Operative management of type III extension supracondylar fractures in children

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Received: 15 May 2008 / Revised: 20 May 2008 / Accepted: 21 May 2008 / Published online: 3 July 2008
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Abstract The purpose of this study was to compare primarily open versus primarily closed surgical treatment of Gartland type III extension supracondylar fractures in children. Also the outcomes of different pinning techniques in open surgery were evaluated retrospectively. Eighty displaced type III extension supracondylar fractures treated consecutively at two different centres were included. The treatment protocol of one institute was primarily closed reduction and percutaneous cross-pinning ($n=43$). The treatment protocol of the other institute was primarily open reduction and internal fixation ($n=37$) with two lateral parallel pins ($n=11$), cross pins ($n=11$) and two lateral and one medial pin ($n=15$) according to the stability and configuration of the fracture. According to Flynn's criteria the outcomes of the open and closed reduction groups were not statistically significant ($P>0.05$). Although the outcomes of closed reduction showed no superiority over open reduction, it should be the first choice of treatment due to its low morbidity and short hospital stay.

Résumé Le but de cette étude est de comparer le traitement par réduction orthopédique ou réduction sanglante des fractures supracondyliennes type III de Gartland en extension chez l'enfant. Par ailleurs, l'évolution des différentes

techniques d'embrochage à foyers ouverts ont également été évaluées de façon rétrospective. Matériel et méthode: 80 fractures en extension de type III supracondyliennes ont été traitées de façon consécutives dans deux centres différents. Le protocole du traitement dans un des centres était la réduction à foyer fermé avec brochage percutané ($n=43$) et dans l'autre établissement, à foyer ouvert avec fixation interne ($n=37$), deux broches parallèles ($n=11$), deux broches en croix ($n=11$), deux broches externes et une interne ($n=15$), ceci en fonction de la stabilité et de l'aspect de la fracture. Résultats: selon les critères de Flynn, il n'y a pas de différence de résultats entre les traitements à foyer fermé ou après réduction sanglante ($p>0,05$). En conclusion: l'évolution des fractures traitées à foyers fermés n'est pas meilleure que celles traitées à foyers ouverts les conditions du choix doivent être la diminution des complications et l'abaissement de la durée moyenne de séjour.

Introduction

Supracondylar fracture of the humerus is the second most common fracture in children (16.6%) and the most frequent before the age of 7 years [2]. The surgical treatment of type III fractures is complicated and entails technically difficult procedures for orthopaedic surgeons. These fractures are classified, according to Gartland's criteria, as nondisplaced fractures (type I), partially displaced fractures with the posterior cortex intact (type II) and completely displaced fractures (type III). Completely displaced (type III) fractures may be associated with neurovascular injuries, and treatment may be complicated by malunion, elbow stiffness, iatrogenic neurovascular injury and compartment syndrome [2, 6, 14].

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Even though the treatment guidelines for type I and II fractures have been well established, controversies still persist for the treatment of type III fractures.

Many methods have been recommended for the treatment of type III fractures including closed reduction and cast immobilisation, traction by various methods and reduction via closed or open means and fixation by Kirschner (K-) wires [1, 11–15]. The aim of this study was to evaluate the outcomes of two different treatment options (primarily closed reduction and percutaneous pinning versus primarily open reduction with pinning) for type III extension fractures performed at two different institutes. Besides this, we compared the effectiveness of three different pin configurations in open surgery.

Material and method

The study included 80 children with displaced Gartland type III extension fractures treated at two different institutes with different protocols (primarily open reduction versus primarily closed reduction). Medical records of the patients were assessed in respect of the side of the fracture, presence of an open wound and timing of the surgical treatment. Postoperative complications including infection, nerve injury and compartment syndrome were also recorded. Table 1 presents the demographic data for both groups.

The patients were divided into two groups. At one institute (İzmir Atatürk Training and Research Hospital) all of the patients with displaced Gartland type III fracture ($n=37$) had been treated with primarily open reduction through a lateral incision (ORIF). Different pin configurations were used according to the stability and configuration of the fractures. Eleven patients had been treated with two lateral, 11 patients with one lateral and one medial and 15 patients with two lateral and one medial K-wires in the open reduction group. Thirty patients had been treated within 24 hours in this group and seven patients had been treated 24 hours after the injury.

Table 1 Patient characteristics

	Open reduction group	Closed reduction group
	($n=37$)	($n=43$)
Age, years (range)	5.9 (2–12)	6.5 (2–12)
Sex, M/F	26/11 (70%, 30%)	29/14 (63%, 37%)
Side, R/L	14/23 (38%, 62%)	16/27 (37%, 63%)
Follow-up time (months)	29.5 (19–62)	32.9 (13–63)
Ipsilateral fracture	2 (5.4%)	3 (6.9%)

Table 2 Outcomes of the patients with a nerve lesion

	Open group	Outcome	Closed group	Outcome
Preoperative				
Ulnar	1 (2.7%)	Satisfactory	-	
Radial	2 (5.4%)	One poor result	-	
Median	-		1 (2.3%)	Satisfactory
A. interossea	-		1 (2.3%)	Satisfactory
Postoperative				
Ulnar	2 (5.4%)	One poor result	4 (9.4%)	All satisfactory

At the other institute (İzmir Tepecik Training and Research Hospital) all patients with displaced Gartland type III fractures ($n=46$) were treated primarily with closed reduction and two cross pins placed percutaneously (CRPF). In the closed reduction group 38 patients had been treated within 24 hours after the injury. Seven patients had had an unsuccessful closed reduction attempt initially and surgical treatment could only be performed after the application of skeletal overhead traction for four to five days. Two patients had been treated with open reduction because of an unsuccessful delayed closed reduction attempt and one patient had been treated with open reduction initially because of concomitant brachial artery injury. These three patients were excluded from the study.

