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Displaced supracondylar humeral fractures in children: open reduction vs. closed reduction and pinning

Abstract *Introduction:* In the literature the best results for pediatric supracondylar humerus fractures have been achieved by closed reduction and wire fixation. However, in these reports the patient group of open reduction and pinning contained the patients who had had previous ineffective closed reduction trials. This retrospective study compared open and closed reduction with pinning, in which the first group of patients was all consecutively treated with open reduction. *Materials and methods:* The study included 99 children with displaced extension-type supracondylar fractures of humerus who had complete follow-up. Open reduction patients had not had a previous attempted closed reduction. Open reduction and pinning were performed through a posteromedial incision in the first 44 patients and closed reduction and pinning in the subsequent 55 patients. Mean duration surgery was 15 h with open reduction and 17 h with closed reduction. Mean follow up was 35 months with the open reduction and 21 months with closed reduction. Humeral-ulnar angle was compared to the contralateral elbow, clinical flexion deficiency and extension lag, and complications were evaluated. *Results:* At the latest follow-up the open group had an average of 5.1° valgus change and the closed group 3.6° valgus change in humeral-ulnar angle compared to their uninvolved elbow. Average flexion deficiency was 8.61° in the open and 5.25° in the closed group. Average extension lag was 6.23° in the open and 0.6° in the closed group. Functional results were satisfactory in 71% of patients in the open and 93% of those in the closed reduction group. Cosmetic results were satisfactory in 95% of both groups. *Conclusions:* Closed reduction and pinning is superior to open reduction and pinning for the treatment of pediatric supracondylar humerus fractures. In the case of technical insufficiencies open reduction and pinning through a posteromedial incision is an alternative treatment for decreasing the surgical time and complications. Complications was not caused in either group by the delayed surgical timing compared to reports in the literature.

Keywords Supracondylar fractures · Children · Humerus · Percutaneous pinning

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Introduction

Supracondylar humerus fracture (SCHF) is the most common fracture in children under 8 years of age [3]. The main objectives of treatment for displaced SCHFs in children are prevention of Volkmann's contracture, avoidance of deformities, and restoration of normal function [22]. In the orthopedic literature it is reported that the best results are achieved by closed reduction and wire fixation [2, 5, 7, 14, 17, 19, 20]. However, in these reports the patient group of open reduction and pinning included patients who had had previous ineffective closed reduction trials. In this study we compared open and closed surgical treatment of SCHFs. Since we did not at the time have an image intensifier, the former contained only the open reduction and pinning without any previous attempt at closed reduction.

Material and methods

Between July 1996 and July 1998 we surgically treated 145 children with displaced extension-type SCHFs (Gartland [6] type III). This study included the 99 children with complete follow-up. These patients were referred from other hospitals with a long arm

Fig. 1 **a** Lateral and anteroposterior radiograph of a type III supracondylar humerus fracture of a 4-year-old girl. The patient was treated with open reduction and Kirschner wire fixation. **b** Radiographs 1 month after the surgery. **c** Clinical and radiological outcome was excellent 2 years after the injury

splint at 30°-60° flexion without having undergone any reduction maneuver. Medical records of the patients were examined to determine the age and gender of the patients, side of the fracture, presence of an open wound, time of the injury, and timing of the surgical treatment. The patients were recorded for the presence of neurovascular injury, compartment syndrome, ipsilateral upper-extremity fracture, type of surgical method, and number of pins used. These patients were also recorded for presence of postoperative infection, surgery-related nerve injury, and postoperative compartment syndrome. We compared these rates with those reported in the literature. Follow-up records and radiographs were examined for determining the time of the pin removal and healing of the fracture.

The patients were divided into two groups. Since we did not have an image intensifier at the time, all SCHFs treated between July 1996 and May 1997 underwent open reduction through posteromedial incision, exploring the ulnar nerve and pinning with two Kirschner wires with crossed fashion (Fig. 1). In this first group there were 44 patients with a mean age of 10.7 years (range 3–15). Between May 1997 and July 1998 we treated all SCHFs with closed reduction and percutaneous crossed pin fixation (Fig. 2). In this group there were 55 patients with a mean age of 7.6 years (4–14). All injuries were closed. Neither group had neurovascular problems or compartment syndromes before the surgery. Table 1 presents the demographic data on both groups.

