Long-term Outcome of Displaced, Transverse, Noncomminuted Olecranon Fractures

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Abstract

Background Operative treatment of a displaced, transverse, noncomminuted fracture of the olecranon is associated with good to excellent elbow function in retrospective short-term followup studies. However, to our knowledge, no studies have evaluated objective and subjective outcomes using standardized outcome instruments (ie, DASH and Mayo Elbow Performance Index [MEPI]) to quantify long-term outcome of these specific fractures.

Questions/purposes We evaluated (1) factors associated with disability, as measured with the DASH questionnaire; (2) factors associated with ulnohumeral motion; (3) factors

associated with pain intensity; and (4) general descriptive findings for posttraumatic arthrosis, MEPI, ulnar neuropathy symptoms, and return to work between 10 and 32 years after open reduction and internal fixation (ORIF) of a transverse, noncomminuted fracture of the olecranon.

Methods Between 1977 and 1997, we performed ORIFs of transverse, noncomminuted olecranon fractures in 109 patients, of whom 35 had died, 14 had incomplete data in our registry, and 19 were lost to followup or declined participation, leaving 41 patients available for followup at a minimum of 10 years after surgery. During that time, our general indication for performing ORIF was greater than 2 mm displacement. The average age of these patients at the time of injury was 35 years (range, 18–73 years). Patient-reported outcome was quantified using the DASH questionnaire, and physician-based outcome was evaluated using the MEPI. To identify factors associated with disability (DASH), impairment (MEPI), ulnohumeral motion, and pain, we examined demographic and clinical data in bivariate analyses, and subsequently significant factors in

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multivariate analysis to identify independent predictors of outcome.

Results The sole factor associated with higher DASH scores in multivariable analysis was age at surgery, explaining 20% of the variability, with younger patients performing better. The mean arc of elbow flexion was 142° (range, 110°–160°), and the variation was associated with arthrosis alone (ie, a greater arc of motion was associated with a lesser grade of arthrosis according to the system of Broberg and Morrey). Pain was uncommon and generally was correlated with adverse events.

Conclusions The good results of operative fixation (tension-band wiring) of a transverse, displaced olecranon fracture are durable with time. Patient-reported outcomes are excellent in the majority of patients. Residual patient-rated disability does not correlate with arthrosis or loss of extension.

Level of Evidence Level IV, therapeutic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

The operative treatment of a displaced, transverse, non-comminuted fracture of the olecranon is associated with good to excellent elbow function in retrospective short-term followup studies [5, 26]. Figure-of-eight tension-band wiring is a common and widely used operative technique [8], although alternative techniques continue to evolve [14–16, 20, 25]. Major complications are uncommon [4, 9, 27, 28], and functional results are satisfactory in the majority of patients [5, 11, 26, 29].

Karlsson et al. [12] reported excellent outcomes in 96% of patients an average of 19 years after operative treatment of closed olecranon fractures; however, they did not discriminate between fragmented and simple fractures. They did not use standardized outcome instruments (DASH and Mayo Elbow Performance Index (MEPI)) to quantify long-term outcome, and AO tension-band wiring was used in only 30% of patients [12]. The concept of tension-band wiring has been challenged in recent literature [2, 30], as the premise that distraction forces on the outer cortex are converted to compression forces over the fracture fragments does not hold in biomechanical studies. van der Linden et al. [28] however, reported an average score on the DASH questionnaire of 12 points (SD, ± 16) and 71% excellent, 24% good, and 5% poor categorical ratings using the MEPI a median 59 months after surgery, provided that K wires are placed transcortical.

To our knowledge, there are no studies evaluating patients' pain and function using standardized instruments (ie, patient-reported outcome measures) at a minimum

followup of 10 years after operative treatment of olecranon fractures. In addition, satisfactory long-term elbow function (according to physician-based outcome instruments) of tension-band wiring for simple olecranon fractures would weaken the argument for more advanced expensive fixation techniques, despite the current biomechanical literature that challenged the concept of tension-band wiring [2, 30].

The objective of our study was to evaluate disability (patient-based outcome) and impairment (physician-based outcome) at a minimum of 10 years after operative treatment of a displaced, transverse olecranon fracture. Specifically, we evaluated factors associated with (1) disability, as measured with the DASH [10]; (2) ulnohumeral motion; (3) pain intensity; and (4) general descriptive findings for posttraumatic arthrosis, MEPI, ulnar neuropathy symptoms, and return to work.

