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ORIGINAL PAPER

Olecranon fractures: factors influencing re-operation

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Abstract
Purpose We evaluated factors influencing re-operation in tension band and plating of isolated olecranon fractures.
Methods Four hundred eighty-nine patients with isolated olecranon fractures who underwent tension band (TB) or open reduction internal fixation (ORIF) from 2003 to 2013 were identified at an urban level 1 trauma centre. Medical records were reviewed for patient information and complications, including infection, nonunion, malunion, loss of function or hardware complication requiring an unplanned surgical intervention. Electronic radiographs of these patients were reviewed to identify Orthopaedic Trauma Association (OTA) fracture classification and patients who underwent TB or ORIF.
Results One hundred seventy-seven patients met inclusion criteria of isolated olecranon fractures. TB was used for fixation in 43 patients and ORIF in 134. No statistical significance was found when comparing complication rates in open versus closed olecranon fractures. In a multivariate analysis, the key factor in outcome was method of fixation. Overall, there were higher rates of infection and hardware removal in the TB compared with the ORIF group.
Conclusions Our results demonstrate that the dominant factor driving re-operation in isolated olecranon fractures is type of fixation. When controlling for all variables, there is an increased chance of re-operation in patients with TB fixation.

Keywords Olecranon · Fracture · Tension band · Plate fixation · Hardware removal

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Introduction

Simple olecranon fractures account for approximately 10 % of upper-extremity fractures and occur across all age groups [1, 2]. The majority of olecranon fractures is treated surgically with favourable outcomes, with 84 % of patients in one 15–25-year follow-up study reporting no long-term complications [3]. However, despite the availability of several different fixation techniques for treating olecranon fractures, there exists relatively little comparative outcomes research to guide surgical decision making. The decision regarding which surgical technique to use in repairing simple olecranon fractures is largely dependent on surgeon preference (Figs. 1 and 2).

Commonly used treatment methods for internal fixation of olecranon fractures include plate fixation, tension-band (TB) wiring and intramedullary screw fixation [4]. Whereas open reduction internal fixation (ORIF) is considered the most effective treatment for comminuted olecranon fractures, there is debate about whether TB or ORIF is more effective for treating simple fracture patterns [5]. Previous studies comparing rates of re-operation following TB and ORIF of olecranon fractures have yielded equivocal results [6–8]. For both types of fixation, the most common postoperative complications leading to re-operation include arthrosis, infection, ulnar neuritis and symptomatic hardware issues requiring removal [8–11]. Whereas the overall incidence of complications for both TB and ORIF of olecranon fractures is relatively low, it would be advantageous for surgeons to possess additional outcome data for both techniques in order to guide their surgical decisions and reduce re-operation rates. The primary goal of this study was to compare factors influencing complication rates for both TB and ORIF of isolated olecranon fractures over the course of ten years at a single level 1 trauma centre. An additional aim of the study was to compare the two types of fixation techniques in terms of rates of re-operation requiring hardware removal.

Fig. 1 Typical olecranon fracture. Orthopaedic Trauma Association (OTA) classification B1–21

Methods

After receiving approval from the Vanderbilt Institutional Review Board, we performed a retrospective study of patients who underwent fixation of an olecranon fracture (CPT code 24685) at our level 1 trauma centre. All patients who underwent operative treatment from August 2003 to July 2013 were included in the study. We excluded patients with other injuries to the ipsilateral extremity and skeletally immature patients. The fracture pattern was determined from analysis of preoperative images and classified using the Orthopaedic Trauma Association (OTA) system. Open fractures were identified on the basis of resident and attending physician documentation. Each patient chart was examined to obtain demographic information, including age, sex, body mass index (BMI) and American Society of Anesthesiologists (ASA) classification. Operative reports and electronic radiographs were reviewed to identify patients who underwent TB or ORIF. Individual charts were reviewed for complications following operative management. These included nonunion, malunion, postoperative infection, loss of function, fixation failure, elective implant removal and other complications requiring an unplanned surgical intervention. Information regarding postoperative course was obtained from follow-up clinic notes, emergency department notes and subsequent operative reports. To confirm and validate interobserver reliability in our review, two authors performed the chart analysis of all notes and reports.

