Factors Associated With Reoperation After Fixation of Displaced Olecranon Fractures

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Abstract

Background Surgery for fixation of olecranon fractures is associated with reoperation, mostly for implant removal. A study of a large cohort of patients treated by many different surgeons allows us to determine if specific techniques or implants are associated with a higher rate of reoperation.

Questions/purposes After open reduction and internal fixation of isolated olecranon fractures, what factors are associated with (1) reoperation and (2) implant removal?

Methods Three hundred ninety-two adult patients who had operative treatment of a displaced olecranon fracture not associated with other fractures, dislocation, or subluxation at two area hospitals between January 2002 and May

2014 were analyzed to determine factors associated with reoperation. One hundred thirty-eight (35%) patients had plate and screw fixation and 254 (65%) tension band wiring. Nearly 100% of patients with displaced olecranon fractures are currently treated operatively at our hospitals. All patients were followed for at least four months. Two hundred three of the 392 (52%) patients were followed for one year or more. Ninety-nine patients (25%) had a second operation, 92 (93%) at least in part for implant removal (12 for wire migration [3% of all fractures, 12% of reoperations]). We considered patient-related, fracture-related, and implant-related endpoints as possible factors associated with reoperation. With a total sample size of 99 reoperations, an α of 0.05, and an effect size of 0.3, we had 87% power.

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

This work was performed at Massachusetts General Hospital–Harvard Medical School, Boston, MA, USA.

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Results Reoperation was less common in men (36 [36%], women: 63 [64%]; adjusted odds ratio, 0.32; 95% confidence interval, 0.18–0.56; $p < 0.001$) and older patients (adjusted odds ratio, 0.75; 95% confidence interval, 0.65–0.87; $p < 0.001$). Similarly, request for implant removal was less in men (33 [36%], women: 59 [64%], adjusted odds ratio, 0.31; 95% confidence interval, 0.18–0.56; $p < 0.001$) and older patients (adjusted odds ratio, 0.75; 95% confidence interval, 0.65–0.87; $p < 0.001$).

Conclusions Patients who have operative fixation of a fracture of the olecranon can be counseled that most patients keep their implants, that only 3% experience implant migration, and that technical factors such as the type or configuration of an implant seem less important than personal factors in determining who requests a second surgery for implant removal.

Level of Evidence Level III, prognostic study.

Introduction

Operative fixation of displaced olecranon fractures achieves union and excellent elbow function but is associated with reoperation, usually for implant removal [8, 20, 21]. A substantial rate of second surgeries to remove tension band wires led orthopaedic surgeons to consider alternatives such as plate fixation [14] or intramedullary screws or rods [13] for olecranon fractures [3, 7]. On the other hand, it is estimated that the total costs—even after reoperation—are much lower for tension band wires than for plate fixation [13] and it is not clear that plates (which are also prominent) cause fewer symptoms.

Attempts to decrease reoperation for implant removal have focused on techniques for decreasing the prominence and tendency for migration of tension band wires and the development of lower profile plates and intramedullary implants [1–7, 10–14, 17, 18, 20]. Saeed and colleagues [20] studied 182 patients and found that older age, bent wires, medullary/transcortical wire positioning, proximal prominence, ulnar shaft angle, distance from the articular surface, and articular step were associated with wire migration after tension band wire fixation of a displaced fracture of the olecranon.

Our observation is that all implants on the olecranon are somewhat prominent and that requests for removal of implants may relate more to personal than to technical factors. Patient-related factors associated with reoperation and implant removal after open reduction and internal fixation of isolated olecranon fractures are not well studied.

After open reduction and internal fixation of isolated displaced olecranon fractures, what factors are associated with (1) reoperation and (2) implant removal?

Material and Methods

This retrospective study was approved by our institutional review board. We identified 625 patients who had open reduction and internal fixation of an isolated displaced olecranon fracture (Mayo Type 2A or 2B) that was not part of a fracture-dislocation between January 2002 and May 2014 using the institutions' Research Patient Data Registry (RPDR) database covering all surgeries at two Level I trauma centers: 418 patients treated at one and 207 at the other. Current Procedural Terminology (CPT) procedure codes for proximal ulna fracture were used to identify patients who had operative treatment of an olecranon fracture (Appendix 1 [Supplemental materials are available with the online version of CORR®.]). Medical record data, International Classification of Diseases, 9th Revision code (ICD-9), demographic information (such as, gender, date of birth, and race), and operative and radiology reports of patients with this CPT code were retrieved through the institutional RPDR. For patients who had more than one olecranon fracture surgery, we tracked the first surgery as the index procedure.

