Displaced supracondylar fractures of the humerus in children

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Received 6 June 2014
Accepted 15 July 2014

The Egyptian Orthopaedic Journal
2017, 52:153–157

Objective and design
Supracondylar fractures of the humerus in children are the most commonly diagnosed fractures in childhood. The aim of this study was to evaluate the results of surgical treatment for displaced supracondylar fractures of the humerus.
Patients and methods
Between 2006 and 2009, 318 patients who met inclusion and exclusion criteria of the study were included. All of them were treated with closed versus open reduction and percutaneous K-wire pinning.
Results
Patients were followed-up for a period from 24 to 48 months with an average of 36 months. Time elapsed from trauma to surgery was less than 6 h in 213 children with good-to-excellent results in all of them. In 66 children, it was 6–12 h with good-to-excellent results in 58 and fair results in eight children. Among the remaining 39 children who were operated up on more than 12 h after trauma, 24 children showed good-to-excellent results, 11 showed fair results, and four children showed poor results.
Conclusion
Percutaneous pinning is a successful method for treating displaced supracondylar fractures of the humerus in children. The time elapsed from trauma to surgery is the most important determining factor regarding indications for open reduction and complications.

Keywords:
Gartland, percutaneous pinning, supracondylar humeral fractures, ulnar neurapraxia

Egypt Orthop J 52:153–157

1110-1148

Introduction

Supracondylar fractures of the humerus are the most commonly diagnosed elbow fractures in children and represents about 3% of all fractures [1–5]. Gartland [6] classified these fractures and it was modified by Wilkins [7]. Type III and type IV were described by Leitch *et al.* [8] as being similar to fractures with multidirectional instability and are considered to be totally displaced with an incidence of 16.7% [9]. Severely displaced supracondylar fractures of the humerus in children are challenging injuries to treat [10–12]. There remains controversy in the literature with regard to the definitive management of these types of fractures [13,14]. The differences among authors relate mainly to the choice between treatment by closed versus open reduction with the suitable approach and percutaneous K-wire fixation [15,16]. Closed reduction and percutaneous pinning is the treatment of choice for these fractures [10,17,18]; however, they could be associated with various complications, such as neurovascular compromise ranging from 5 to 30%, skin problems, compartment syndrome, Volkmann's ischemia, and cubitus varus with an incidence as high as 30% [19–22]. Irreducible fractures within 2–12% are uncommon and require open reduction, mostly because of interposition of the brachialis muscle, median nerve, and brachial artery [12,18].

Patients and methods

Between 2006 and 2010, 318 patients with displaced supracondylar fracture of the humerus were treated by the same doctor. This work has been approved by the ethical committee of Assiut University. This study was approved by the local health and scientific committee. Inclusion criteria were children aged 1–7 years, with closed, displaced supracondylar fractures of the humerus. The male-to-female ratio was 3 : 1. All children presented to the trauma center within 2–24 h with an average of 10 h. On admission to the emergency department, all children presented with a history of falling down, swelling, and deformity at the elbow region, with good hand function. There was good capillary refill in all of them. Radiologically, all of them had displaced supracondylar fracture of the humerus – Gartland type II in 245 children, type III in 52, and type IV in 21

children. Fifteen children had absent radial pulse with good hand perfusion, with an incidence of about 4.7%. Computed tomography angiography was indicated, revealing spasm of the brachial pulse with good distal circulation. Children were classified into three groups (Table 1) according to the time elapsed from trauma to surgery: group A included children operated on in less than 6 h after trauma, group B included children who were operated within 6–12 h after trauma, and group C included children who were operated on more than 12 h after trauma.

Patients with palpable radial pulse were operated on an emergency basis, whereas those with impalpable radial pulse were operated on an urgent basis. Preoperative parenteral antibiotics were prescribed to all patients. In the operating theater, under tourniquet in the supine position and under radiography control, a trial for closed reduction was performed to obtain an anatomical reduction of the supracondylar region of the humerus. Subsequently, percutaneous pinning with two lateral parallel K-wires was performed to fix the fracture, and the stability of reduction and fixation was examined clinically and radiologically (Fig. 1). Closed reduction under anesthesia failed in 19 (6%) patients. Minimally invasive open surgery was performed to attain anatomical reduction. Through two incisions – one lateral approach of the supracondylar region of the humerus about 2 cm and another medial approach just anterior to the medial humeral condyle about 2–3 cm – open reduction under vision was performed and the fracture was fixed using two crossed K-wires (Fig. 2). The upper limb was placed above the elbow in a posterior slab at 90° flexion for 3–4 weeks, and children were discharged to the outpatient department for follow-up. Patients with open reduction and crossed K-wire fixation were hospitalized for two postoperative days.