To test for differences in average age of treatment and hardware removal groups, Student's t test for independent samples was used. All differences in proportions were tested with Pearson's chi-squared test, except in cases with fewer than ten variables, in which case Fisher's exact test was used. To determine differences in outcomes between treatment groups, multivariate logistic regression was used. In analysing re-operation rates within the study, we controlled for treatment type, age, ASA score, gender and open fractures. After analysis, we reported adjusted odds ratios (OR) and their corresponding 95 % confidence intervals (CI) along with p values. P values for all analyses were considered to significantly depart from chance at a $p<0.05$.

Results

Four hundred ninety-six charts of patients treated for olecranon fractures were originally surveyed. We excluded patients who were < 16 years and limited the study to patients who treated only by ORIF or TB. Patients treated nonoperatively and with triceps advancement were surveyed but not used in analysis. Additionally, only isolated olecranon fractures were considered. After all charts were reviewed, 177 patients met inclusion criteria. One hundred thirty-four (75.70 %) were treated with ORIF and 43 (24.30 %) with TB. No significant differences in demographic data were found between groups. Average age ($p=0.503$) and ASA score ($p=0.159$) were slightly higher in the ORIF group. Female patients accounted for 26 (60.47 %) in the TB group and 70 (52.2 %) in the ORIF group ($p=0.383$) (Table 1).

Within the ORIF group, 40 patients (29.85 %) had open fractures compared with ten (23.26 %) in the TB group, though the difference in proportion was not significant ($p=0.443$). Within the open fracture group, the proportions of types 1, 2 and 3 open fractures were roughly equal across the two treatment methods ($p=0.715$), with type 2 open fractures being the most common. The most common OTA fracture classification was 21–B1, which made up 172 (97.17 %)

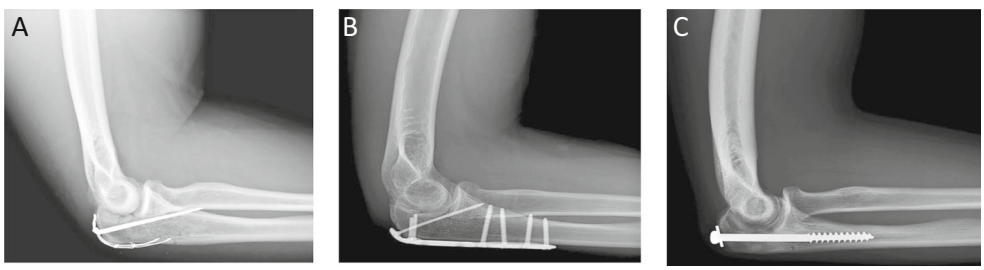

Fig. 2 Olecranon fracture after operative fixation. **a** Tension band (TB). **b** Open reduction internal fixation (ORIF). **c** Screw fixation

Table 1 Demographics of olecranon fracture patients

	ORIF (*N*=134)		Tension band (*N*=43)		*P* value
	N	%	*N*	%	
Age years (mean)	45.8 (27–61) [20.3]		43.27 (22–54) [21.8]		0.503
Sex					
Male	64	47.76	17	39.53	0.383
Female	70	52.24	26	60.47	
ASA					
Mean	2.48 (0.809)		2.23 (0.777)		0.159
1	12	8.95	8	18.60	
2	61	45.52	18	41.86	
3	44	32.84	15	34.88	
4	16	11.19	2	4.65	

ORIF open reduction internal fixation, *ASA* American Association of Anaesthesiologists

of the 177 patients, though there were 12 patients whose OTA status was unreported (Table 2).

Table 3 outlines the measured outcomes in the study. Twenty-three patients (53.49 %) in the TB group had some sort of complication after surgery, which was a significantly higher proportion than the 41 patients (30.60 %) in the ORIF group (p=0.011). The rates of re-operation were statically significant. Twenty patients (46.51 %) with TB fixation required hardware removal, which was a remarkably higher percentage than the 25 patients (18.66 %) in the ORIF treatment group (p=0.0006). Hardware prominence made up the greatest proportion of complications in both groups, accounting for 39.53 % and 65.22 % of the complications in the ORIF and TB treatment cohorts, respectively (Fig. 3).