We excluded (1) patients younger than 18 years of age ($n = 24$); (2) patients with prior surgery elsewhere ($n = 11$); and (3) miscoded patients with no olecranon fracture ($n = 52$). After reviewing the radiographs, we excluded (4) patients with an olecranon fracture-dislocation (Mayo Type 3) ($n = 91$); (5) patients with a concomitant distal humerus fracture ($n = 8$); (6) patients with multiple elbow fractures ($n = 41$); and (7) patients with Mayo Type 1 (nondisplaced) olecranon fractures ($n = 6$). The final cohort included 392 patients with an isolated Mayo 2A or 2B (displaced without instability) fracture of the olecranon: 138 patients treated with plate and screw fixation and 254 with tension band wiring. All patients were followed for at least four months. Two hundred three of the 392 (52%) patients were followed for one year or more.

The vast majority of patients with displaced fractures of the olecranon were treated with open reduction and internal fixation at these hospitals during the study period. The choice and configuration of the implants were at the surgeon's discretion. All surgeons used both techniques for fixation of a simple olecranon fracture.

We reviewed the medical records of all patients for our primary outcome variables: reoperation and implant removal. In total, 99 patients underwent reoperation. Reasons included prominent hardware ($n = 69$), infection ($n = 15$), elbow release for contracture ($n = 5$), ulnar nerve release ($n = 5$), failure of fixation ($n = 4$), and nonunion of irradiated bone without fixation failure ($n = 1$). Five patients had a second surgery for incision and drainage for infection without implant removal, and two patients had reoperation

for ulnar nerve release without implant removal. We only considered the first reoperation in the calculations.

Among the 92 patients who had implant removal, 69 were for implant prominence (75%) and 23 were at the time of another surgical procedure. Seven patients who had a prominent migrated wire removed in the office under local anesthesia were counted as second procedures. Twenty-seven patients with plate and screw fixation and 42 patients with tension band wiring requested implant removal for implant prominence. Wire migration was described in 12 patients as contributing to implant prominence. In the other 57 cases no reason for implant prominence was mentioned. Twelve implant removals were for tension band wire migration representing 3% of all fractures, 4.7% of all tension band wirings, and 12% of all reoperations.

Ninety-nine of 392 fractures (25%) had a second operation, 92 (93%) at least in part for implant removal (56 of 254 [22%] after tension band wiring; 36 of 138 [26%] after plate and screw fixation). Sixty-nine patients (18% of the total and 75% of all reoperations) had reoperations specifically for dissatisfaction with or loosening or breakage of the implants (42 of 254 [16%] after tension band wiring; 27 of 138 [20%] after plate and screw fixation).

ICD-9 codes and text search were used (Appendix 2 [Supplemental materials are available with the online version of CORR®.]) to search for the explanatory variables used in our bivariate analysis. We included the following explanatory variables: age at operative treatment, gender, race, obesity, head injury, Charlson Comorbidity Index (CCI) [19], smoking, duration of surgery, open fracture, other fracture of the same limb, other fractures elsewhere, surgeon, surgeon experience in years since graduation from residency, hospital, and type of implant (plate versus tension band wire). We only analyzed head injuries as a risk factor if they occurred at the same time as the olecranon fracture.

We also reviewed radiographs and included the following explanatory variables to our bivariate analysis: comminution (Type 2B versus Type 2A) [16], Kirschner wires parallel (yes/no), Kirschner wire size (0.045 inch versus 0.062 inch or metric equivalent), Kirschner wires angled anteriorly to engage anterior cortex or straight intramedullary (yes/no), Kirschner wires turned at least 150° and impacted into the proximal ulna (yes/no), tension wire (size: 16- or 18- and 20- or 22-gauge wire), single or double tension wire, one knot or two in each tension wire, plate length (cm distal to the fracture), and plate type.

Statistical Analysis

Normality of our continuous data was tested using the Shapiro-Wilk test. The difference in explanatory variables among failure of fixation and implant removal was

assessed using a Fisher's exact test for dichotomous and categorical variables and an unpaired t-test for continuous variables. Variables were presented with frequencies and percentages for categorical variables and as mean with SD for continuous variables.

Factors with $p < 0.10$ in bivariate analysis were entered into a multivariable logistic regression analysis to assess if possible risk factors were independently associated with failure of fixation and implant removal. A two-sided p value < 0.05 was considered to indicate statistical significance. With a total sample size of 99 reoperations, an α of 0.05, and an effect size of 0.3, we had 87% power.

