracture of radius with ulna upper end (any part) closed
	813.42	Other closed fractures of distal end of radius (alone)
	M84.421A	Pathological fracture right humerus init for fracture
	S42.401	Unspecified fracture of lower end of right humerus
	S42.401A	Unspecified fracture of lower end of right humerus, init
	S42.401 K	Unspecified fracture lower end of r humerus, subs for fx w nonunion
	S42.402	Unspecified fracture of lower end of left humerus
	S42.402A	Unspecified fracture of lower end of left humerus, initial encounter for closed fracture
	S42.402 K	Unspecified fracture of lower end of left humerus, subsequent encounter for fracture with nonunion
	S42.41	Simple supracondylar fracture without intercondylar fracture of humerus
	S42.411A	Displaced simple supracondylar fracture without intercondylar fracture of right humerus, initial encounter for closed fracture
	S42.411 K	Displaced simple supracondylar fracture without intercondylar fracture of right humerus, subsequent encounter for fracture with nonunion
	S42.412A	Displaced simple supracondylar fracture without intercondylar fracture of left humerus, initial encounter for closed fracture
	S42.421A	Displaced comminuted supracondylar fracture without intercondylar fracture of right humerus, initial encounter for closed fracture
	S42.422A	Displaced comminuted supracondylar fracture without intercondylar fracture of left humerus, initial encounter for closed fracture
	S42.422B	Displaced comminuted supracondylar fracture without intercondylar fracture of left humerus, initial encounter for open fracture
	S42.432A	Displaced fracture (avulsion) of lateral epicondyle of left humerus, initial encounter for closed fracture
	S42.451A	Displaced fracture of lateral condyle of right humerus, initial encounter for closed fracture
	S42.451 K	Displaced fracture of lateral condyle of right humerus, subsequent encounter for fracture with nonunion
	S42.452A	Displaced fracture of lateral condyle of left humerus, initial encounter for closed fracture
	S42.471A	Displaced transcondylar fracture of right humerus, initial encounter for closed fracture
	S42.472A	Displaced transcondylar fracture of left humerus, initial encounter for closed fracture
	S42.491A	Other displaced fracture of lower end of right humerus, initial encounter for closed fracture
	S42.492A	Other displaced fracture of lower end of left humerus, initial encounter for closed fracture
	S52.121	Displaced fracture of head of right radius
	S52.121A	Displaced fracture of head of right radius, initial encounter for closed fracture
	S52.572A	Other intraarticular fracture of lower end of left radius, initial encounter for closed fracture

and 74.5% female. Average demographics for fracture patients were 70.8 ± 12.4 years ($p < 0.001$), 28.8 ± 6.6 kg/m^2 ($p = 0.135$), and 87.2% female ($p < 0.001$). Mean ASA class was 2.6 ± 0.6 for the arthropathy population and 2.7 ± 0.7 for the fracture population ($p = 0.271$). Current smoking status was prevalent in 13.9% and 11.0% of arthropathy and fracture repair patients, respectively ($p = 0.375$). For the unmatched arthropathy and fracture groups, the most common comorbidities were diabetes (14.2% and 22.9%, $p = 0.024$), steroid use (23.1% and 7.8%, $p < 0.001$), and COPD (7.9% and 7.3%, $p = 0.874$) (Table 2).

After matching, each group had 218 patients for analysis. No significant difference was found in operative time ($p = 0.354$), but length of stay was greater in the fracture

group (3.1 ± 3.2 days vs. 1.5 ± 10.4 days, $p = 0.028$). Among comorbidities, the steroid use was significantly different ($p < 0.001$), with the arthropathy group having a higher rate (22.9%) compared to the fracture group (7.8%). There was a greater prevalence of bleeding disorders in the fracture group compared to the arthropathy group (9.6% vs. 4.1%, $p = 0.036$). Demographics and comorbidities are summarized in Table 2.

