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Timing of surgical treatment for type III supracondylar humerus fractures in pediatric patients

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Abstract

Background   Type III supracondylar humeral fracture is a common cause of emergency hospitalization among children requiring surgical treatment. The configuration of the internal fixation material, surgical technique, and optimal timing of surgery (TS) have always been popular topics of debate. The TS in uncomplicated cases is usually determined by surgeons.

Methods   In this study, we prospectively followed children with type III supracondylar fractures. We aimed to clarify the effects of injury side, gender, and post-injury delay on switching to open surgery and the ease of the reduction.

Results   Based on our results, the probability of switching to open surgery increased by a factor of 4 every 5 h beginning 15 h after injury. Open surgery was necessary after 32 h.

Conclusion   Reduction became technically more difficult as TS increased.

Keywords   Humerus supracondylar fractures ·
Pediatric fractures · Surgical timing · Surgical technique ·
Closed reduction

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Introduction

Supracondylar fracture of the distal humeral bone is one of the most common fractures of childhood, particularly among boys between 5 and 7 years of age. The most accepted treatment method for type III and some type II fractures is closed reduction and percutaneous pinning, whereas type I fractures are usually treated conservatively [1–3]. In some cases, such as dysvascular limbs and open fractures, open reduction is indicated initially [4]. The timing of surgery (TS) remains a topic of debate. A very logical approach is that early surgery obtains better results; however, most studies fail to show a significant difference between early and delayed surgical treatment for supracondylar humeral fractures when the rates of perioperative complications and converting to the open surgical technique are taken into account [5–9].

In the present study, we evaluated the effects of TS on the reduction time and surgical technique in pediatric patients with type III isolated supracondylar fractures.

Patients and methods

This clinical study was conducted between 1998 and 2006 at the Department of Orthopedics and Traumatology. Patients who underwent surgery for supracondylar humeral fractures were followed prospectively. Among these patients, those with additional injuries (7), preoperative nerve deficits (2), vascular compromise (1), open fractures (4), Gartland type II fractures (9), and flexion type fractures (5) were excluded from the study. The remaining 190 children with isolated Gartland type III supracondylar fractures were evaluated.

The standard emergency room management of supracondylar fractures in our hospital includes obtaining alignment, examination of the neurovascular structures, and immobilizing the extremity in a comfortable position. Following preoperative preparation, closed reduction under general anesthesia is performed. We use Bauman's angle and anterior humeral line evaluation to confirm fracture reduction under C-arm scope guidance. The standard cross-pin technique is used for fixation. First, a lateral pin is applied. Then, a small incision and blunt dissection are made, followed by placement of the medial pin. We switch to open reduction under two circumstances: (1) when acceptable reduction is not achieved after two manipulations and (2) when the crepitation between two fracture fragments cannot be felt and there is a sensation of soft-tissue entrapment. We expose the fracture through a posterior approach. The triceps muscle is detached from the humerus medially and laterally, instead of midline splitting; ulnar nerve elevation is performed and fragments are fixated with two cross-pins after reduction.

Tourniquets were not used in any of the patients included in the study. The same two senior surgeons performed all of the procedures. The TS (from the time of injury to the induction of anesthesia) and the timing of reduction (TR) (from the initiation of anesthesia to intraoperative reduction confirmation) were noted. Patients were followed up on the 1st, 3rd, 4th, and 6th postoperative weeks, and the 3rd, 6th, and 12th postoperative months. The pins were removed 3 weeks postsurgery. A long arm cast was worn for 4–6 weeks for postoperative immobilization, after which time an active exercise program was initiated. Functional status of the elbow and forearm were evaluated in terms of carrying angle and elbow motion, as compared with the non-injured arm, at each follow-up visit. Complications were recorded. The study patients were also followed up once a year for the duration of the study.

Data analysis was performed using SPSS v11.5 for Windows. Student's t and Mann–Whitney U tests were used when applicable. Distributions of the continuous variables were determined using the Shapiro–Wilk test. Nominal data were expressed as the number of cases and percentages. The degree of association between continuous variables was calculated with Spearman's rho correlation coefficient. Nominal data were evaluated using Pearson's Chi-square test. TS records were divided into quartiles, using the weighted average to determine the best predictors of switching to open surgery. Odd ratios and 95% confidence intervals were calculated using both univariate and multivariate analysis. A P-value <0.05 was considered to be statistically significant.