Results

After controlling for potentially relevant confounding variables in multivariable analysis, we found that women and younger patients were more likely to undergo a reoperation (Table 1). For gender, men (36 [36%]) were less likely to request implant removal than women (63 [64%]) (adjusted odds ratio [OR], 0.32; 95% confidence interval [CI], 0.18–0.56; $p < 0.001$). Analysis of age per decade demonstrated that younger age is associated with reoperation (adjusted OR, 0.75; 95% CI, 0.65–0.87; $p < 0.001$). Initial bivariate analysis revealed younger age, lower CCI, and gender to be associated factors (Table 2).

Similarly after controlling for potentially relevant confounding variables, request for implant removal was less in men (33 [36%], women: 59 [64%]; adjusted OR, 0.31; 95% CI, 0.18–0.56; $p < 0.001$) and older patients (adjusted OR, 0.75; 95% CI, 0.65–0.87; $p < 0.001$) (Table 3).

Initial bivariate analysis revealed younger age, lower CCI, injury side, and gender to be associated factors (Table 4).

Discussion

Reoperation is common after surgery for internal fixation of olecranon fractures. Most of these are the result of implant removal. Saeed and colleagues [20] found several surgically modifiable factors related to spontaneous wire

Table 1. Multivariable analysis—factors associated with reoperation ($n = 392$)

Parameter	Adjusted odds ratio	Adjusted 95% confidence interval	Adjusted p value
Age per 10 years	0.75	0.65–0.87	< 0.001
Charlson Comorbidity Index	0.91	0.78–1.0	0.186
Gender	0.32	0.18–0.56	< 0.001
Injury side	0.71	0.43–1.2	0.166

Table 2. Bivariate analyses—factors associated with reoperation (n = 392)

Parameter	Reoperation (n = 99 [25%])		Odds ratio (CI)	p value
	Yes Mean (SD)	No Mean (SD)		
Age (years)	50 (18)	58 (20)	0.98 (0.97–0.99)	< 0.001
Charlson Comorbidity Index	0.70 (1.7)	1.4 (2.3)	0.83 (0.72–0.96)	0.011
Experience surgeon (years)	11 (8.5)	10 (8.5)	1.1 (0.98–1.0)	0.79
Duration (hours)	1.3 (1.5)	1.4 (1.2)	0.93 (0.73–1.2)	0.59
Plate length (cm distal to fracture)	6.2 (1.4)	6.5 (1.9)	0.90 (0.71–1.1)	0.39
	Number (%)	Number (%)	Odds ratio (CI)	p value
Gender			0.58 (0.36–0.92)	0.027
Men	36 (36)	146 (50)		
Women	63 (63)	147 (50)		
Diagnosed obesity			1.3 (0.57–2.9)	0.52
Yes	9 (9)	21 (7)		
No	90 (91)	272 (93)		
Smoking*			1.3 (0.72–2.4)	0.43
Yes	19 (19)	45 (15)		
No	80 (81)	248 (85)		
Head injury			0.73 (0.27–2.0)	0.64
Yes	5 (5)	20 (7)		
No	94 (95)	273 (93)		
Open fracture			1.5 (0.69–3.4)	0.28
Yes	10 (10)	20 (7)		
No	89 (9)	273 (93)		
Other fracture			0.83 (0.39–1.7)	0.72
Yes	10 (10)	35 (12)		
No	89 (90)	258 (88)		
Other fracture same limb			0.49 (0.20–1.2)	0.13
Yes	6 (6)	34 (12)		
No	93 (94)	259 (88)		
Hospital			1.4 (0.84–2.2)	0.21
Hospital 1	65 (66)	212 (72)		
Hospital 2	34 (34)	81 (28)		
Fracture type			1.2 (0.78–2.0)	0.41
Mayo 2A	54 (55)	174 (60)		
Mayo 2B	45 (45)	117 (40)		
Figure of eight			0.88 (0.55–1.4)	0.63
Yes	62 (63)	192 (66)		
No	37 (37)	101 (34)		
Plate fixation			0.96 (0.55–1.7)	0.63
Yes	37 (37)	101 (34)		
No	62 (63)	192 (66)		
Kirschner wires parallel			1.1 (0.57–2.2)	0.73
Yes	16 (30)	42 (28)		
No	37 (70)	110 (72)		
Size of Kirschner wires			1.2 (0.58–2.4)	0.73
0.045 inch	13 (23)	44 (26)		
0.062 inch	44 (77)	127 (74)		