Table 2 Factors influencing treatment for patients with olecranon fractures

	ORIF (*N*=134)		Tension band (*N*=43)		*P* value
	N	%	*N*	%	
Open fracture (*N*=50)					
Yes	40	29.85	10	23.26	0.443
No	94	70.15	33	76.74	
Open type					
1	11	27.50	2	20.00	0.715
2	22	55.00	5	50.00	
3	7	17.50	3	30.00	
OTA class					
21–A1	2	1.49	1	2.33	0.248
21–B1	131	97.76	41	95.34	
21–C1	0	0.00	1	2.33	

ORIF open reduction internal fixation, *OTA* Orthopaedic Trauma Association

In a univariate analysis of patients who underwent re-operation, the only significant difference in patients with and without re-operation was the original method of fixation (Table 4). Twenty (44.44 %) of the 45 patients who had hardware removed were within the TB group, whereas 23 (17.42 %) of the 132 patients who did not have hardware removal fell within the TB group. This difference significant, with p=0.0004. Re-operated patients were 41.3 years old on average, but this was not significantly different from the 46.5-year average of single-surgery patients (p=0.134). Gender distribution of re-operation patients was nearly equal, with 23 men (51.11 %) undergoing re-operation, and in the group without re-operation, 74 were women (56.06 %) (p=0.489). ASA scores of re-operated patients averaged 2.29, which was slightly lower than the rest of patients, who averaged 2.47 (p=0.667). Open fractures accounted for 24.44 % of re-operated patients, which was not significantly different from the 29.55 % of patients who were not re-operated and who had open fractures (p=0.569). The distribution of open fracture grades was also equal within the two groups (p=0.815), with grade 2 being most common in each group. Remarkably, the OR comparing re-operated TB to ORIF was 4.0 (Table 5), indicating a four-times increased chance of re-operation in the TB group.

Discussion

Although TB and ORIF are both effective treatments for olecranon fractures, studies are inconclusive as to the ideal method of fixation due to the lack of comparative outcomes research. This study sought to gain insight into the factors influencing complication rates for both TB and ORIF and compare rates of re-operation in order to assist with

Table 3 Outcomes for patients with olecranon fractures

	ORIF (*N*=134)		Tension band (*N*=43)		*P* value
	N	%	*N*	%	
Overall complication rate					0.011
Yes	41	30.60	23	53.49	
No	93	69.40	20	46.51	
Hardware removal					0.0006
Yes	25	18.66	20	46.51	
No	109	81.34	23	53.49	
Other complications					
Prominent hardware	17	39.53	15	65.22	
Infection	8	18.60	6	26.09	
Arthritis	1	2.33	0	0.00	
Loss of range of movement	4	9.30	0	0.00	
Heterotopic ossification	10	23.26	2	8.70	
Nonunion	4	9.30	0	0.00	
Hardware failure	1	2.33	0	0.00	

ORIF open reduction internal fixation

surgical decision making. Both TB and ORIF of olecranon fractures have low overall complication rates [3]. In recent years, plate fixation has been favored over TB due to biomechanical studies that have exposed some deficiencies in TB [6, 12]. A study conducted by Wilson et al. demonstrated that ORIF applied significantly greater fracture compression compared with TB in treatment of transverse olecranon fractures [13]. In addition, cadaver models of transverse olecranon fractures have demonstrated a biomechanical advantage for ORIF over TB both at rest and during active movements [14]. However, despite the biomechanical evidence suggesting the advantage of ORIF over TB, relatively little comparative outcomes research comparing the two surgical techniques in the context of olecranon fractures exists. The results of this study determined that patients with olecranon fractures who underwent TB were significantly more likely to undergo re-operation and hardware removal compared with patients who underwent ORIF.

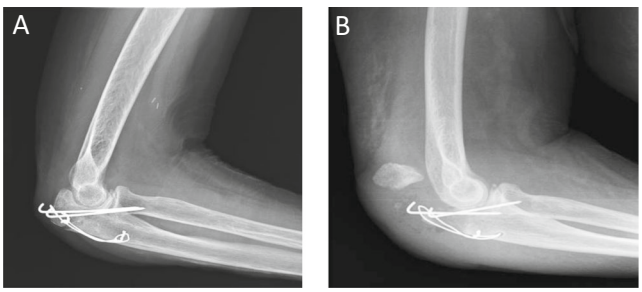

Fig. 3 Complications with tension band (TB). **a** A 77-year-old woman had a ground-level fall. She sustained a 21–B1 closed olecranon fracture, which was treated with TB. She complained of hardware prominence at her first clinic visit. Hardware removal was delayed until postoperative week 8 to allow for union. The single prominent pin was removed, and she went on to union. **b** An 84-year-old woman fell down stairs. She sustained a 21–B1 closed olecranon fracture, which was treated with TB. On postoperative week 4, she had increased pain and redness at her elbow. X-rays confirmed loss of fixation due to infection. She underwent hardware removal without further fixation

