Journal of Hand Surgery Global Online 6 (2024) 53–57

Contents lists available at ScienceDirect

Journal of Hand Surgery Global Online

journal homepage: www.JHSGO.org

Original Research

Timing of Olecranon Fracture Fixation Does Not Affect Early Complication or Reoperation Rates

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A R T I C L E I N F O

Article history:
Received for publication September 5, 2023
Accepted in revised form September 11, 2023
Available online October 13, 2023

Key words:
Olecranon fracture
Olecranon open reduction and internal fixation
Olecranon tension-band wiring
Surgical complications
Surgical timing

Purpose: Surgical fixation of olecranon fractures can lead to soft-tissue complications and return to the operating room for hardware removal. While some risk factors of complications after olecranon fracture fixation have been described, the effects of fixation timing on complications and reoperation have not been evaluated. The purpose of the present study was to assess whether the timing of olecranon fracture fixation affects complication and reoperation rates.
Methods: All patients who underwent olecranon fracture open reduction and internal fixation at a single level 1 trauma center from January 2012 to February 2022 were included in the study. A retrospective review was performed to evaluate patients for inclusion and to identify patient demographic factors, medical comorbidities, concomitant injuries, mechanism of injury, and time to fixation. Operative and clinical notes were evaluated to identify fixation type and outcomes of interest. Patients were stratified into early, standard, and delayed fixation groups (0-3 days, 4–14 days, and >14 days, respectively) for independent analyses, and Fisher's exact test was used to identify differences in complications and reoperations between groups. Multivariate analysis was used to assess associations between patient demographic factors, complication rates, and time to surgery.
Results: A total of 97 patients met inclusion criteria of having an olecranon open reduction and internal fixation and had a minimum follow-up of at least 10 weeks, with an average follow-up of 7.1 months. The average time to surgery in the overall cohort was 9.3 days. There were no differences in the number of total complications and rate of reoperation among the three cohorts. Smoking was found to be significantly associated with total complications, while open fracture was significantly associated with reoperation. Polytrauma and open fracture were significantly associated with earlier operation, while smoking was significantly associated with delayed fixation.
Conclusions: The timing of fixation of displaced olecranon fractures does not significantly increase the rate of early complications or reoperation.
Type of study/level of evidence: Symptom Prevalence Study III.

The unique anatomic considerations of the posterior elbow place it at high risk for hardware and wound healing complications as the subcutaneous position of the olecranon places significant tension on the soft-tissue envelope throughout the range of motion.[1–3] Fracture of the olecranon is common, accounting for up to 10% of upper extremity fractures, and fracture fixation is associated with a multitude of complications.[4–6] These complications include symptomatic hardware (most common), stiffness, ulnar neuritis, heterotopic ossification, post-traumatic arthrosis, nonunion, and infection.[1]

Olecranon fractures commonly occur in younger patients who have experience high-energy trauma or in elderly patients after ground-level falls.[3] Traditionally, nonsurgical management is reserved for nondisplaced fractures, whereas open reduction and internal fixation (ORIF) is the standard of care for displaced

Declaration of interests: No benefits in any form have been received or will be received related directly to this article.

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https://doi.org/10.1016/j.jhsg.2023.09.002
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olecranon fractures.[3,4,7,8] Traditional options for ORIF include surgical intervention, including tension-band wiring and plate fixation.[3,7,9] Less common options for fixation include intramedullary nails, a modified cable pin system, tension banding through cannulated screws, and cancellous screw tension-band wiring (TBW).[10]

Numerous studies have assessed outcomes after olecranon fracture ORIF, specifically comparing the effect of plate fixation versus TBW on clinical outcomes and complication rates. [10–16] While some risk factors for complications after olecranon fracture fixation have been described, the effect of fixation timing on outcomes has not been evaluated. Few studies have assessed the effects of timing of fracture fixation timing in other areas on clinical and patient-related outcomes. For example, while the timing of ankle fracture fixation does not seem to influence wound or fracture healing, delayed fixation of clavicle, and distal radius fractures has been shown to have higher complication rates.[17–20]

The purpose of the present study was to assess whether the timing of olecranon fracture fixation affects the rate of complication and reoperation given the unique anatomic considerations of the posterior elbow and its soft-tissue envelope. The study hypothesis was that there would not be a difference in early complication or reoperation rates when stratified by timing of fracture fixation.

Materials and Methods

A retrospective chart review of 165 olecranon fracture patients surgically treated from January 2012 to February 2022 was performed. Patients under the age of 18 years and those who did not meet the required minimum follow-up time of 10 weeks were excluded from the cohort. All olecranon fracture types that underwent surgical fixation were included. A total of 97 were eligible for analysis. This study was approved by the institutional review board and was granted a waiver of the Health Insurance Portability and Accountability Act (HIPPA) authorization under 45CFR 164.512(i)(2).

