Eur J Orthop Surg Traumatol
DOI 10.1007/s00590-011-0824-8

ORIGINAL ARTICLE

Surgical treatment of olecranon fractures in children

Stephanie Arbes · Patrick Platzer · Vilmos Vécsei

Received: 13 April 2011 / Accepted: 24 May 2011

Abstract
Background Fractures of the olecranon are relatively uncommon in children and most are non-displaced or minimally displaced. Wire and suture methods have been used to stabilize displaced pediatric olecranon fractures. This study compares differences in the clinical outcome of 15 children either treated with open reduction and screws, tension band suture (TBS), tension band wires (TBW), or plating.
Methods The treatment consisted of open reduction and internal fixation in 15 cases with a mean of 7.6 years of age. Twelve patients underwent stabilization with K-wires and tension band wires or tension band sutures; one patient, isolated K-wires; one patient, screw fixation; and one patient, plate fixation. At follow-up, clinical and radiological assessments were made according to Murphy score.
Results At follow-up, 7 patients showed excellent results; 3 patients, good results; 3 patients, fair results; and two patients, poor results. Three patients had an extension deficit of 5°, 2 patients with tension band wires, and one patient with plate. None of the patients had developed non-union.
Conclusions Open reduction and internal fixation leads to satisfactory results in children with displaced olecranon fractures. The most common cause of unsatisfactory results was loss of motion, although this usually did not prevent good function.

S. Arbes (✉) · P. Platzer · V. Vécsei
Departement of Traumatology, Medical School Vienna,
Währinger Gürtel 18-20, 1080 Vienna, Austria
e-mail: stephanie.arbes@meduniwien.ac.at

P. Platzer
e-mail: patrick.platzer@meduniwien.ac.at

V. Vécsei
e-mail: vilmos.vecsei@meduniwien.ac.at

Keywords Children · Olecranon fractures · Surgical treatment

Introduction

Olecranon fractures in children are uncommon, accounting for 4–6% of all fractures around the elbow in the pediatric population [4, 5, 8, 11, 12]. It may occur as the result of direct trauma but is more commonly caused by a force transmitted up the forearm after a fall on the outstretched hand [1]. The presence of associated injuries is a common finding, with the reported incidence varying from 14 to 77% [1]. The secondary center of ossification for the olecranon appears at about the ninth year of life and fuses by about the age of 14 years [1].

Appropriate treatment of olecranon fractures depends on the anatomic site and pattern of the fracture, fracture displacement, fracture stability, extensor mechanism integrity, and the presence of associated injuries. Most olecranon fractures in children can be treated conservatively with good results. Generally, accepted indications for surgical reduction and fixation are displacement of 2–4 mm [11]. The AO technique of pinning with tension band wires is widely accepted as the primary treatment choice of transverse fractures of the olecranon in the adult and pediatric populations, as well [7]. The main disadvantages of this technique is the occurrence of hardware irritation due to packing out of the pins and the subcutaneous position of the tension band wires, which requires reoperation in up to 80% of the cases to remove the implants. Furthermore in children, the extensive exposure needed to perform accurate reduction increases the risk for ischemic insult of the growth plate. On the other hand, closed reduction does not give the surgeon the opportunity to scrutinize the quality of reduction.

Published online: 07 June 2011

This study assesses fixation techniques commonly used in the present-day management of displaced olecranon fractures. Clinical and radiographic results in open reduction and fixation either with screws, plates, or fixation with percutaneously placed Kirschner wires and absorbable tension band suture or tension band wire were compared.