Patients in both groups had been placed in a long arm cast with the elbow at 90° flexion postoperatively. All patients were discharged the day after the reduction in the closed reduction group whereas the average hospitalisation period was 3.8 days in the open reduction group (2–6). The pins were removed at 3–4 weeks in both groups. In the case of inadequate callus formation, the pins were removed at the sixth week for 11 patients in the open group. Active range of motion was encouraged after the pin removal.

All injuries were closed except one in the open reduction group. Two of the patients in the open reduction group had radial nerve palsy before the operation. One patient with radial palsy recovered completely in three months and one patient made good recovery after sural nerve grafting, which was done during the fracture fixation. All ulnar nerve injuries recovered completely within 12 weeks postoperatively without any complication. The number of patients with a nerve lesion in each group and their outcomes are summarised in Table 2.

The patients were followed up radiologically and clinically and were called for final evaluation at a mean of 29.5 (19–62) months for the open reduction group and 29 (13–70) months for the closed reduction group (Fig. 1a–d). Patients were evaluated for the humeral-ulnar angle as the carrying angle and clinically for flexion and extension degrees according to Flynn's criteria [4]. At the latest

Fig. 1 **a–d** A type III Gartland fracture that was treated with closed reduction and percutaneous pinning. **a** Preoperative anteroposterior (AP) and lateral X-rays. **b** Postoperative AP X-ray. **c** Postoperative lateral X-ray. **d** Final follow-up AP and lateral X-rays

follow-up, radiological and clinical examinations were compared with the uninjured elbow.

Statistics

The functional and cosmetic results were analysed using the chi-square statistical analysis method. All of the parameters were summarised by mean 95% confidence interval (CI), graphics and tables. Significance was set at $P < 0.05$.

Results

Both the cosmetic and functional outcomes were similar between the two groups (Table 3). Based at the criteria of Flynn et al., 28 patients (75.6%) had an excellent result, six patients (18.9%) had a good result, two patients (4.6%) had a fair result and one patient (2.7%) had a poor result in the ORIF group. In the CRPF group 33 (76.7%) patients had an

excellent result, seven (16.2%) patients had a good result, two (4.6%) patients had a fair result and one (2.4%) patient had a poor result. The cause of fair and poor results in the CRPF group was due to varus angulation with excellent

Table 3 Results of two different surgical methods by using the outcome criteria of Flynn et al.

	Open reduction		Closed reduction	
	<i>n</i>	%	<i>n</i>	%
Cosmetic				
Excellent	28	75.6	33	76.7
Good	8	21.6	7	16.2
Fair	0	0	2	4.6
Poor	1	2.7	1	2.3
Functional				
Excellent	34	91.8	43	100
Good	1	2.7	0	0
Fair	2	5.4	0	0
Poor	0	0	0	0

functional outcome. The two patients with fair results in the ORIF group had significant loss of range of motion and one patient with a poor result had 20° varus angulation.

Two patients in the open group and three patients in the closed group had pin tract infection which responded well to the oral antibiotic treatment. All of the 43 patients in the CRPF group revealed perfect range of motion outcome, but three patients in the ORIF group revealed fair functional outcome. One patient in the ORIF group (two lateral pin fixation group) who had an unsatisfactory outcome had radial palsy preoperatively and underwent nerve repair. One patient (one lateral and one medial group) with fair outcome had pin tract and superficial wound infections and ulnar nerve palsy postoperatively. The ulnar nerve palsy did not affect the functional and cosmetic outcomes adversely in the CRPF group. No patient in either group had a major loss of fixation. There was no history of reoperation in either group.

In the ORIF group the functional and cosmetic outcomes of the two lateral and one medial pin fixation group showed better results than the two lateral group and one lateral and one medial group, but the difference was not statistically significant ($P > 0.05$).

Discussion

The main aim of the treatment of supracondylar fractures is to gain a functional and cosmetically acceptable extremity. There is no definitive treatment for Gartland type III supracondylar fractures. Proponents of closed reduction with percutaneous pinning state that fewer complications such as infection and loss of movement occur with closed reduction [12, 13]. Also the hospital stay is reduced. On the other hand, proponents of the open surgery approach claim that anatomical restoration of the displaced fractures is difficult by closed means and repeated manipulations may result with joint stiffness and myositis ossificans [3, 8].