Table 2. continued

	Number (%)	Number (%)	Odds ratio (CI)	p value
Angle Kirschner wires			0.92 (0.43–1.9)	1.0
Anteriorly to engage anterior cortex	36 (75)	110 (73)		
Straight intramedullary	12 (25)	40 (27)		
Kirschner wire turned 150° and impacted into the proximal ulna			1.2 (0.66–2.4)	0.52
Yes	31 (62)	88 (59)		
No	18 (36)	60 (40)		
1 impacted, 1 not impacted	1 (2)	1 (1)		
Tension wire size			0.95 (0.65–1.4)	0.40
16 and 18 gauge	32 (67)	95 (60)		
20 and 22 gauge	16 (33)	64 (40)		
Number of tension wires			0.87 (0.47–1.6)	0.76
Single	41 (67)	116 (64)		
Double	20 (33)	65 (36)		
Number of knot per wire			1.2 (0.51–2.8)	0.83
One	8 (15)	28 (17)		
Two	46 (85)	134 (83)		
Location of knot(s)			0.87 (0.51–1.5)	0.82
Lateral	5 (10)	11 (7)		
Medial	1 (2)	4 (3)		
Each side	45 (88)	136 (90)		
Plate type			0.87 (0.53–1.4)	0.76
Synthes precontoured (Paoli, PA, USA)	22 (76)	58 (66)		
Acumed (Hillsboro, OR, USA)	3 (10)	17 (19)		
LCP (Synthes, Paoli, PA, USA)	2 (7)	8 (9)		
LC-DCP (Synthes)	2 (7)	4 (5)		
EPS Ortholoc (Wright Medical, Arlington, TN, USA)	0 (0)	1 (1)		
Injury side			0.62 (0.39–0.99)	0.061
Left	63 (64)	153 (52)		
Right	36 (36)	140 (48)		

* According to the medical records; CI = confidence interval.

Table 3. Multivariable analysis—factors associated with implant removal (n = 392)

Parameter	Adjusted odds ratio	Adjusted 95% confidence interval	Adjusted p value
Age per 10 years	0.75	0.64–0.87	< 0.001
Charlson Comorbidity Index	0.89	0.76–1.0	0.139
Gender	0.31	0.17–0.55	< 0.001
Injury side	0.66	0.40–1.1	0.105

pullout. However, the number of reoperations and implant removal after open reduction and internal fixation of isolated olecranon fractures remains high and patient-related

and fracture-related factors associated with reoperation and implant removal are incompletely understood.

The objective of this study was to investigate factors associated with reoperation and implant removal after open reduction and internal fixation of a displaced olecranon fracture that is not part of a fracture-dislocation. One-fourth of the patients requested implant removal. The most common single indication for reoperation was for implant removal, but only a small percentage of these procedures was performed for implant migration. Women and younger patients were more likely to request reoperation and implant removal. The specific surgeon and the type and configuration of the implant were not associated with implant removal.

Table 4. Bivariate analyses—factors associated with implant removal (n = 392)

Parameter	Implant removal (n = 92 [23%])		Odds ratio (CI)	p value
	Yes Mean (SD)	No Mean (SD)		
Age (years)	50 (18)	58 (20)	0.98 (0.97–0.99)	< 0.001
Charlson Comorbidity Index	0.64 (1.7)	1.4 (2.3)	0.81 (0.79–0.95)	< 0.001
Experience surgeon (years)	11 (8.5)	10 (8.5)	1.0 (0.98–1.0)	0.81
Duration (hours)	1.3 (1.6)	1.4 (1.1)	0.94 (0.73–1.2)	0.62
Plate length (cm distal to fracture)	6.2 (1.5)	6.5 (1.9)	0.90 (0.70–1.1)	0.40
	Number (%)	Number (%)	Odds ratio (CI)	p value
Gender			0.57 (0.35–0.92)	0.023
Men	33 (36)	151 (50)		
Women	59 (64)	149 (50)		
Diagnosed obesity			1.4 (0.64–3.3)	0.38
Yes	9 (10)	21 (7)		
No	83 (90)	279 (93)		
Smoking*			1.2 (0.66–2.2)	0.52
Yes	17 (18)	47 (16)		
No	75 (82)	253 (84)		
Head injury			0.80 (0.29–2.2)	0.81
Yes	5 (5)	20 (7)		
No	87 (95)	280 (93)		
Open fracture			1.4 (0.64–3.3)	0.38
Yes	9 (10)	21 (7)		
No	83 (90)	279 (93)		
Other fracture			0.92 (0.44–1.9)	1.0
Yes	10 (11)	35 (12)		
No	82 (89)	265 (88)		
Other fracture same limb			0.55 (0.22–1.3)	0.24
Yes	6 (7)	34 (11)		
No	86 (93)	266 (89)		
Hospital			1.5 (0.91–2.4)	0.12
Hospital 1	59 (64)	218 (73)		
Hospital 2	33 (36)	82 (27)		
Fracture type			1.2 (0.73–1.9)	0.55
Mayo 2A	51 (22)	177 (59)		
Mayo 2B	41 (25)	121 (41)		
Figure of eight	56 (22)		0.80 (0.49–1.3)	0.38
Yes	56 (61)	198 (66)		
No	36 (39)	102 (34)		
Plate fixation			1.3 (0.78–2.1)	0.38
Yes	36 (39)	102 (34)		
No	56 (61)	198 (66)		
Kirschner wires parallel			1.2 (0.57–2.3)	0.72
Yes	15 (31)	43 (28)		
No	34 (69)	113 (72)		
Size of Kirschner wires			1.1 (0.55–2.4)	0.86
0.045 inch	12 (23)	45 (26)		
0.062 inch	40 (77)	131 (74)		