All eligible patients underwent surgical fixation performed by four fellowship-trained orthopedic hand surgeons at a single level 1 trauma center. The ORIF technique varied based on individual surgeon preference and fracture pattern. In this patient cohort, 89 underwent plate fixation, whereas 8 underwent TBW. All 97 patients included in the study had a duration of follow-up greater than 10 weeks.

Electronic medical records were reviewed to identify patient demographic factors and medical comorbidities, including age, sex, body mass index (BMI), concomitant injuries, presence of diabetes, and tobacco use. The time elapse from date of injury to definitive fixation was also determined for each patient. Information regarding postoperative complications or subsequent elbow surgeries was gathered from postoperative follow-up appointment notes.

Patients were divided into early (0–3 days), standard (4–14 days), and delayed (>14 days) fixation groups, and comparison of demographic variables, complication rates, and reoperation rates was performed between groups. The primary outcomes of interest were total complication and reoperation rates. Complications included symptomatic hardware (pain/irritation, stiffness, foreign body sensation, etc.), ulnar neuropathy, delayed union, nonunion, wound dehiscence/infection, and refracture. Reoperations included removal of hardware (ROH), wound irrigation and debridement (I&D), revision ORIF, or a combination of these. Secondary outcomes were patient-specific factors associated with complications, reoperation, and/or timing of surgical fixation.

Statistical analysis

Statistical analyses were carried out using IBM SPSS Statistics 26 (International Business Machines Corporation, Armonk, NY). Descriptive statistics, including means and standard deviations, were calculated for continuous variables. Independent *t* tests were used to identify any significant differences among normally distributed demographic factors (mean age, mean BMI). Given the small cohort sizes, Fisher's exact test was used to identify any significant differences in complication or reoperation rates among the early, standard, and delayed fixation groups. Multivariate regression was used to identify if any demographic or preoperative risk factors were associated with nonsurgical complications and reoperation or with time to surgical fixation. The threshold of $P < .05$ was considered statistically significant for all comparisons.

Results

A total of 97 patients were identified who underwent olecranon fracture ORIF and had a minimum of 10 weeks of follow-up postoperatively. The average follow-up time for the entire study population was 7.1 months. The average follow-up time for early, standard, and delayed fixation cohorts was 8.7, 6.7, and 6.1 months, respectively. Twenty-two (22.7%) patients were included in the early fixation cohort, 59 (60.8%) patients were classified in the standard fixation cohort, and 16 (16.5%) patients were in the delayed fixation cohort.

There were no significant differences in BMI, obesity, and smoking status noted between any of the groups as seen in Table 1. However, polytrauma and open fracture were significantly more common in the early fixation cohort when compared to the standard fixation cohort ($P = .003$ and $P < .001$, respectively) and the delayed fixation cohort ($P = .005$ and $P = .014$, respectively). The early fixation cohort was also found to have a significantly younger average age when compared to the standard fixation cohort ($P < .01$) and the delayed fixation cohort ($P < .05$) and significantly more men when compared to the standard fixation cohort ($P < .01$) and the delayed fixation cohort ($P < .05$). There were no significant differences in sex, age, and incidence of polytrauma or open fracture between the standard and delayed fixation cohorts (Table 1).

There were no significant differences in the percent of patients with a reported complication among any of the cohorts (45.5% vs 33.9% vs 37.5%; $P = .439$ [early vs standard], $P = .744$ [early vs delayed], and $P = .776$ [standard v. delayed]) as seen in Table 1. The most common complications were painful hardware followed by ulnar neuropathy and wound dehiscence/infection. There was also no significant difference in rates of reoperation between any of the groups (36.4% vs 16.9% vs 31.3%; $P = .076$ [early v. standard], $P = .735$ [early v. delayed], and $P = .289$ [standard v. delayed]) as seen in Table 1. The most common reason for reoperation was ROH followed by I&D. There were no significant differences among any of the cohorts with respect to specific types of complications or reoperations (Table 1).

Multivariate analysis

Multivariate regression analyses were carried out to determine associations between patient demographic factors, complication rates, and time to surgery. A binary logistic regression model using forward selection was used to examine factors related to total complications, and a separate model was used to examine factors related to reoperation rates. As seen in Table 2, smoking was significantly associated with increased complication rates (odds ratio (OR) = 3.99, $P = .020$), while open fracture was significantly

Table 1
Comparison of 10-Week Follow-Up Cohort Demographics, Total Complications, and Reoperations Among the Early, Standard, and Delayed Fixation Cohorts