Results

Among the 190 patients, 135 (71.1%) were treated with open surgery and 55 patients (28.9%) were treated with closed reduction and cross-pin fixation. The mean age was 7.6 years for males and 6.7 years for females at the time of injury. The male to female ratio was 129:61, the left to right side injury ratio was 110:80, and the non-dominant to dominant side of injury ratio was 116:74 (Table 1). The mean TS was 32 h (range 6–122 h). The mean TR, used as a determinant of the ease of reduction, was 12 min (range 7–51 min). The mean follow-up period was 66.8 months for patients that were treated with open reduction and 72.1 months for those treated with closed reduction.

During the follow-up period, four patients had pin site infection (three open, one closed), two patients had temporary (one open, one closed) iatrogenic ulnar nerve palsy, five patients had cubitus varus (three open, two closed) deformity, and six patients had temporary extension limitation (four open, two closed). None of the patients had iatrogenic vascular injury or compartment syndrome. The total complication rate was 8.9%. Gender and injury side had no significant effect on the TR ($P = 0.929$ and $P = 0.096$, respectively) (Table 2). The carrying angle and range of motion measures showed no significant differences between the two extremities of the patients at the end of the follow-up period ($P = 0.718$ and $P = 0.320$, respectively) (Table 3).

Using weighted averages to determine the best predictors of switching to open surgery, the TS data were divided into quartiles (Table 4). According to the logistic regression analysis, each 5-h delay in TS increased the probability of switching to open reduction by a factor of 4 (95% safety zone, confidence interval [CI]: 2.5–6.4) ($P < 0.001$).

Table 1 Demographic data

Variables	$n = 190$ (%)
Age (years)	7.4 ± 3.1
Gender	
Female	61 (32.1)
Male	129 (67.9)
Side	
Right	80 (42.1)
Left	110 (67.9)
Time to surgery (TS), h	32 (6–122)
Time to reduction (TR), min	12 (7–51)
Dominant	74 (39)
Non-dominant	116 (61)
Technique	
Open	135 (71.1)
Closed	55 (28.9)

Table 2 The effects of gender, side, and technique on the time of reduction (TR)

Variables	TR (min)	P-value*
Gender		
Female	12 (8–27)	0.929
Male	12 (7–51)	
Side		
Right	13 (7–51)	0.096
Left	12 (8–43)	
Technique		
Open	14 (8–51)	<0.001
Closed	10 (7–43)	

* Mann–Whitney U test

Table 3 The comparison of injured and uninjured sides of the patients at the last follow-up

$n = 190$	Injured side (°)	Uninjured side (°)	P-value*
Carrying angle	7.3 ± 1.8	7.1 ± 1.9	0.718
Total range of motion	129 ± 3.2	130 ± 2.1	0.320

* Student's t test

Table 4 Quartiles of the time to surgery (TS) to determine the effect of it on switching to open surgery

Time to surgery (TS)	Closed technique ($n = 55$)	Open technique ($n = 135$)
<15 h	42 (76.4%)	4 (3%)
15–32 h	13 (23.6%)	37 (27.4%)
33–58 h	–	48 (35.5%)
>58 h	–	46 (34.1%)

Open reduction was required for the cases with TS >32 h. The TR was significantly longer in the open reduction cases than in the closed reduction cases ($P < 0.001$), and it increased as TS increased (rho = 0.742, $P < 0.001$) (Figs. 1 and 2).