In the unmatched cohort, the overall incidence of any adverse event was 9.7%, with significantly higher rates in the fracture group compared to the arthropathy group (13.8% vs. 7.3%, $p = 0.014$), with 21 of the 30 adverse events in the fracture group being blood transfusions. Transfusions were more prevalent in the fracture group than in the arthropathy group (9.6% vs. 2.9%, $p < 0.001$). Blood transfusions were less common in the arthropathy cohort, comprising only 11 of 28 AAE. Surgical site

Table 2 Demographic and comorbidity characteristics for patients undergoing TEA for Arthropathy or Fracture

	Arthropathy (%)	Fracture (%)	*p* value	Arthropathy matched (%)	Fracture matched (%)	*p* value
Patients, n (%)	381 (63.6)	218 (36.4)		218 (50.0)	218 (50.0)	
Age (mean ± SD, years)	64.0 ± 13.1	70.8 ± 12.4	< 0.001	69.5 ± 10.6	70.8 ± 12.4	0.264
BMI (mean ± SD, kg/m^2)	29.7 ± 7.7	28.8 ± 6.6	0.135	29.4 ± 6.8	28.8 ± 6.6	0.352
Male sex	97 (25.5)	28 (12.8)	< 0.001	34 (15.6)	28 (12.8)	0.493
Operative Time (mins)	168.1 ± 69.1	157.1 ± 67.8	0.061	163.3 ± 71.5	157.1 ± 67.8	0.354
Length of Stay (days)	2.0 ± 8.2	3.1 ± 3.2	0.041	1.5 ± 10.4	3.1 ± 3.2	0.028
Outpatient status	134 (35.2)	63 (28.9)	0.125	79 (36.2)	63 (28.9)	0.125
ASA Class	2.6 ± 0.6	2.7 ± 0.7	0.271	2.7 ± 0.6	2.7 ± 0.7	0.706
1—no disturbance	6 (1.6)	9 (4.1)		3 (1.4)	9 (4.1)	
2—mild disturbance	151 (39.6)	70 (32.1)		81 (37.2)	70 (32.1)	
3—severe disturbance	209 (54.9)	123 (56.4)		124 (56.9)	123 (56.4)	
4—life-threatening disturbance	15 (3.9)	16 (7.3)		10 (4.6)	16 (7.3)	
5—moribund	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Race			0.001			0.451
White	274 (71.9)	180 (82.6)		176 (80.7)	180 (82.6)	
Black	26 (6.8)	2 (0.9)		5 (2.3)	2 (0.9)	
Other	13 (3.4)	6 (2.8)		5 (2.3)	6 (2.8)	
Unknown	68 (17.8)	30 (13.8)		32 (14.7)	30 (13.8)	
Dependent Functional Status (partial or total)	19 (5.0)	18 (8.3)	0.083	13 (6.0)	18 (8.3)	0.305
Current smoker	53 (13.9)	24 (11.0)	0.375	26 (11.9)	24 (11.0)	0.881
Comorbidities n(%)						
CHF	4 (1.0)	4 (1.8)	0.471	3 (1.4)	4 (1.8)	1.000
Renal failure	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	–
Dialysis	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	–
Steroid use	88 (23.1)	17 (7.8)	< 0.001	50 (22.9)	17 (7.8)	< 0.001
Malnourishment	1 (0.3)	2 (0.9)	0.301	1 (0.5)	2 (0.9)	1.000
Bleeding disorder	9 (2.4)	21 (9.6)	< 0.001	9 (4.1)	21 (9.6)	0.036
Ascites	0 (0.0)	0 (0.0)	–	0 (0.0)	0 (0.0)	–
Pre-operative transfusion	2 (0.5)	1 (0.5)	1.000	0 (0.0)	1 (0.5)	1.000
Diabetes			0.024			0.483
IDDM	22 (5.8)	20 (9.2)		17 (7.8)	20 (9.2)	
NIDDM	32 (8.4)	30 (13.8)		23 (10.6)	30 (13.8)	
DOE	17 (4.4)	14 (6.4)	0.227	8 (3.7)	14 (6.4)	0.181
COPD	30 (7.9)	16 (7.3)	0.874	17 (7.8)	16 (7.3)	1.000

BMI body mass index, *CHF* congestive heart failure, *COPD* chronic obstructive pulmonary disease, *DOE* dyspnea on exertion, *Renal failure* wherein renal function has been compromised within 24 h prior to surgery, *Dialysis* acute or chronic renal failure requiring dialysis within 2 weeks of indexed procedure, *Malnourishment* considered as greater than 10% decrease in body weight in six−month interval preceding surgery; *IDDM* insulin−dependent diabetes mellitus, *NIDDM* non−insulin dependent diabetes

infections were more common in the arthropathy cohort (3.1% vs. 1.4%) but did not significantly differ ($p=0.227$). Wound dehiscence was more common in the fracture group, but it failed to reach significance (1.4% vs. 1.0%, $p=0.709$). No other adverse events reached significance in the unmatched cohorts (Table 3).