Patients and Methods

Between 1974 and 1997, all trauma patients treated and admitted to our Level I trauma center were prospectively documented in a trauma database classified according to the Comprehensive Classification of Fractures [23]. Among 201 patients treated for an olecranon fracture during this time, 109 skeletally mature patients had a displaced transverse, noncomminuted fracture treated with open reduction and internal fixation, and so were considered for review in this study.

Of these 109 patients, 35 (34%) had died and 14 could not be included because of incomplete demographic data (incorrect or missing name and/or date of birth). Among the remaining 60 patients, one had left The Netherlands, seven did not respond or could not be contacted after three written and/or three phone requests, and 11 declined participation. The remaining 41 patients (68% of the 60 available subjects) returned for a free evaluation and radiographs a minimum of 10 years after injury under a protocol approved by our institutional review board. The evaluation was performed an average of 20 ± 6 years after surgery (range, 10–32 years).

There were 23 men and 18 women with a mean age of 35 years (range, 18–73 years) at the time of injury. The right arm was involved in 12 patients (nine dominant) and the left in 29 patients (three dominant). At the time of injury 33 patients were working: four were laborers, 20 were professionals, four were homemakers, four were students, and one was in the military. Five were unemployed, one was retired, and occupation was not recorded for two patients. Of the 41 patients, 12 were injured in a fall from a standing height, five in a fall from a greater height, nine in a bicycle accident, eight in a motor vehicle collision, five had a sports-related injury, one had a

crushing injury (between a conveyer belt), and one was injured by a direct blow.

Fracture classification was based on injury radiographs and intraoperative observations documented in the medical record according to the Comprehensive Classification of Fractures [23]. One patient had an ipsilateral fracture of the distal radius and one had an ipsilateral shoulder dislocation. Five patients had fractures at other sites.

Twenty-six different orthopaedic and general trauma surgeons treated these patients and no general standardized protocols were used. Our general indications for performing surgical treatment were displacement greater than 2 mm and surgical indications, technique, and implant choice were per surgeon preference. Tension-band wiring was used in 37 patients (four with an additional screw and one with an additional K wire), plate and screw fixation was used in three patients, and one patient was treated with screws alone. We have insufficient data regarding patients' individual postoperative exercises. Rehabilitation protocol was per surgeon preference as well, ranging from immediate postoperative mobilization to 2 weeks of complete immobilization wearing a cast for wound healing.

Three patients (7%) had subsequent surgery to address a complication: one for a deep surgical site infection, one for a prominent screw penetrating the radius, and one for loss of alignment. One of these patients had disproportionate pain and disability at the time of followup.

Implant removal was routine during the study period. Thirty-six (88%) patients had implants removed by the time of the long-term followup: 34 with tension-band wiring and two with plate fixation. Twenty-two patients had their implants removed during the first year after surgery. Three patients retained the implant: two had part of a K wire and one had part of a screw retained.

One investigator (HF), who was not involved in the initial care of the patients, evaluated patients in a research-specific followup, which consisted of an interview, physical examination, radiographs, and completion of the MEPI [22] and the DASH questionnaire [10].

The MEPI consists of the physician's assessment of pain, ulnohumeral motion, stability, and ability to perform functional tasks in activities of daily living. Categorical ratings are assigned as follows: 90 to 100 points is excellent; 75 to 89 points is good, 60 to 74 points is fair, and less than 60 points is poor [22].

The DASH questionnaire evaluates difficulty performing specific tasks and symptoms, social function, work function, sleep, and confidence. The score is scaled between 0 and 100 with higher scores indicating worse upper extremity function. For this study, a validated Dutch language translation of the DASH questionnaire was used [10].

As a quantitative measure of pain for use in all analyses, we used the pain subscales of the American Shoulder and

Elbow Surgeons (ASES) Elbow Evaluation Instrument [13]. Patients rated their pain from 0 (no pain) to 10 (worst imaginable pain) on five 11-point ordinal scales: pain when it is at its worst; pain at rest; pain lifting a heavy object; pain when doing a task with repeated elbow movements; and pain at night. The summary pain score ranges from 0 to 50 points with 0 point indicating no pain [13].