Materials and methods

A total of 105 children, with a mean age of 7.7 years old (range 1–16 years), were treated at our hospital between January 1999 and December 2009, for a fracture of the olecranon. Ninety patients had undisplaced or minimal displaced fractures and were treated non-operatively. Surgery was performed in 15 patients. Mean follow-up was 14 months (range from 7 to 48 months). For the 15 patients, 11 boys and 4 girls, reviewed mean age at time of injury was 7.6 years (range 1–16 years). The dominant right side was most frequently involved (9 cases), compared with 6 cases in which the left side was affected. Accident mechanism was, in 14 cases, a fall on the outstretched hand and, in one case, a car accident. The exact mechanism of injury could not be determined. Implant removal was performed after the mean of 105 days, 3.5 months (range from 52 to 360 days; 1.7 to 12 months). Fracture type and displacement were assessed on anteroposterior and lateral radiographs of the elbow and classified according to Bracq, as seen in Fig. 1 and in Fig. 2 [3]. Fracture classification according to the fracture line showed 40% type C, 26.7% type D, 13.3% type A or E, and 6.7% type B. Twelve patients were treated with K-wires, 8 of them with tension band wires (10–16 years of age), 4 of them with absorbable tension band sutures (2–10 years of age), one patient with isolated K-wires (1 year of age), one patient with screws (5 years of age), and one patient with a plate (16 years of age). *The preferred method of surgical stabilization was mainly depending on the age of the patient. In 9 patients, we had major concomitant injuries at the same region.* Five fractured their radial head, one its radial condyle, one sustained an undisplaced subcapital humeral fracture and two sustained a Monteggia lesion.

All patients received open reduction. Twelve patients were treated with K-wires, 8 of them with tension band wires, 4 of them with absorbable tension band sutures, one patient with isolated K-wires, one patient with screws, and one patient with a plate. Tension band wiring (TBW) was performed through a posterior approach using longitudinal Kirschner wires and a wire loop. The elbows were immobilized in a plaster cast at 90 degrees postoperatively for 3 weeks. The quality of reduction was assessed by looking for malalignment of the subchondral bone (step-off), or a gap in concentricity (contour defect) measured between the

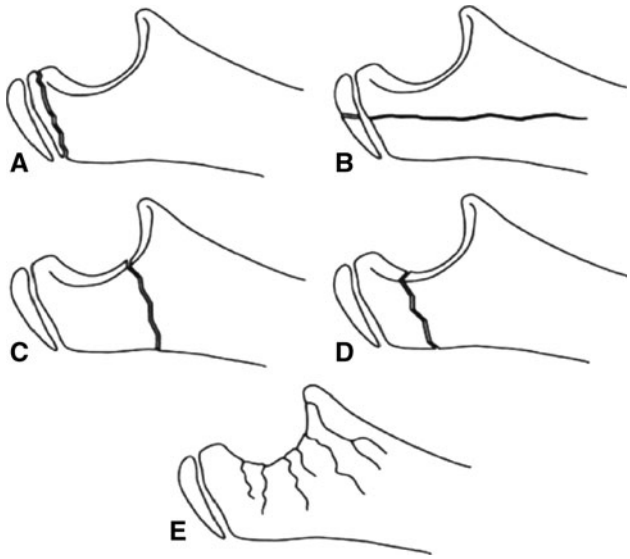

Fig. 1 Classification of olecranon fractures in children according to the fractures line. **a** *Unique line*, parallel to the growth plate. **b** Vertical. **c** Oblique. **d** Distal. **e** Complex fracture with multiple fragments or comminuted

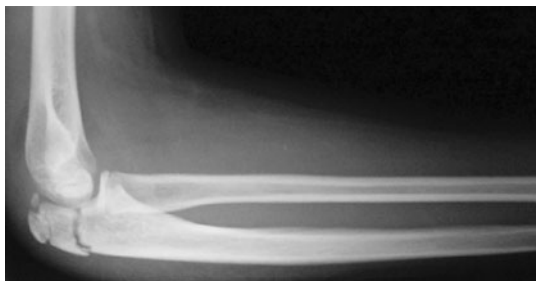

Fig. 2 A 12-year-old boy with an olecranon fracture Bracq C performed K-wires and tension band suture

center of the circle including the major sigmoid cavity and the center of the trochlea, according to the method described by Murphey et al. [10]. At follow-up, clinical and radiologic assessments were based on a 19-point score adapted for children from the Murphey score proposed for adult olecranon fractures, as seen in Table 1 and Fig. 3. The criteria included pain, function, and roentgenogram (joint space, step-off, contour defect). A total of $\geq$18 was considered an excellent result, a score $\geq$17 was considered a good result, a score $\geq$16 was considered a fair result, and a score <16 was considered a poor result.