Discussion

The present study considered age, gender, side of injury, injury time, preoperative period, surgical technique, perioperative and postoperative complications, and functional results of surgery as the parameters to be evaluated. Although there were 218 postoperative patients in total, we included only 190 cases due to the exclusion criteria. We conducted the study with patients that had non-complicated
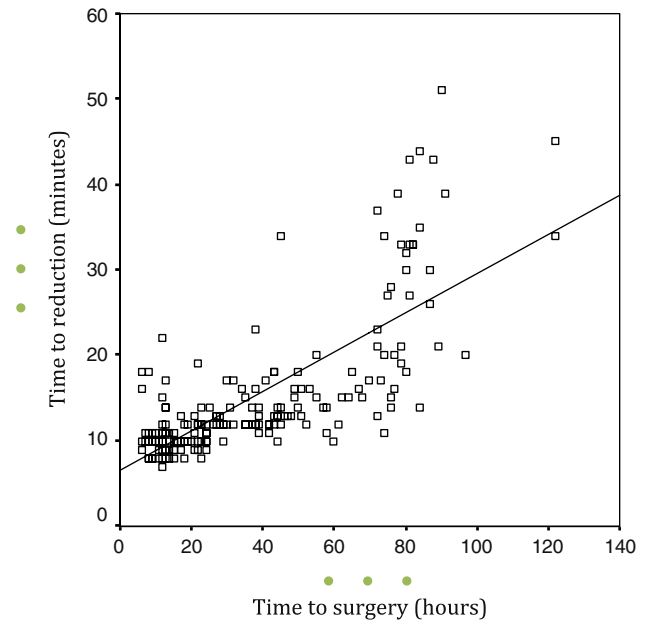

Fig. 1 Distribution plot of the time to surgery (TS) and reduction time (TR)

isolated Gartland type III fractures. Our aim was to define the predictors of surgical technique.

Our hospital is one of the largest referral centers of the Turkish Ministry of Health, and supracondylar fracture is a common injury for which we hospitalize children. The time between injury and presentation to the emergency department has been decreasing, along with the advances in communication, patient transfer, and staged health care services. Yet, we still treat patients that have been manipulated by unlicensed caregivers in the rural parts of Turkey several days before presenting to the hospital. This is why the time between injury and emergency presentation varies widely. Preoperative preparation procedures, including immobilization, laboratory studies, organization of the operating room, and oral intake restriction for at least 4 h before surgery, also took a certain amount of time. As a result, TS was considerably long (mean 32 h; range 6–122 h) in this study group.

In the middle of the 1990s, open reduction was the treatment of choice in our clinic for type III fractures. After the arrival of a new surgeon in 1998, closed reduction was adopted as the initial treatment. Currently, two senior surgeons in particular treat this patient group. We have standard management protocols for those patients—in the emergency room, in the operating room, and during postoperative follow-up—which all of the fellows and assistants are required to follow.

Closed reduction and percutaneous pinning is our primary treatment approach. There are two particular conditions for which we switch to open reduction during surgery.

Fig. 2 Bar chart of the TS and TR
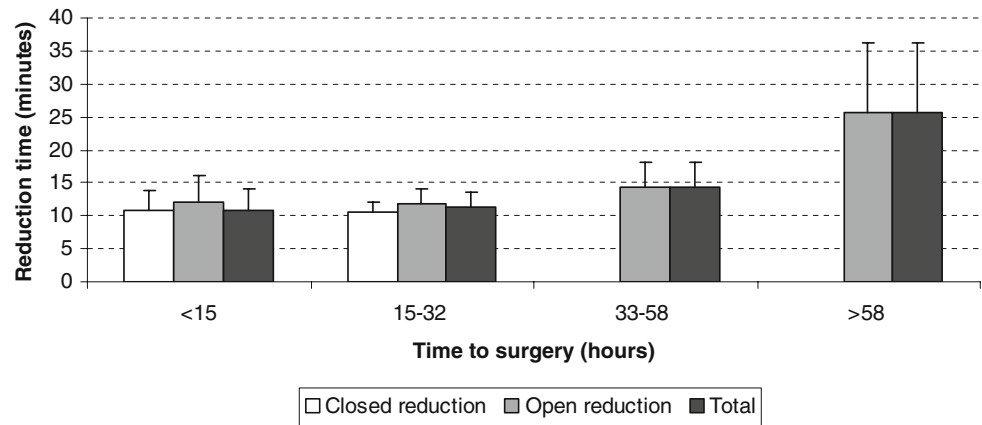
The first is failing to achieve fracture reduction after two sequential manipulations under C-arm scope guidance. We pay particular attention to this principle because we do not want to crush the fragments and damage the delicate physeal plates. The other is the sensation of soft tissue between the fracture fragments during the maneuver. When we do not achieve crepitation between the fragments, and determine that they are not touching each other and that the fragments' interface is slippery, we conclude that there is soft tissue interposition and change the technique to open reduction.