Ulnar neuropathy was graded according to the McGowan scale: Grade 1, minimal lesions with no detectable motor weakness of the hand; Grade 2, intermediate lesions; and Grade 3, severe lesions with paralysis of one or more of the ulnar intrinsic muscles [21].

Arthrosis was rated by an independent observer (PK) according to the system of Broberg and Morrey [3]: Grade 0, normal joint; Grade 1, slight joint-space narrowing with minimum osteophyte formation; Grade 2, moderate joint-space narrowing with moderate osteophyte formation; and Grade 3, severe degenerative change with gross destruction of the joint.

Statistical analyses were performed to evaluate the role of pain in measurements of elbow function [6], and these analyses subsequently were used to identify predictors of long-term outcome for fractures around the elbow [1, 7, 18]. Continuous data are presented in terms of the mean, standard deviation, and range. To find factors associated with disability, ulnohumeral motion, pain, patient-based outcome (DASH), and physician-based outcome (MEPI), we examined demographic and clinical data. To evaluate the association between predictor variables and each outcome instrument we used the Pearson product-moment correlation coefficient for continuous variables, the Mann-Whitney U test for dichotomous nominal variables, and the Kruskal Wallis test for variables on ranks. We identified significant factors associated with the outcome instruments when p was less than 0.10. Multivariate analysis was based on a backward stepwise procedure using the significant independent predictors for each outcome instrument as described above, with use of adjusted r squared. We considered pain related to DASH and did not use them as explanatory variables in the multivariable statistics. The data were analyzed using SPSS software package, version 17.0.0 (SPSS Inc, Chicago, IL, USA).

Results

Patient-reported outcomes (DASH) are excellent in the majority of patients. Residual patient-rated disability does not correlate with posttraumatic arthrosis or loss of extension. Multivariate analyses to identify factors associated with disability, as measured with the DASH, revealed that the only risk factor for greater disability in terms of the DASH score was older age at surgery; and this

Table 1. Multivariable analysis

Models and variables	Backward stepwise linear regression analysis	
	Adjusted R2*	p value
DASH		
Age at surgery	0.20	< 0.01
Arc of elbow flexion and extension		
Arthrosis (Broberg & Morrey)	0.08	0.03

* R2 = percentage of overall variability in the dependent variable explained or accounted for by the independent variables in the model.

explained 20% of the variability ($p < 0.01$, adjusted $R^2 = 0.20$) (Table 1). Leading up to this, bivariate analysis revealed associations between DASH scores and age at surgery, age at time of followup, time since surgery, extension, and occupation at time of injury (Table 2). The average score on the DASH questionnaire was 10 ± 15 points (range, 0–65 points). Only four patients (10%) scored greater than 30 on the DASH (33, 37, 46, and 65), all resulting from pain; two of these were related to other conditions of the upper extremity (olecranon bursitis and frozen shoulder) and two were unexplained.

Elbow motion was functional an average of 20 years after surgery. The mean arc of elbow flexion was 142° (range, 110° – 160°), and the presence of posttraumatic arthrosis was the sole predictor for diminished ulnohumeral motion. The degree of arthrosis explained 8% of the variability in the final model ($p = 0.03$, adjusted $R^2 = 0.08$) (Table 1). The factors we used for this model were age at surgery and degree of arthrosis (correlation with flexion, extension, pronation, and supination were not taken into account), which were derived from initial bivariate analysis (Table 2). The average arc of flexion was $142^\circ \pm 9^\circ$ (range, 110° – 160°) and the average flexion contracture was $2^\circ \pm 7^\circ$. The average arc of forearm rotation was $175^\circ \pm 7^\circ$ (range, 150° – 180°) with an average pronation of $87^\circ \pm 4^\circ$ (range, 80° – 90°) and an average supination of $87^\circ \pm 6^\circ$ (range, 60° – 90°).

Pain was seen only infrequently at long-term followup and generally was correlated with adverse events, however, only with a correlation coefficient of 2.1 ($p = 0.02$) in exploratory analyses (Table 1). No other significant descriptive factors were found in our analyses; therefore we did not construct a multivariate model. The average pain score was 2 ± 6 (range, 0–34 points) on a scale from 0 (best) to 50 (worst).