In the matched cohort, 43 of 536 patients experienced an adverse event, resulting in an overall incidence of 9.9%. The difference in adverse events between the two groups increased in the matched cohorts, with the fracture patients continuing to have a higher incidence (13.8% vs. 6.0% in the arthropathy group, $p=0.009$). Blood transfusions accounted for the majority of complications in the fracture population (21 of 30) and occurred more frequently than in the arthropathy group (9.6% vs. 1.8%, $p<0.001$). Although the rate of surgical site infections was higher in the arthropathy group (3.7% vs. 1.4%), it did not reach statistical significance. The cohorts demonstrated identical wound dehiscence rates of 1.4%. A detailed summary of adverse events can be found in Table 3.

Logistic regression revealed an increased risk of any adverse event in the combined matched cohort for those undergoing fracture treatment (OR = 2.447, CI: 1.047–5.717, $p=0.039$) and those with longer operative times (OR = 1.007, CI: 1.002–1.012, $p=0.006$). Outpatient status was associated with a lower risk of adverse events in the fracture (OR = 0.075, CI: 0.007–0.757, $p=0.028$) and combined matched cohorts (OR = 0.207, CI: 0.058–0.739, $p=0.015$). Fracture patients with longer lengths of stay (OR = 1.262, CI: 1.053–1.511, $p=0.012$), non-insulin dependent diabetes mellitus (NIDDM) (OR = 10.712, CI: 2.052–55.962, $p=0.005$), and longer operative time (OR 1.013, CI: 1.005–1.021, $p=0.002$) had an increased odds of developing a complication after surgery. Increases in ASA score were associated with increased complications in the arthropathy group ($p=0.034$). These findings and those that did not reach significance are further elaborated in Table 4.

Discussion

The purpose of this study was to compare the incidence of adverse events after total elbow arthroplasty in patients with arthropathy versus patients with a fracture. Our secondary aim was to identify risk factors contributing to these complications. These findings provide important prognostic information for understanding a patient's risk profile given their surgical indication, which promotes more targeted clinical decision making.

After matching, there were few demographic and comorbidity differences between the groups. In both the matched and unmatched analyses, operating for a

Table 3 Incidence of adverse events for patients undergoing TEA for Arthropathy or Fracture

	Arthropathy unmatched (n = 381)		Fracture unmatched (n = 218)			Arthropathy matched (n = 218)		Fracture matched (n = 218)			Overall matched	
	No	Rate (%)	No	Rate	*p* value	No	Rate	No	Rate	*p* value	No	Rate (%)
Any adverse event	28	7.3	30	13.8	0.014	13	6.0	30	13.8	0.009	43	9.9
Death	3	0.8	1	0.5	1.000	1	0.5	1	0.5	1.000	2	0.5
Wound dehiscence	4	1.0	3	1.4	0.709	3	1.4	3	1.4	1.000	6	1.4
Sepsis	4	1.0	1	0.5	0.658	2	0.9	1	0.5	1.000	3	0.7
Pulmonary embolism	2	0.5	0	0.0	0.536	0	0.0	0	0.0	–	0	0.0
Renal complication	0	0.0	0	0.0	–	0	0.0	0	0.0	–	0	0.0
MI	0	0.0	1	0.5	0.364	0	0.0	1	0.5	1.000	1	0.2
Cardiac arrest	2	0.5	0	0.0	0.536	0	0.0	0	0.0	–	0	0.0
Stroke	0	0.0	2	0.9	0.132	0	0.0	2	0.9	0.499	2	0.5
Transfusion	11	2.9	21	9.6	< 0.001	4	1.8	21	9.6	< 0.001	25	5.7
DVT	4	1.0	1	0.5	0.658	0	0.0	1	0.5	1.000	1	0.2
UTI	0	0.0	2	0.9	0.132	0	0.0	2	0.9	0.499	2	0.5
Pneumonia	2	0.5	1	0.5	1.000	1	0.5	1	0.5	1.000	2	0.5
Intubation issues	2	0.5	0	0.00	0.536	1	0.5	0	0.00	1.000	1	0.2
SSI	12	3.1	3	1.4	0.227	8	3.7	3	1.4	0.221	11	2.5
Return to OR	18	4.7	4	1.8	0.075	10	4.6	4	1.8	0.172	14	3.2