In 1992, Hume et al. studied 41 patients with displaced olecranon fractures and compared TB and ORIF. Although their study found that ORIF resulted in higher rates of favourable clinical and roentgenographic results compared with TB wiring, there was no significant difference in complication rates or elbow range of motion (ROM) after surgery between the two techniques [6]. However, results from our study suggest that ORIF of olecranon fractures results in lower re-operation rates compared with TB. In fact, our study reports that re-operation after TB of olecranon fractures is more than twice as likely compared with ORIF (46.51 % vs. 18.66 %, respectively). TB fixation is the only statistically significant factor in differentiating between patients who underwent re-operation.

The clinical implications of these results are significant in the context of both patient welfare and costs to the health-care system as a whole. At our level 1 trauma institution, the cost of a TB construct, which includes a 4.0-mm cannulated screw or 2-mm K wires and one 18-gauge wire, costs between US $150 and $353. By comparison, a six-hole locking olecranon plate costs US $755.00 without accounting for screws. However, if a patient requires hardware removal, there is an additional cost of operation room time, hospital stay and surgeon cost. More importantly, there is increased patient morbidity, including the risk of additional anaesthesia and another operation.

Table 4 Analysis of hardware removals for patients with olecranon fractures

	Removed (*N*=45)		Not removed (*N*=132)		*P* value
	N	%	*N*	%	
Age	41.3 (22–53) [19.1]		46.5 (27–63) [21.1]		0.134
Gender					
Male	23	51.11	58	43.94	0.489
Female	22	48.89	74	56.06	
ASA					
Mean	2.29 (0.814)		2.47 (0.803)		0.667
1	6	13.33	12	9.09	
2	20	44.44	57	43.18	
3	12	26.67	46	34.85	
4	3	6.67	13	9.85	
Unlisted	4	8.89	4	3.03	
Treatment					
ORIF	25	55.56	109	82.58	0.0004
Tension band	20	44.44	23	17.42	
Open fracture					
Yes	11	24.44	39	29.55	0.569
No	34	75.56	93	70.45	
Open grade					
1	3	27.27	10	25.64	0.815
2	5	45.45	22	56.41	
3	3	27.27	7	17.95	
OTA class					0.248
21–A1	1	2.22	2	1.52	
21–B1	42	93.33	119	90.15	
21–C1	0	0.00	1	0.76	
Unlisted	2	4.44	10	7.58	
Reason for removal					
Prominent hardware	32	71.11		N/A	
Infection	6	13.33		N/A	
Arthritis	0	0.00		N/A	
Loss of ROM	0	0.00		N/A	
Heterotopic ossification	5	11.11		N/A	
Union	0	0.00		N/A	
Hardware failure	1	2.22		N/A	
Multiple	1	2.22		N/A	

ASA American Society of Anaesthesiologists, *ORIF* open reduction internal fixation, *OTA* Orthopaedic Trauma Association, *ROM* range of motion, *N/A* not available

Table 5 Multivariate analysis of complications in patients with olecranon fractures

	OR	95 % CI	*P* value
Re-operation (Tension banding vs. ORIF)	4.03	1.78–9.06	0.000624

ORIF open reduction internal fixation, *OR* odds ratio, *CI* confidence interval

This study determined the most common postoperative complication for both TB and ORIF of olecranon fractures was hardware prominence. The same complication requiring revision re-operation has been noted as common in previous literature, as well [1]. However, the findings in this study demonstrate that the incidence of complications differs postoperatively for TB and ORIF. Whereas similar types of complications arise after both TB and ORIF, including infection, nonunion, and hardware prominence, this study found that complication rates were significantly higher after TB

compared with ORIF [7, 9]. After controlling for demographic factors, the relationship between TB and increased incidence of complications remained evident—a trend that may lead to increased overall risks and cost of care for patients who undergo TB.