Results

Radiographic results

Regarding the radiographic outcome, all fractures had healed at a mean of 3 months. Successful fracture healing was defined by regular trabecula crossing the fracture site

Table 1 Rating system, adapted from Murphy

Criteria	Score	Level
Pain	5	None
	4	Occasional mild aching
	3	Pain with vigorous activity
	2	Pain with routine activity
	1	Pain at rest and night
Function	5	Unlimited
	4	Avoidance of heavy lifting and throwing
	3	Avoidance of repetitive lifting (>10 *lbs*)
	2	Activities limited to self-care (*lifting <5 lbs)*
	1	All activities severely limited
Range of motion	5	FC < 10° (20°), FF > 130°, LR < 40°
Flexion contracture: FC	4	FC < 30° (40°), FF > 115°, LR < 60°
Further flexion: FF	3	FC < 60°, FF > 100°, LR < 90°
Loss of rotation: LR	2	Flexion/extension are <40°, Rotation are <40°
	1	Essentially no motion
Roentgenogram	4	JS = normal, SO < 1 mm, CD < 1 mm
Joint space: JS	3	JS < 50% narrowing, SO < 2 mm, CD < 2 mm
Step-off: SO	2	JS > 50% narrowing, SO < 2 mm, CD < 2 mm
Contour defect: CD	1	JS = obliterated, SO ≥ mm, CD ≥ 3 mm

Fig. 3 Same patient as in Fig. 2 6 month later: The clinical result is excellent; the joint space is <50% narrowing, step-off <1 mm, contour defect <1 mm

and absence of sclerotic borders on the standard radiographs.

Failures of reduction or fixation occurred in five patients. In two patients, we found an incomplete primary reduction; in another two patients, we found a secondary loss of reduction, and in the fifth patient, one of the two k-wires did not fix the fracture. Revision surgery was not necessary in any of the patients.

Clinical results

Relating to the clinical outcome of the patients, Murphey score was considered excellent in 7 cases (4 tension band wires, 2 tension band sutures, and one isolated K-wires), good in 3 cases (one screw fixation and two tension band wires), fair in 3 cases (3 tension band sutures), and poor in 2 cases (1 plate and one tension band wire) . The two patients with the poor outcome had pain with vigorous activities and showed a joint space >50% narrowing, step-off <2 mm and a contour defect <2 mm. Range of motion revealed that three patients had a deficit in extension of more than 5°. Two of them were treated with tension band wires, and the third one, by plate fixation. All other patients had an unlimited range of motion compared with the pre-operative status. Presence of relevant pain symptoms post-operatively was noted in five patients. In two patients, the symptoms nearly remained unchanged after cast removal. These two patients also had a poor outcome regarding the Murphey score.

Discussion

Fractures of the olecranon are rather rare in clinical practice. Corresponding to several other studies in literature, our clinical series is small, with only 15 children, treated over a period of 10 years. This represents a mean frequency of 1.5 cases per year representing the low incidence of this injury. The mean follow-up in our study is 14 months. The mean follow-up of other published studies is longer than that in our study [1, 8, 9]. The mean age was 7.6 years, and the male predominance is confirmed as in other studies [3]. The dominant right side is slightly more often involved, with a ratio of 1.5. This fact differs to other studies [3].

Associated lesions were found in 60%, with a predominance of radial head, in our series. This incidence is commonly observed [1]. Evans reported on 40 fractures which were management with open reduction and different treatment options, such as TBW, TBS, screws, or K-wires alone. The overall results were excellent.

Gicquel et al. [5] reported on six patients treated with a technique, where two threaded pin which were fitted with an adjustable lock, introduced through a minimal skin incision. From a radiological standpoint, reduction criteria were considered satisfactory in five cases, and from clinical standpoint, grading was excellent in five cases. The goal of this method of fixation was to propose an easy and minimally invasive technique that could reduce the risk for growth problems [5]. Karlsson et al. [9] published on 23 children, whereas open reduction and internal fixation was performed in 11 cases. At follow-up, none had developed non-union or osteoarthritis.