The intubated patient was placed prone with a sandbag underneath the abducted arm. The surgery was performed through a posteromedial incision posterior to the medial epicondyle. After isolating the ulnar nerve the distal humerus was exposed between the brachialis and triceps muscles as in the medial approach. The average period between injury and operation was 15 h (range 11–48) in the open group and 17 h (10–72) in the closed group. In both groups two smooth Kirschner wires were used. After the operation three to 4 weeks of dorsal long arm splint at 90° was used for each group. By the end of fourth week the fracture was examined by radiology, and wires were removed. In the case of improper radiology,

logical callus formation follow-up radiography was performed in the 6th week. Active elbow range of motion rehabilitation program was encouraged in the 4th week under the supervision of a physical therapist. The patients were followed radiologically and clinically and were called for a final assessment at a mean of 35 months (range 27–46) in the open reduction group and 21 months (16–27) in the closed reduction group after the initial surgery. Patients were evaluated for the radiological humeral-ulnar angle [25] as the carrying angle and clinically for flexion and extension degrees, and the findings were compared with those in the contralateral normal elbow. Final results were graded by the criteria of Flynn et al. [5] (Table 2). Statistical analysis used Student's t test for quantitative variables and the χ^2 with Yates' correction for qualitative variables.

Results

Both closed and open surgical groups had two ulnar nerve lesions and all of them recovered 6 months postoperatively without any additional treatment. Two patients in the open group and three in the closed group had pin-tract infection. None of the patients had drainage from their incisions in open group. They were diminished with oral antibiotic treatment and wound care. Each resolved after the removal of the pins. Average radiological fracture healing time was 5.3 months (range 4–6) in the open reduction group and 4.8 months (4–6) in the closed reduction group (Table 3).

At the latest follow-up the open surgical group had 5.1° (0°–20°) valgus change in humeral-ulnar angle com-

Fig. 2 a Lateral radiograph of a type III supracondylar humerus fracture of a 4-year-old girl who was treated with closed reduction and Kirschner wire fixation. **b** Lateral radiograph 1 month postoperatively. **c** Radiographs at 18 months, with excellent outcome

Table 1 Patient characteristics

	Open reduction group (*n*=44)	Closed reduction group (*n*=55)
Age (years; range)	10.7 (3–15)	7.6 (4–14)
Sex: M/F	25/19 (57%/43%)	30/25 (54%/46)
Side: R/L	13/31 (30%/70%)	13/42 (24%/76%)
Ipsilateral fracture	2 (4%)	1 (2%)

Table 2 Cosmetic (carrying angle) and functional results (movement loss) according to criteria of Flynn et al. [5]

	Cosmetic (°)	Functional (°)
Satisfactory		
Excellent	0–5	0–5
Good	5–10	5–10
Fair	10–15	10–15
Unsatisfactory: poor	>15	>15

Table 3 Surgery-related data

	Open reduction group (*n*=44)	Closed reduction group (*n*=55)
Timing of the surgery (h)	15 (11–48)	17 (10–72)
Postoperative infection	3 (7%)	2 (4%)
Ulnar nerve lesion	2 (5%)	2 (4%)
Fracture healing time (months)	5.3 (4–6)	4.8 (4–6)

Table 4 Clinical and radiological final assessment

	Open reduction group (*n*=44)	Closed reduction group (*n*=55)
Follow-up time (months)	35 (27–46)	21 (16–27)
Valgus change in the humeral-ulnar angle	5.1 (0–20)	3.6 (0–23)
Flexion deficiency	8.61 (0–20)	5.25 (0–15)
Extension lag	6.23 (0–22)	0.6 (0–12)

Table 5 Final results of two different surgical methods by using the outcome criteria of Flynn et al. [5]

	Open reduction		Closed reduction	
	n	%	*n*	%
Cosmetic				
Excellent	31	70	40	73
Good	6	14	6	11
Fair	5	11	6	11
Poor	2	5	3	5
Functional				
Excellent	21	48	39	71
Good	6	14	5	9
Fair	4	9	7	13
Poor	13	29	4	7

pared to their noninvolved extremity and the closed reduction group 3.6° (0°–23°; *P*=0.8336). Average flexion deficiency in the open surgical group was 8.61° (0°–20°), and that in the closed reduction group was 5.25° (0°–15°; *P*=0.2182). The average extension lag that the patient lost compared to the noninvolved extremity was 6.23° (0°–22°) in the open group and 0.6° (0°–12°) in the closed group (*P*=0.005; Table 4).