Our surgeons are extremely familiar with the technique. They adhere to the above-mentioned principles. Objective criteria are used to evaluate the results. An extended post-injury period is the only significant factor that seems to have a strong relationship with switching to open reduction.

When we evaluated the TS–TR scatter graph, we observed that, whether open or closed, most of the reductions were accomplished within the first 20 min. There were a few extraordinary results; therefore, logarithmic transformations were applied to TR and linear regression analysis was performed. A strong positive relationship between TR and TS was observed.

In different epidemiological studies on children, no gender predilection is reported [10, 11]. Most of our patients were boys (67.8%) and this is concordant with other reports from Turkey [12, 13]. Differences in the incidence rate between genders may be due to social factors and economic conditions. In the present study, the girls were younger than the boys at the time of injury.

The non-dominant side is reported to be involved in supracondylar humeral fractures most often [1, 10]. In the present study, left-sided fractures were predominant (57.9%) and 61% of the fractures occurred in the non-dominant arm.

Technically, different types of pinning are defined as lateral parallel pinning and lateral cross-pinning [14–17].

Each has its own mechanical and anatomical advantages. It is safer for the ulnar nerve to apply pins laterally than bilaterally. In our opinion, sufficient stability to apply two lateral pins from the distal fragment and protect the reduction is not always present. Lateral cross-pinning may be a good alternative for fixation; however, as yet, we do not have enough experience with the procedure. As we have qualified experience with cross-pinning, we prefer this technique for fixation. We apply the lateral pin primarily under C-arm guidance. For medial pin applications, we make a small incision (not longer than 1 cm) over the medial epicondyle and use blunt dissection to keep the nerve away from its route. We had two transient iatrogenic partial ulnar nerve injuries with this technique during an 8-year period.

Even though our mean post-injury period was long, the complication rate was quite low in comparison with other reports [1, 18, 19]. Pin site infections (2.1%) were treated with oral antibiotics and localized wound care. Ulnar nerve palsy (1%) in two patients resolved during follow-up. All of the patients with an extension gap (3.1%) healed without any functional deficit in a mean of 3 months. None of the patients with deformities (2.6%) needed further treatment. None of the patients had non-union, permanent functional deficit, or compartment syndrome. Moreover, there was no significant functional difference between the injured and uninjured sides at the end of the follow-up period.

TS has been investigated in numerous studies. The mean delay was 4 days in a report from India [20]. Satisfactory results were obtained in 88% of 40 patients, and closed reduction was not performed more than 7 days after injury. In another study of 42 patients, delayed intervention was defined as >8 h post-injury [7]. It was reported that, in type II and type III injuries without neurovascular compromise, delaying surgery until the following day did not compromise the quality of reduction. In a multicenter study [5], it was reported that 11 patients had compartment syndrome secondary to supracondylar fractures after a mean TS of

22 h. In another study that included 198 patients [21], early and late surgical treatments were compared and no significant differences in perioperative complications were observed. Delayed treatment was not recommended for open and pulseless fractures; the TS was left to the discretion of the surgeon for simple and uncomplicated fractures.

In our clinic, we do not delay surgical intervention electively. The post-injury period in our series was long—most often because of delayed patient presentation. When we evaluated the TS data in quartiles, each 5-h delay of surgery after the first quartile increased the probability of switching from closed reduction to open reduction fourfold above that during the second quartile (15–32 h). No closed reduction was possible 32 h after injury and all cases were switched to open reduction. In addition, if we consider the TR as a predictive measure of the ease of reduction, it increases as the TS gets longer.

Conclusion

Although the management of type III supracondylar humeral fracture is regarded as an urgency rather than an emergency, surgeons should be aware of the fact that they may lose the opportunity to perform closed reduction after 32 h post-injury. We showed that, the longer the delay, the greater the number of the cases which will require open operation. Also, the reduction of the fracture will be more difficult if the post-injury period increases beyond that point.

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