The most common patient complaint leading to revision surgery was painful hardware, which was seen in > 80 % of the re-operation group. This was a result of prominent hardware, infection or hardware failure. Other complaints included inability to perform activities of daily living, loss of motion and the desire not to have hardware in for the rest of their life.

The authors recognise several limitations to this study. First, data was gathered retrospectively and limited to patients treated at a single level 1 trauma centre. A comprehensive electronic medical record allowed for effective data collection, but the study is also limited by the inability to prospectively define study parameters and to randomise surgical treatments received by the patients. In addition, variability in surgeons' experience and preference for TB versus ORIF is not accounted for. Some fractures most likely were not appropriate for TB due to comminution and ORIF was thus used. Our findings remain relevant to all fractures that can be treated with either TB or ORIF. Different surgeons may have different parameters for using TB versus ORIF for olecranon fractures, such as injury pattern or patient demographics, thereby influencing study results. Surgeons also vary in their willingness to remove hardware. In addition, variability in postoperative patient behaviours, such as rehabilitation programmes, is not accounted either, and may have an effect on postoperative complication rates.

Overall, this study demonstrated that ORIF has lower complication and re-operation rates compared with TB for olecranon fracture fixation. The robust sample size of this study increases the significance of these results. Despite the fact that overall complication rates for olecranon fractures is low for both surgical techniques, the increased risk of re-operation with TB compared with plate fixation has major patient consequences. Orthopaedic surgeons need to consider these differences in postoperative outcomes when deciding between fixation techniques for olecranon fractures.

Conflicts of interest and source of funding Author William Obremskey has previously consulted for Biometrics and done expert testimony in legal matters. The institution of WTO has received a grant from the Department of Defense. The remaining authors have no conflict of interests.

References

1. Rommens P, Schneider R, Reuter M et al (2004) Olecranon fractures in adults: factors influencing outcome. Injury 35(11):1149–1157
2. Baecher N, Edwards S (2013) Olecranon fractures. J Hand Surg 38(3):593–604
3. Karlsson MK, Hasserius R, Karlsson C et al. (2002) Fractures of the olecranon: a 15 to 25-year followup of 73 patients. Clin Orthop Relat Res (403):205–212
4. Newman SD, Mauffrey C, Krikler S (2009) Olecranon fractures. Injury 40(6):575–581
5. Buijze G, Kloen P (2009) Clinical evaluation of locking compression plate fixation for comminuted olecranon fractures. J Bone Joint Surg Am 91(10):2416–2420
6. Hume MC, Wiss DA (1992) Olecranon fractures. A clinical and radiographic comparison of tension band wiring and plate fixation. Clin Orthop Relat Res 285:229–235
7. Romero JM, Miran A, Jensen CH (2000) Complications and re-operation rate after tension-band wiring of olecranon fractures. J Orthop Sci Off J Japan Orthop Assoc 5(4):318–320
8. Bailey CS, MacDermid J, Patterson S et al (2001) Outcome of plate fixation of olecranon fractures. J Orthop Trauma 15(8):542–548
9. Macko D, Szabo RM (1985) Complications of tension-band wiring of olecranon fractures. J Bone Joint Surg Am 67(9):1396–1401
10. Lindenhovius AL, Brouwer K, Doornberg J et al (2008) Long-term outcome of operatively treated fracture-dislocations of the olecranon. J Orthop Trauma 22(5):325–331
11. Ishigaki N, Uchiyama S, Nakagawa H et al (2004) Ulnar nerve palsy at the elbow after surgical treatment for fractures of the olecranon. J Shoulder Elbow Surg 13(1):60–65
12. Hutchinson DT, Horwitz DS, Ha G et al (2003) Cyclic loading of olecranon fracture fixation constructs. J Bone Joint Surg Am 85-A(5):831–837
13. Wilson J, Bajwa A, Kamath V et al (2011) Biomechanical comparison of interfragmentary compression in transverse fractures of the olecranon. J Bone Joint Surg Br 93(2):245–250
14. Duckworth AD, Clement N, Aitken S et al (2012) The epidemiology of fractures of the proximal ulna. Injury 43(3):343–346