General findings revealed posttraumatic arthrosis in the minority of patients, good to excellent elbow function as quantified using the MEPI, nondisabling symptoms of ulnar neuropathy, and all patients could return to work: eight (20%) of 41 patients showed radiographic signs of Grade 1 arthrosis according to Broberg and Morrey [3] (slight joint-space

narrowing with minimum osteophyte formation). The average MEPI score was 98 ± 7 points (range, 65–100 points) with 36 excellent, four good, and one fair (an unemployed woman with disproportionate pain and disability). Five patients had symptoms suggestive of ulnar nerve compression at the elbow, all classified as Grade 1 according to the scale of McGowan [21]. All employed patients with isolated olecranon fractures returned to work, however one patient with a lower limb amputation had to change jobs.

Discussion

Simple olecranon fractures are relatively uncommon injuries but they are considered the simplest intraarticular fractures to treat [8]. To our knowledge, there are no studies evaluating patient-reported outcome (DASH) and physician-based outcome (MEPI) an average of 20 years after tension-band wiring. Moreover, although clinical results of tension-band wiring are satisfactory in the short term [5, 11, 26, 29], biomechanically the concept of converting distraction forces to compression forces has been challenged [2, 30]. If good to excellent long-term elbow function is obtained clinically (as quantified with standardized outcome instruments) with inexpensive tension-band wiring for transverse olecranon fractures (90% treated with tension-band wiring), this would weaken the argument for more advanced expensive fixation techniques [2, 30]. The objective of our study was to evaluate clinical results at an average of 20 years to identify factors associated with (1) disability (DASH); (2) elbow motion; (3) pain; and (4) impairment (MEPI) and general findings (posttraumatic arthrosis, ulnar neuropathy symptoms, and return to work).

These data should be interpreted in light of the fact that this study presents the long-term results of simple olecranon fractures for 41 (55%) of 74 patients who were alive. Therefore, only a subset of patients was evaluated, likely the youngest and healthiest patients, because many of the older patients had died and missing patients generally might not be doing as well as those who return for followup. In addition, as in previous studies based on our AO database [1, 7, 18], the retrospective study design allows opportunities for the introduction of bias, and we tried to minimize these by relying on the prospective trauma database and long-term followup data collected as part of this study. Furthermore, many surgeons cared for these patients and treatment was according to the surgeon's preference because no standard protocols were used. However, fractures were treated using general AO principles which are still used today (tension-band wiring). Outcome was derived from multiple surgeons with different surgical skills, training, and expertise. This makes the results more generalizable as it resembles clinical practice, in which surgeons who perform these operations differ in skill,

Table 2. Results of bivariate analysis

Variables	DASH	p value	Arc of elbow flexion and extension	p value	Pain	p value
Spearman correlation						
Age at surgery	0.61	< 0.01	−0.46	< 0.01	NS	0.20
Age at the time of followup	0.42	0.01	NS	0.06	NS	0.54
Time since surgery	−0.43	0.01	NS	0.08	NS	0.23
Days between injury and surgery	NS	0.32	NS	0.34	NS	0.90
Flexion	NS	0.42	0.90	< 0.01	NS	0.77
Extension	−0.36	0.02	0.65	< 0.01	NS	0.21
Arc of elbow flexion and extension	NS	0.14			NS	0.58
Pronation	NS	0.38	NS	0.18	NS	0.19
Supination	NS	0.22	0.32	0.04	NS	0.65
Arc of pronation and supination	NS	0.16	0.36	0.02	NS	0.34
Pain score	0.35	0.03	NS	0.20		
Mann-Whitney U test						
Sex	NS	0.09	NS	0.07	NS	0.49
Injury to dominant arm	NS	0.90	NS	0.31	NS	0.72
Early mobilization	NS	0.23	NS	0.12	NS	0.69
Signs of ulnar neuropathy	NS	0.67	NS	0.42	NS	0.07
Complications	NS	1.00	NS	0.18	2.1	0.02
Tension band reinforcement	NS	0.98	NS	0.86	NS	0.60
Kruskal Wallis test						
Mechanism of injury	NS	0.59	NS	0.12	NS	0.29
Occupation at time of injury		0.01	NS	0.23	NS	0.36
Type of implant	NS	0.33	NS	0.06	NS	0.51
Broberg and Morrey arthrosis rating	NS	1.00	NS	0.16	NS	0.72

NS = Not significant.

training, and experience as well. Finally, the majority of the correlations were small and might be clinically insignificant.