	0-3 days*	4–14 days†	>14 days‡	A/B *P* value	A/C *P* value	B/C *P* value
Demographics						
n	22	59	16			
Sex, # female (%)	6 (27.3%)	37 (62.7%)	10 (62.5%)	.006*	.047*	>.99
Age, average +/- SD	41.0 +/- 20.3	55.2 +/- 19.3	56.3 +/- 16.2	.005*	.018*	.835
BMI, average +/- SD	27.4 +/- 6.9	25.7 +/- 6.6	26.2 +/- 5.2	.312	.563	.780
Obesity (BMI > 30), n (%)	8 (36.4%)	12 (20.3%)	4 (25%)	.156	>.99	.735
Everyday smoking, yes (%)	2 (9.1%)	12 (20.3%)	5 (31.3%)	.330	.108	.501
Polytrauma, yes (%)	9 (40.9%)	6 (10.2%)	0	.003*	.005*	.331
Open fracture, yes (%)	7 (31.8%)	0	0	<.0001*	.014*	>.99
Patients' with complications	10 (45.5%)	20 (33.9%)	6 (37.5%)	0.439	0.744	.776
Complications						
Total	13	22	7	.169	.634	.644
Painful hardware	8	10	3	.489	.642	>.99
Ulnar neuropathy	2	6	0	.680	.521	.289
Delayed union	1	0	1	.371	>.99	.241
Nonunion	1	2	0	>.99	>.99	>.99
Wound dehiscence/infection	1	3	3	>.99	.101	.132
Refracture	0	1	0	>.99	>.99	>.99
Reoperations						
Total (rate)	8 (36.4%)	10 (16.9%)	5 (31.3%)	.076	.735	.289
ROH	6	6	2	.638	.293	.608
Revision ORIF	1	1	0	>.99	>.99	>.99
Revision ORIF + I&D	0	1	0	>.99	>.99	>.99
ROH + I&D	1	2	3	>.99	.217	.251

SD, standard deviation; BMI, body mass index; ORIF, open reduction and internal fixation; I&D, irrigation and debridement; ROH, removal of hardware.
* Early fixation cohort.
† Standard fixation cohort.
‡ Delayed fixation cohort.

Table 2
Binary Logistic Regression Results for Patient Characteristics Versus Total Complications

Characteristic	Odds Ratio	95% Confidence Interval	*P* Value
Age	0.99	(0.9741–1.0262)	.989
BMI	0.93	(0.8220–1.0429)	.205
Days to surgery	1.00	(0.9322–1.0823)	.908
Sex (male)	1.24	(0.4242–3.6176)	.695
Obesity (yes)	2.72	(0.5068–14.6389)	.243
Smoking (yes)	3.99	(1.2460–12.8067)	.020*
Diabetes (yes)	0.40	(0.0571–2.8598)	.364
Polytrauma (yes)	1.12	(0.3090–4.0767)	.861
Open fixation (yes)	2.42	(0.3943–14.8078)	.340

BMI, body mass index.
* Statistically significant at $P < .05$.

Table 3
Binary Logistic Regression Results for Patient Characteristics Versus Reoperation

Characteristic	Odds Ratio	95% Confidence Interval	*P* Value
Age	0.99	(0.9705–1.0291)	.966
BMI	0.91	(0.7895–1.0464)	.184
Days to surgery	0.99	(0.8966–1.0853)	.779
Sex (male/female)	1.1	(0.3131–3.6308)	.918
Obesity (yes/no)	1.2	(0.1626–9.5571)	.832
Smoking (yes/no)	2.6	(0.7329–9.0879)	.140
Open Fracture (yes/no)	8.0	(1.0650–60.5884)	.043*
Polytrauma (yes/no)	0.39	(0.0789–1.9241)	.415

BMI, body mass index.
* Statistically significant at $P < .05$.

associated with increased reoperation rates (OR = 8.0, P =.043) (Table 3).

A separate multiple regression model was used to determine potential factors associated with time to surgery as a continuous outcome variable. The average time to surgery was 9.3 days across the entire study population. Multivariate regression analysis found that polytrauma (P =.031) and open fracture (P =.027) were significantly associated with earlier surgical fixation, while smoking (P =.016) was significantly associated with later surgical fixation (Table 4).

Discussion

The current study identified 97 patients who underwent olecranon fracture ORIF at a single institution from 2012 to 2022 and assessed how timing of fixation affects reoperation and complication rates. The innate anatomy of the elbow and limited soft-tissue window of the olecranon make it vulnerable to postoperative complications.[1–3] While there are many studies that have assessed outcome after olecranon ORIF, no study has assessed the effect of fixation timing on the rate of complication and reoperation.[10–15]

The overall complication rate was 37.1% for the entire cohort. This is consistent with reported rates of up to 31% following ORIF and 53% following TBW in the literature.[21,22] Complications observed included painful hardware, ulnar neuropathy, delayed union, nonunion, wound dehiscence/infection, and refracture. The overall rate of reoperation in the cohort was 23.7%. Reasons for reoperation included ROH, revision ORIF, I&D, or a combination of these. The complication and reoperation rates reported in this study are likely overestimated as patients who develop complications are followed longer than those who recover uneventfully and do not typically return to clinic after the routine 6-week postoperative visit.