Table 4. continued

	Number (%)	Number (%)	Odds ratio (CI)	p value
Angle Kirschner wires			0.92 (0.43–2.0)	1.0
Anteriorly to engage anterior cortex	33 (75)	113 (73)		
Straight intramedullary	11 (25)	41 (27)		
Kirschner wire turned 150° and impacted into the proximal ulna			1.1 (0.55–2.0)	0.59
Yes	18 (39)	60 (39)		
No	27 (59)	92 (60)		
1 impacted, 1 not impacted	1 (2)	1 (1)		
Tension wire size			0.91 (0.61–1.4)	0.39
16 and 18 gauge	29 (67)	98 (60)		
20 and 22 gauge	14 (33)	66 (40)		
Number of tension wires			0.84 (0.45–1.6)	0.64
Single	38 (68)	119 (64)		
Double	18 (32)	67 (36)		
Number of knot per wire			1.3 (0.53–3.2)	0.67
One	7 (14)	29 (17)		
Two	43 (86)	137 (83)		
Location of knot(s)			0.97 (0.54–1.7)	1.0
Lateral	4 (9)	12 (8)		
Medial	1 (2)	4 (3)		
Each side	42 (89)	139 (90)		
Plate type			0.90 (0.55–1.5)	0.77
Synthes precontoured (Paoli, PA, USA)	21 (75)	59 (66)		
Acumed (Hillsboro, OR, USA)	3 (11)	17 (19)		
LCP (Synthes, Paoli, PA, USA)	2 (7)	8 (9)		
LC-DCP (Synthes)	2 (7)	4 (4)		
EPS Ortholoc (Wright Medical, Arlington, TN, USA)	0 (0)	1 (1)		
Injury side			0.58 (0.36–0.94)	0.031
Left	60 (65)	156 (52)		
Right	32 (35)	144 (48)		

* According to the medical records; CI = confidence interval.

This study should be interpreted with its limitations in mind. The data registry is drawn from two Level I trauma centers that might not be representative of all Level I trauma centers.

We used ICD-9 and CPT codes to identify the initial diagnoses and procedures rather than review of the medical records. ICD-9 and CPT codes could be miscoded. We may have had insufficient power to detect small but important differences related to implant choice and configuration. Lastly, this study design is retrospective, which makes it inherently more susceptible to data loss, bias, and confounding than a prospective study. For example, in 189 patients, the followup was less than one year.

Women and younger patients were more likely to have a reoperation for any reason and more likely to request implant removal specifically. Consistent with our results, prior research found infection, implant failure, and symptoms related to the implants were the most common reasons for reoperation [9, 15]. Our study found that personal rather than technical or injury factors had the greatest influence on requests for implant removal. Only 12 implants (3%) in our study were removed as a result of migration or loosening. Implant removal was mostly discretionary. Contrary to our findings, Saeed and colleagues [20] found that reoperation and implant removal were more common with age and thought this might be related to fixation problems in

osteoporotic bone. It is not clear why this difference was observed. The mean age was similar to the age in our cohort. Their cohort was smaller than ours and they only included patients with tension band wire fixation.

Women and younger patients were more likely to have a second operation or request or accept the offer of implant removal no matter the type of implant and the technical variations. In an attempt to understand our findings, we posit that women—younger women in particular—might have smaller elbows and less subcutaneous fat leading to more bothersome implants. On the other hand, they might simply prefer to remove the implants more than older patients and men. The selection of method of fixation should be based on the treatment of the fracture. Patients who have operative fixation of a fracture of the olecranon can be counseled that most patients keep their implants, that only 3% experience implant migration, and that technical factors such as the type or configuration of an implant seem less important than personal factors in determining who requests a second surgery for implant removal.

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