Patient-reported outcome is excellent after an average of 20 years, with average DASH scores similar to those of patients with more complex proximal ulna fractures treated at the same institution (10 ± 15 versus 9 ± 14) [18]. One could argue that short-term patient-rated results [5, 11, 26, 29] are durable with time. We were able to account for only a small amount of variation in outcome among patients in terms of

disability, as results are good to excellent for the majority of patients. It is difficult to explain statistically the variability of unsatisfactory results when a surgery has satisfactory clinical outcomes [1]. For example, in the study by van der Linden et al. [28], other conditions (eg, shoulder problems) accounted for poor DASH scores. In our study, two patients with the highest scores on the DASH questionnaire also had other upper extremity conditions (olecranon bursitis and frozen shoulder).

Fig. 1A–C (A) A lateral radiograph of the elbow shows a fracture of the olecranon. (B) This radiograph of the patient's elbow was obtained after open reduction and internal fixation with the AO tension band wiring technique. (C) A lateral radiograph obtained at

the time of followup shows no radiographic signs of arthrosis and no impairment in ROM. The patient had an excellent outcome according to the MEPI. The patient, with a pain score of 24.3, scored 0.8 points on the DASH.

Fig. 2A–C (A) A lateral radiograph of the elbow shows a fracture of the olecranon. (B) This radiograph of the patient's elbow was obtained after open reduction and internal fixation with the AO tension band wiring technique. (C) A lateral radiograph obtained at

the time of followup shows no radiographic signs of arthrosis and no impairment in ROM. The patient had an excellent outcome according to the MEPI. This patient, with a pain score of 23.4, scored 17 points on the DASH.

Ulnohumeral motion was only slightly impaired. Average flexion of our patients was greater (140°) than those reported by Karlsson et al. [12] (134°) and Lindenhovius et al. [19] (122°). This probably is because we excluded patients with comminuted fractures and fracture-dislocations. However, consistent with van der Linden et al. [28] and Villanueva et al. [29], all but one patient had a good or excellent outcome according to the MEPI.

Pain was uncommon and correlated with adverse events. Prior studies found the most common adverse event with tension-band wiring was prominence of the K wires at the insertion site into the olecranon leading to pain and skin breakdown [17, 23, 24, 28]. However, in our setting, implant removal was routine and not considered an adverse event. As in previous studies [1, 18], pain intensity correlated with magnitude of disability. Also consistent with prior studies, neither pain nor disability correlated with measures of pathophysiology or impairment [1, 7, 18]. This was shown in two patients with an excellent outcome

according to the MEPI, no impairment in terms of elbow ROM, and no radiographic signs of arthrosis, but with one patient scoring excellent (Fig. 1) and the other scoring relatively poor on the DASH (Fig. 2). Bot et al. [1] suggested that psychosocial factors provide an explanation for differences between impairment and disability, but we did not study this.

Physician-based outcome was good to excellent as quantified using the MEPI, with all employed patients returning to work. Therefore, despite the biomechanical inferiority of tension-band wiring compared with plating [2, 30], our study showed that the construct is superior clinically with excellent function after an average of 20 years. Slight arthrosis (Grade 1) was present in 20% of patients. Arthrosis was more frequent (70%) and more severe among the complex proximal ulna fractures studied by Lindenhovius et al. [18]. Radiographic signs of arthrosis did not correlate with pain intensity or magnitude of disability. This is consistent with prior studies [5, 18].

Karlsson et al. [12] found a relationship between degenerative changes and length of followup, but with the numbers available, we could not confirm that finding in our study. We were able to account for only small amounts of the variation in disability (age at surgery), ulnohumeral motion (arthrosis), and pain intensity (adverse events after surgery), and all three factors were limited in the long term.

We found that good results [5, 11, 26, 29] for operative treatment of a transverse, displaced olecranon fracture are durable with time. The technique of tension-band wiring seems to be sufficient from a clinical point of view, although recently disputed in biomechanical studies [2, 30]. Impairment is limited to a minority of patients and corresponds with age, ulnohumeral arthrosis, and associated nonrelated upper extremity conditions. The magnitude of disability and pain intensity reported in previous studies [1, 6] do not correlate well with measures of impairment in our study.

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