The treatment of non-displaced or minimally displaced olecranon fractures has been basically conservative (long arm cast with flexed elbow), with or without reduction. For displaced fractures, treatment has been basically surgical, including the management of associated lesions. The most common technique described in the literature involves pining with tension banding usually performed with metallic wires, but sometimes with resorbable sutures. We used resorbable sutures in patients, who were aged between 2 and 10 years of age. The TBS technique used in the latter part of our study provided fixation equal to that of TBW. In addition, TBS is associated with fewer hardware problems and easier hardware removal. The longitudinal K-wires are easily removed by using local anesthetic. TBW need extensive dissection for removal. Previous biomechanical studies have focused on the comparison of wire and suture methods [13]. Forty-four synthetic ulnas were randomized to suture or wire fixation, and compression was measured after fixation. There was no difference in fracture displacement during low loads, but sutures had significantly greater displacement during high loads. Gortzak [6] presented six patients treated with TBS. One patient had a loss of extension of 10 degrees. Gaddy et al. [2] stressed that the initial amount of displacement observed on radiographs is less pronounced because most of the bone is still cartilaginous. Clinical results were good in 46.7%, good in 20%, fair in 20%, and poor in 13.3% of cases. The poor results were for the patients with an extension deficit of 5°, occasional mild aching, and a contour defect on the roentgenograms. Both patients had coexisting fractures. However, an excellent or good clinical outcome is commonly observed in most of the series. Radiologic results are less satisfying and they impair the global score, with three fair and two poor results. Quality of reduction is one of the weak points of our series, with a 26.7% rate of reduction failure.

Growth disturbance could have been induced by damage to the blood supply at the growth plate level related to the trauma and exacerbated by the surgical approach or associated lesions at the elbow joint.

Conclusions

The treatment of displaced olecranon fractures in children achieves satisfactory results from a clinical standpoint, whereas radiologic results are usually less satisfying. These observations seem to be related to the quality of the postoperative reduction. The results of a variety of treatments were good, and the advent of TBS technique may decrease local complications while providing excellent fixation of the fracture.

Conflict of interest None.

Ethical standards All persons gave their informed consent prior to their inclusion in the study.

References

1. Evans MC, Graham KH (1999) Olecranon fractures in children: part 1: a clinical review, part 2: a new classification and management algorithm. J Pediatr Orthop 19(5):559–569
2. Gaddy BC, Strecker WB, Schoenecker PL (1997) Surgical treatment of displaced olecranon fractures in children. J Pediatr Orthop 17(3):321–324
3. Gicquel PH, De Billy B, Karger C, Clavert JM (2001) Olecranon fractures *in 26 children* with mean follow-up of 59 months. J Pediatr Orthop 21(2):141–147
4. Gicquel P, Maximin MC, Boutemy P, Karger C, Kempf JF, Clavert JM (2002) Biomechanical analysis of olecranon fracture fixation in children. J Pediatr Orthop 22(1):17–21
5. Gicquel P, Giacomelli MC, Karger C, Clavert JM (2003) Surgical technique and preliminary results of a new fixation concept for olecranon fractures in children. J Pediatr Orthop 23(3):398–401
6. Gortzak Y, Mercado E, Atar D, Weisel Y (2006) Pediatric olecranon fractures. J Pediatr Orthop 26(1):39–42
7. Grantham SA, Kiernan HA (1975) Displaced olecranon fractures in children. J Trauma 15(3):197–204
8. Graves SC, Canale ST (1993) Fractures of the olecranon in children: long-term follow-up. J Pediatr Orthop 13(2):239–241
9. Karlsson MK, Hasserius R, Karlsson C, Besjakov J, Josefsson PO (2002) Fractures of the olecranon during growth. J Pediatr Orthop Part B 11(3):251–255
10. Murphy DF, Greene WB, Dameron TB Jr (1987) Displaced olecranon fractures in adults. Clinical evaluation. Clin Orthop Relat Res 224:215–223
11. Newell RL (1975) Fractures of the olecranon in children. Injury 7(1):33–36
12. Papavasiliou VA, Beslikas TA, Nenopoulos S (1987) Isolated fractures of the olecranon in children. Injury 18:100–102
13. Parent S, Wedemeyer M, Mahar AT, Anderson M, Faro F, Steinman S, Lalonde F, Newton P (2008) Displaced olecranon fractures in children: a biomechanical analysis of fixation methods. J Pediatr Orthop 28(2):147–151