Results

A total of 318 children with extension-type supracondylar fracture of the humerus presented to our level I tertiary trauma center. Among them,75.5% were boys; their ages ranged from 1 to 7 years (mean age: 4.28±1.25 years). The right side was affected in 59% of cases. All of them were noncomplicated fractures. According to the modified Gartland's classification, 188 (59%) children had type IIB fractures, 109 (34%) children had type III, and 21 children [7] had type IV fractures.

Group A included 213 (67%) children who were operated within 6 h after trauma, group B included 66 (20.7%) children who were operated within 6–12 h, and group C included 39 (12.3%) children who were operated on more than 12 h after trauma. The incidence ratio of emergency to urgent surgery was 303 to 15 with an incidence of 20 to 1. All patients underwent surgery in the supine position; the incidence of failed closed reduction was 6% (19 patients).

Figure 1

(a) Displaced type III supracondylar fracture of the humerus in a 4-year-old girl. (b) Percutaneous pinning using two crossed K-wires.

Table 1 Patient data

	Group A	Group B	Group C
Time elapsed after trauma (h)	6	6–12	>12
Number of patients	213	66	39
Absent radial pulse	None	2	13
Failed closed reduction	None	None	19
K-wire fixation	2 lateral	2 lateral	2 crossed wires
Hospitalization	1 day	1 day	2 days

Two lateral parallel K-wires were used in 94% of patients, and two crossed K-wires were used in the remaining 6%.

Patients were followed-up for a period of 24–48 months, with an average of 36 months, and all data were recorded regarding restoration of normal elbow mechanics and functional range of motion.

On outpatient follow-up, local pin-tract infection was noticed in 27 patients, which spontaneously resolved with dressing and oral antibiotics within one week. Posterior slabs and K-wires were removed after 3–4 weeks to start elbow mobilization. A physiotherapy program was started immediately for restoration of elbow function. Complete union was noticed within 5–8 weeks with an average of 6. Functional outcome was evaluated according to Flynn criteria [23] (Table 2). Follow-up at 24 weeks revealed restoration of full elbow function in the majority of children. Five degrees decrease in carrying angle was noticed in 38 patients, 10° was noticed in 19 patients with fair outcome, and loss up to 15° was noticed in four patients with poor outcome (Table 3).

At the 1-year follow-up, there was restoration of normal elbow function; loss of 5–10° in carrying angle persisted in 57 children and 15° loss in normal carrying angle in four children. At the last follow-up, all children had normal elbow function and the residual loss of carrying angle was not apparent.

Discussion

The aim of treatment for displaced supracondylar fractures of the humerus is to gain a functionally and cosmetically accepted extremity without residual deformity or neurovascular deficits [24].

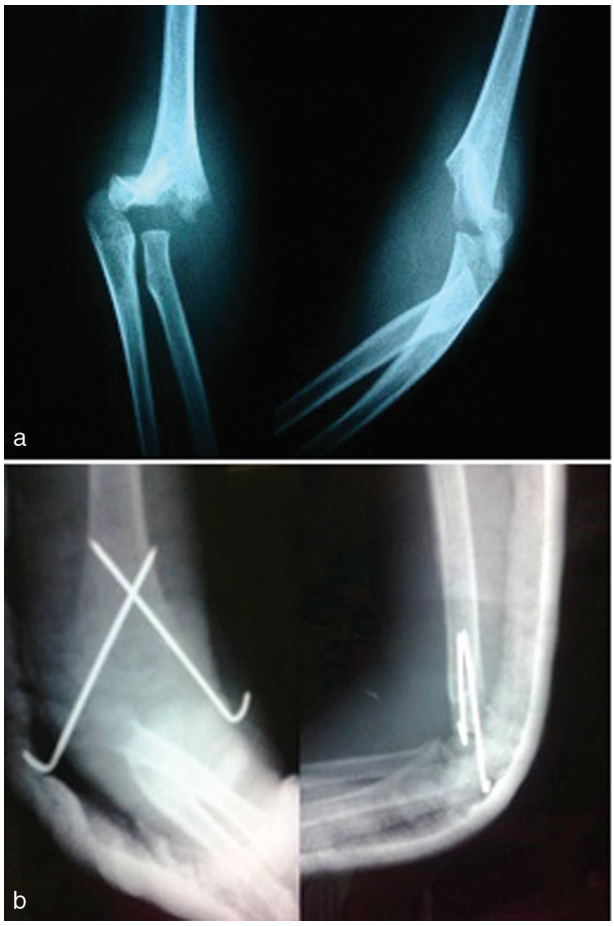
Closed reduction and percutaneous pinning under fluoroscopic guidance was originally described by Swenson [25] and became the standard treatment for displaced supracondylar fractures of the humerus in children [26,27]. Swenson [25], Flynn *et al.* [23], and Nacht *et al.* [28] used the crossed K-wire fixation with an incidence of 2–8% of ulnar nerve palsy [29,30].