Table 5 summarizes the cosmetic and functional results in the two groups. The cosmetic outcome did not differ between the two groups, with satisfactory results in both the open reduction group (42/44) and the closed reduction group (52/55). However, the functional outcome differed significantly between the groups, with satisfactory results in 31 of 44 patients (71%) in the open group and 51 of 55 (93%) in the closed group (*P*=0.036). Two patients in the open group with pin tract infection had an unsatisfactory outcome both cosmetically and functionally; one of the

three patients who had pin tract infection in the closed group had unsatisfactory and two satisfactory results both functionally and cosmetically. Functional and cosmetic results in four patients in each group who had ulnar nerve lesion were graded as satisfactory.

Discussion

The ideal treatment for type III SCHF is, according to many authors, closed reduction and percutaneous pinning [1, 2, 5, 7, 14, 17, 19, 20]. However, some series report the results of open reduction and pinning as comparable to or even much better than those of closed reduction and pinning [4, 10, 16, 21, 23, 24]. The relatively large number of poor results after open reduction and wire fixation is believed to have been occurred for two reasons: (a) the high proportion of severely displaced grade III fractures in this group and (b) the delay in initiating treatment because of the late arrival at the hospital which was up to 10 days [1]. A number of studies initially tried closed reduction and pinning for SCHFs, and open reduction was carried out only if closed reduction failed, displacement recurred, or vascular complications occurred during the closed attempt [1]. Therefore open reduction groups generally included the more complicated patients and ended up with worse results than expected.

Although this was not a randomized study, the first group of patients were all consecutively treated with open reduction. We found no statistically significant differences between open and closed groups for flexion range and humeral-ulnar angles. Extension lag was significantly better in the closed treatment group. Cosmetically the outcome did not differ between the two surgical groups. However, closed reduction and percutaneous pinning proved to have a significantly better functional outcome. As results in two pin tract infections in the open reduction group and one of the three pin tract infections in the open reduction group were graded to be unsatisfactory, it seems that infection is directly related to the poor outcome.

We agree with most of the previously reported literature that closed reduction and percutaneous pinning should be the first choice for the treatment of supracondylar humerus fractures of children. However, if closed reduction and pinning is impossible for lack of an image intensifier in the operating room, open reduction and pinning offer an alternative treatment to reduce the surgical time and avoid physeal destruction. We used a posteromedial incision for the open reduction of supracondylar humerus fractures. This is a medial approach with a posteriorly located skin incision. We believe that posteromedial incision is an easy, safe, and cosmetic incision for open reduction of SCHFs. We had two ulnar nerve injuries in the open reduction group and two in the closed reduction patients. They were all fully recovered without exploration. Lyons et al. [11] have reported that ulnar nerve palsies after percutaneous cross- pinning recovered spontaneously. Moreover, ulnar nerve palsies after open reduction are usually a traction injury.

Traditionally many authors have recommend acute treatment of displaced supracondylar fractures in the children within 8 h after the trauma. The purpose is to decrease the risk of perioperative complications (compartment syndrome, infection, nerve injuries) and reduce the probability of conversion to an open reduction by means of minimizing the swelling [8, 15, 18]. On the other hand, there are insufficient data to support this concept. In the literature conversion to open reduction is reported at a rate of between 3% and 46% [13]. In our closed reduction group conversion to open reduction was in 5%, which is low compared to the literature. The pin tract infection rate has been reported as 2.4%–6.6% [2, 3, 4, 12]. In our study the infection rate was 6.8% in the open reduction group and 3.6% at in closed reduction group, which is comparable to the figures reported in the other studies. A review of the literature indicates the rate of iatrogenic nerve injury to be 3.6% [13]. In this study ulnar nerve injury was seen in 4.5% of patients in the open reduction group and 3.6% of those in the closed reduction group. These figure are also comparable with cases of early treated fractures reported in the literature. Compartment syndrome did not occur in either group. Two recent studies demonstrated that the timing of surgical treatment of supracondylar fractures does not have an effect on complication rates [9, 13]. Our study supports these recent reports.

In summary, we believe that early closed reduction and percutaneous pinning is a gold standard for the treatment of displaced supracondylar fractures of the children. However, if there is not an image intensifier in the operating room, open reduction and pinning offer an alternative treatment for decreasing the surgical time and complications. A reasonable delay of the treatment of these fractures does not increase the risk of complications, as is often maintained.

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