In the majority of the studies in the literature, open reduction groups have been formed by the patients who had had an unsuccessful reduction attempt. Because of that open groups in these studies contained the patients with more difficult patterns. In open groups of these studies the fracture pattern generally presented no cortical contact and completely detached periosteum, so that a closed reduction could not possibly be achieved. Obtaining fracture stability is more difficult and the complication rates are higher with these fractures [6]. Our open reduction and pinning group patients were treated with open reduction primarily at one institute without a closed reduction attempt. The most recent studies also formed their closed groups with the patients who had had an adequate reduction by closed

manipulation. Another important factor is that the patients were excluded from the closed group in these studies when satisfactory reduction could not be obtained by closed manipulation. In our study only seven patients had an unsuccessful closed reduction attempt, but five of them were not excluded from the closed group. According to the treatment protocol of the institute, after applying skeletal overhead traction successful delayed closed reduction was undertaken for five patients. Only two patients were treated by open reduction because of inadequate closed reduction of the fracture. We think that these differences make our study distinct from the previous ones [8].

Our results correlate well with most of the current literature reporting that closed reduction is an effective surgical option for type III supracondylar fractures [2, 6, 13, 14]. In our series overall satisfactory results were achieved in approximately 97% of the cases in both groups. There were no significant differences between the two groups with respect to cosmetic and functional evaluation. However, we found it very impressive that the **functional outcome** of each of the 43 children treated with closed reduction and percutaneous pinning was **excellent**.

The complication rates were also almost similar in the two groups. Even though the postoperative ulnar nerve palsy was higher in the closed reduction group (9.7 versus 5.4%), this may be explained by the differences in pin configuration between the two groups. Eleven patients in the open reduction group were treated with two lateral pins avoiding ulnar nerve injury during surgery, whereas all patients were treated with cross-pinning in the closed reduction group.

It is possible to say that closed reduction with cross-pinning is very successful if the reduction can be obtained in an appropriate position with stable fixation. We think that the initial treatment for type III fractures should be closed reduction with percutaneous **cross-pin fixation**. Some authors suggest closed reduction with two lateral pins as an effective method with avoidance of iatrogenic ulnar nerve injury [17]. However, biomechanical studies have shown that cross-pin configuration is more stable than two lateral pin configuration [20]. According to Sankar et al. the loss of fixation is more likely to occur when Gartland type III fractures are treated with two lateral pin fixation [16]. The evaluation of the stability of the fracture line is not easy in closed reduction with the percutaneous pin fixation method. Therefore, we think that more rigid fixation with cross-pin configuration is more suitable for the closed treatment of type III fractures, whereas two lateral pin fixation may be preferable for type II fractures. Despite the higher incidence of ulnar nerve injury with cross-pinning, it is well documented that ulnar nerve injury diminishes by preventing the hyperflexion of the elbow during medial pin placement [5]. Also Lyons et al. and

Kalanderer et al. have reported that ulnar nerve palsies which developed after surgery mostly recover spontaneously without complication [7, 10].

There were no significant ($P>0.05$) differences between the three different pin fixation techniques in the open reduction group with respect to the cosmetic and functional outcomes. The only difference with regard to complications was that there was no ulnar nerve palsy in the two lateral pin group, whereas one ulnar nerve palsy developed in each of the other two groups (one lateral and one medial, two lateral and one medial).

We would like to state that the outcomes of open reduction through a lateral approach are also very *satisfactory* and *comparable* to outcomes of closed reduction percutaneous fixation. Open reduction through a lateral approach is a well known and effective procedure and should be preferred for surgeons who are not familiar with closed reduction and percutaneous fixation methods. It is also an alternative method when there are technical difficulties. Because repetitive manipulations may produce adverse effects on the epiphysis and also lead to myositis ossificans, open surgery should be preferred after one or two attempts at closed reduction.

Most authors claim that two lateral pins alone provide adequate fixation for unstable supracondylar fractures of the humerus and avoid injury to the ulnar nerve [18, 19]. Larson et al. stated in their biomechanical study that medial comminution decreases fracture stability significantly and the most stable pin configuration is two lateral and one medial pin configuration against the torsional forces. An additional pin fixation should be used when medial cortex comminution is present and when stability cannot be obtained with two lateral or cross pins [9].

We think that, in contrast to closed reduction, the initial fixation in open surgery should be with two K-wires from the lateral side if the distal fragment is big enough for two lateral pin fixation; thereafter, the stability of the fracture line should be assessed by flexing and extending the elbow and gently rotating it intraoperatively. If the fracture fragments remain in anatomical alignment, then satisfactory fixation is confirmed. However, if there is any change of the position of the fragments an addition of the one K-wire from the medial side is advisable. If the distal fragment is small, one lateral and one medial pin configuration may be more suitable initially; then the stability is assessed and if needed, a third pin can be placed laterally.

Conclusion

It can be concluded that open reduction and internal fixation is an effective secondary treatment protocol for type III supracondylar fractures with results comparable to

closed reduction and pinning. If the closed reduction fails initially, open reduction or skeletal traction and delayed percutaneous fixation can be preferred according to the surgeon's experience.

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