This study included 318 children with displaced supracondylar fracture of the humerus. The incidence of impalpable radial pulse in the presence of good hand

Table 2 Assessment of treatment outcome according to Flynn's criteria

Results	Loss of elbow motion (deg.)	Loss of carrying angle (deg.)
Satisfactory		
Excellent	0–5	0–5
Good	6–10	6–10
Fair	11–15	11–15
Unsatisfactory		
Poor	>15	>15

Figure 2



(a) Displaced supracondylar fracture of the humerus in a 5-year-old boy. (b) Percutaneous pinning with two lateral K-wires.

Table 3 Results

Groups	Total (*N*=318)	Results [*n* (%)]			
		Excellent	Good	Fair	Poor
Group A	213	177 (83)	36 (17)	None	None
Group B	66	47 (71)	11 (17)	8 (12)	None
Group C	39	13 (33.3)	11 (28.2)	11 (28.2)	4 (10.3)

perfusion was 4.7% (15 child), which was attributed to late presentation and swelling at the fracture site. The incidence ratio of emergency to urgent surgery was 20 to 1. Closed reduction under anesthesia and percutaneous pinning using two lateral wires was successful in 299 children. The incidence of failed closed reduction was 6% and it was attributed to late presentation, very low fully displaced fractures, which are now classified as type IV fractures, and interposition of the brachialis and osteoperiosteal flaps at the fracture site. Open reduction was indicated for those children through the combined minimal invasive lateral and medial approaches. Authors reported variable incidence and complications (2 to >12%) of conversion from closed to open reduction depending mainly up on late presentation, instability, or vascular injury [1,4,31,32].

Superficial pin-tract infection was recorded in 27 children with an incidence of 8.5%; it was managed successfully with oral NSAIDs and antibiotics, and it resolved within 6–14 days. Physiotherapy program was successful in all children in restoring elbow function within 4–10 weeks. Functional results were affected by presentation time to emergency department. All children within group A showed good-to-excellent results. The incidence of good-to-excellent results in group B was 88 and 12% had fair results. The incidence of good-to-excellent results in group C was 61.5%, fair results in 28.2%, and poor results in 10.3%. Late presentation had worse results due to swelling and higher incidence of open reduction. The total incidence of residual varus deformity of the elbow joint was 7.2% (23 children), the angle of varus deformity was less than 10° in 19 (6%) children, and the remaining four (1.2%) children had cubitus varus deformity of about 10–15°.

Shannon's [33] series of 20 children had an infection rate of 5%, and granulation tissues were reported in five children out of 20 with no varus deformity. El-Adl *et al.* [34] showed an infection rate and varus deformity of the elbow joint in 8.6% of their patients. In 2011, Dua *et al.* [35] showed that in their series of 40 children superficial pin-tract infection rate was 7.5%, with no varus deformity, and a total success rate within 90%. In conclusion, the results of the present study revealed that the presentation time of children with supracondylar fractures of the humerus is the major determining factor of functional outcome. Failed closed reduction under anesthesia is an indication to open reduction. The incidence of open reduction is very high in children who present more than 12 h after trauma and for children with very low and fully displaced fractures. Crossed K-wire fixation is the best technique for very low unstable fractures.

Conclusion

Percutaneous pinning is a successful method for treating displaced supracondylar fractures of the humerus in children. The time elapsed from trauma to surgery is the most important determining factor regarding indication for open reduction and complications.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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