Any adverse event (AAE) superficial and deep surgical site infection, organ space infection, renal failure or insufficiency, intubation (fail to wean or reintubation), post–operative transfusion, pneumonia, DVT, PE, UTI, stroke, cardiac arrest, MI, return to OR, *MI* Myocardial infarction, *DVT* deep vein thrombosis, *UTI* urinary tract infection, *SSI* surgical site infection, *OR* operating room, *Intubation issues* re–intubation or failure to wean from intubation, *Renal complication* progressive renal insufficiency or renal failure

Table 4 Odds of developing any adverse event during surgery as related to significant patient demographics and comorbidities

	Arthropathy		Fracture		Combined matched	
	Odds ratio (95% CI)	*p* value	Odds ratio (95% CI)	*p* value	Odds ratio (95% CI)	*p* value
Procedure (fracture)	–	–	–	–	2.447 (1.047–5.717)	0.039
Outpatient	0.490 (0.150–1.603)	0.238	0.075 (0.007–0.757)	0.028	0.207 (0.058–0.739)	0.015
ASA class		0.034		0.294		0.313
NIDDM	0.309 (0.036–2.656)	0.285	10.712 (2.052–55.962)	0.005	2.184 (0.688–6.933)	0.185
COPD	3.073 (0.537–17.585)	0.207	10.572 (1.223–91.418)	0.032	1.930 (0.465–8.012)	0.365
Operative time	1.004 (0.998–1.010)	0.165	1.013 (1.005–1.021)	0.002	1.007 (1.002–1.012)	0.006
Length of stay	1.004 (0.963–1.046)	0.859	1.262 (1.053–1.511)	0.012	0.996 (0.963–1.029)	0.799

fracture increased the risk of developing any adverse event, particularly requiring a blood transfusion. There is controversy in the literature surrounding whether elbow arthroplasty for fracture carries an increased complication risk. In an analysis of a smaller subset of NSQIP patients, Zhang et al. found no significant relationship between presentation for fracture or trauma and the incidence of postoperative complications [8, 9]. Others found indication for a fracture to have no role in local or systemic complications compared to those treated for osteoarthritis [10, 11]. In contrast, Perreta et al. noted that patients treated with TEA for trauma were more likely to require reoperation [12]. Notably, our findings showed that dependent functional status had no association with adverse events, which differs from the findings of Lovy et al. in their analysis of 189 cases of primary TEA [7].

The arthropathy group had a higher rate of chronic steroid use, both before and after matching, which has been shown to increase the risk of overall 30 day complications, wound dehiscence, surgical site infection, sepsis, pulmonary embolism, DVT, UTI, and return to the operating room, which were all included in our analysis [13, 14]. However, in our analysis, the group with higher steroid use actually experienced a lower overall rate of adverse events. Furthermore, chronic steroid use was not associated with increased rates of any acute perioperative complications. In both the unmatched and matched analysis, the arthropathy cohort demonstrated a greater incidence of surgical site infection, though it failed to reach statistical significance. This may be due to poor wound healing and a blunted immune response from the higher rates of steroid use. These findings suggest that appropriately managed steroid use in arthropathy patients is relatively safe in an elective setting.

Consistent with the findings of Cutler et al. and Aziz et al., our analysis found that fracture patients had an increased need for blood transfusions, which were the most frequent complication (5.7% overall) [10, 11]. The greater incidence of bleeding disorders in fracture patients may have contributed to this finding, as these disorders increase the risk of blood loss and subsequent transfusions in orthopaedic procedures [15]. The exact cause of these differences is hard to isolate in a NSQIP data set, but we speculate that the urgent nature of traumatic injuries limits the opportunity for preoperative optimization, including nutrition, diabetes control, and smoking cessation, which may negatively affect recovery. Our results suggest that TEA in the setting of trauma primarily increases the risk of requiring a postoperative blood transfusion, though this may also be influenced by the imperfect match of bleeding disorders. Furthermore, our findings support that aside from the increased transfusion requirements that often follow traumatic injuries, TEA for trauma carries a similar risk profile to TEA for arthropathy.