There is no established recommendation for time-to-surgery after olecranon fracture. In healthy populations, delays to surgery can result in adverse outcomes, including prolonged pain, psychosocial stress, and lost productivity and wages.[20] However, principles of delayed fixation are often discussed in regard to lower extremity fracture care where there is concern for the integrity of the soft tissues.[23,24] Similar soft-tissue considerations are not associated with upper extremity injury. Prior studies assessing the

Table 4
Multivariate Regression Results for Patient Characteristics Versus Time to Surgery as a Continuous Variable

Characteristic	Coefficient	*P* value
Age	-0.001	.972
BMI	-0.05	.778
Obesity (yes)	0.06	.980
Sex (male)	-2.12	.158
Smoking (yes)	3.95	.016*
Diabetes (yes)	2.37	.337
Open Fracture (yes)	-5.77	.027*
Polytrauma (yes)	-4.0	.031*

BMI, body mass index.
* Statistically significant at $P < .05$.

effects of timing on fracture fixation on outcome have used cutoffs including 24 hours, 1–2 weeks, and 5 weeks to discriminate between early versus delayed fixation.[17–20] However, these studies are limited, and only one study to date has defined delayed fixation for upper extremity fracture as 14 days.[20] This study defined delayed fixation similarly as greater than 14 days from injury, early fixation was defined as fracture fixation within 3 days of injury, and standard fixation was defined as fixation between 3 and 14 days from time of injury.

The early fixation cohort (<3 days) was composed of significantly more males and the average age was significantly lower when compared to both the standard and early fixation groups. Additionally, the incidence of polytrauma and open fracture were significantly higher in this cohort compared to the standard and delayed fixation groups. While this group had slightly higher gross complication and reoperation rates then the other two groups, the difference was not statistically significant. Multivariate analyses also showed that open fracture was significantly associated with increased reoperation rates, and all open fractures were contained within the early fixation cohort. This suggests that any difference in outcome within the early fixation group may be attributed to the significantly different patient factors and injury characteristics rather than a function of time to fixation.

As previously stated, delayed fixation was defined as fixation greater than 14 days from injury. Primary callus and contracture can make fracture reduction more technically challenging beyond this timepoint.[20,25,26] However, the delay until after the inflammatory phase of fracture healing may play a role in temporizing soft-tissue complications, allowing for recovery of the soft-tissue envelope. The current study did not find any significant differences in nonsurgical complication and reoperation rates between the early versus delayed fixation groups. These results are similar to other studies that have shown no differences in outcomes after ankle fractures with regards to early versus delayed fixation.[17,18] Additionally, a recent systematic review assessing the effect of time-to-surgery on distal radius fracture outcomes found significantly inferior Disabilities of the Arm, Shoulder, and Hand scores among patients who underwent surgery 14 days after injury, but there were no differences in complication or revision rates.[20] The current study also found a significant association between everyday smoking and total complications. This is concordant with literature that has shown an association between tobacco use and increased complication rates after upper extremity surgery, and more specifically tissue healing and delayed union.[27–30]

There is limited literature assessing patient factors as predictors of time to fracture fixation. This study found that patients with earlier time to surgery sustained polytrauma or open fractures and were more likely to be male and of younger age. Additionally, patients who smoke daily underwent surgical fixation significantly later than average.

There are several limitations of this study. This is a retrospective study with a limited sample size. Although the total sample size was robust compared to other studies of these fractures, the number needed to show differences between groups on a relatively uncommon outcome with 80% power would require several hundred patients in each group. The complication rates were similar between comparison groups, especially between the standard and delayed fixation groups. Moreover, even if a significant threshold were reached, there is unlikely to be any significant clinical difference that would lead one to alter his surgical decision making.

In addition, because of the retrospective nature of this study, fixation was performed by four different surgeons without a standardized operative or postoperative protocol. Follow-up was determined by patient progress, and only 97 patients had a minimum follow-up of 10 weeks. Although the average follow-up for this study population was 7.1 months, patients in this cohort were usually instructed to follow-up as needed after the 6-week postoperative visit. Ten weeks was chosen for minimum follow-up as bony union usually occurs by this time. However, this limits the size of our study population as many patients choose not to return to clinic after their 6-week appointment. While this study was not able to account for all potential confounders, this scenario is more representative of the usual trauma surgery practice. Prospective studies with longer follow-up and the use of both subjective and objective patient outcome measures could better elucidate whether time to fixation has an impact on outcomes following olecranon ORIF.

In conclusion, this study demonstrated that the time of olecranon fixation after injury was not associated with significant different rates of early complication or reoperation. Therefore, surgical planning or medical optimization should take precedence over timing.

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