In our study, we observed complication rates consistent with previously reported data for TEA. Complication rates generally range from 11 to 38%, with clinical loosening being the most frequent reported complication [6]. Other complications include infection, instability, periprosthetic fractures, triceps functionality issues, and ulnar neuropathy, among others [19]. Previously determined rates of complications were a 3.4% rate of deep infection, 2.9% rate of ulnar nerve issues, and 0.4–2.4% rate of triceps complications. Although fewer elbow arthroplasties are performed compared to lower extremity arthroplasties, the proportion of complications is greater with TEA.

Several studies have identified risk factors for poor short-term and long-term outcomes in broad cohorts of TEA patients; however, the influence of these factors on matched patient cohorts with different indications has yet to be defined [6, 8, 10, 11, 16–20]. Outpatient status for the fracture and combined matched groups was associated with lower odds of developing an adverse event after surgery. Zhang et al. saw a similar trend in their results (OR = 0.468), although their association failed to

reach significance [8]. While there is limited information regarding the short-term outcomes of outpatient TEA compared to inpatient TEA, other procedures such as knee, hip, and shoulder arthroplasty have demonstrated equal success [21, 22]. There may be selection bias in that patients with significant comorbidities are more likely to receive inpatient treatment, and future studies could provide better insight into the role of outpatient status in patient outcomes [23]. Increased operative time was an independent predictor of AAE in the fracture and combined matched patients. This may stem from a more technical procedure or less surgeon experience, which is associated with a higher revision rate [9]. Longer operations are well-established as an independent risk factor in orthopaedics, with an abundance of data showing correlations for a variety of procedures, including TEA [8, 24–26]. Interestingly, fracture patients averaged a shorter operative time compared to those with arthropathy, however, it was not a risk factor for the arthropathy subset. Within the matched arthropathy group, only an increased ASA class was associated with an increased rate of adverse events. Some studies have shown increasing ASA scores to predict readmission and adverse events following TEA, while others note no relationship with minor or major complications [7, 8, 11]. Increased ASA has been associated with longer hospital length of stay after TEA, though in our data a longer hospital stay was an independent risk factor in the fracture cohort when ASA class was not [8].

Within the matched fracture group, NIDDM and COPD emerged as comorbidities associated with increased odds of developing a short-term complication. From these findings, we recommend that clinicians effectively optimize these comorbidities before surgery, as they proved to be independent risk factors for complications in the fracture population. Where possible, delaying inpatient treatment could help mitigate the negative influence of prolonged hospital stays and inpatient procedures on their complication risk. A database study of over 3,000 patients undergoing TEA identified diabetes as an independent risk factor for pneumonia, UTI, and cerebrovascular incidents following surgery [27]. In total shoulder patients, COPD patients had a higher incidence and odds of 90 day complications, longer hospital stays, and increased medical costs following surgery [28]. Other database studies have noted trends of increased complications in COPD patients undergoing TEA, though they did not reach significance [8, 10].

This study has several limitations, many of which are innate to using large databases. The outcomes were retrospective in nature and limited to surgeries indexed within NSQIP. Potential confounders such as implant type, surgical technique, surgeon experience, and history of the condition were not available for analysis. The postoperative documentation is limited to 30 days following surgery, thus any long-term complications or outcomes, such as aseptic loosening, implant survivorship, periprosthetic fracture, and patient reported outcomes, are not recorded. Our reported rates of adverse events may underestimate the true values that would emerge with a longer follow-up period. Finally, the exact cause and timing of the arthropathy or fracture were not available for analysis and may skew the findings, as chronic and ignored ailments may carry a worse prognosis than acute injuries treated promptly.

Conclusions

This study utilizes NSQIP data from 2010 to 2020 to compare 30 day outcomes of patients undergoing TEA for fracture and arthropathy. Even with increased chronic steroid use in the arthropathy group, fracture patients demonstrated a greater likelihood of complications, especially requiring a blood transfusion. This suggests that appropriate perioperative steroid use is safe in arthropathy patients. Logistic regression revealed that treatment of a fracture and increased operative time were risk factors for all patients, while outpatient status was protective. In arthropathy patients, an increased ASA score increased their risk while NIDDM, COPD, and longer length of stay negatively affected fracture patients, underscoring the importance of optimizing these conditions before surgery to reduce the risk of postoperative complications. These findings can be used by surgeons performing total elbow arthroplasty to improve their preoperative risk assessment and patient counseling.

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Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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