European Review for Medical and Pharmacological Sciences 2023; 27: 11764-11770

Comparison of complications and results of early *vs.* delayed surgery for pediatric supracondylar humeral fractures

S.A. ULUS, M.S. AKAR

Department of Orthopedics and Traumatology, Dicle University Medical School, Diyarbakır, Turkey

Abstract. – OBJECTIVE: Pediatric supracondylar humerus fracture (SCHF) is one of the most common elbow fractures in children aged 5-7 years. There is a continuous discussion regarding the optimal timing for conducting surgery for fractures of this nature. Therefore, we aimed to determine whether the timing of surgery in pediatric SCHFs has an impact on the frequency of early postoperative complications.

PATIENTS AND METHODS: Between January 2018 and March 2020, pediatric SCHF patients who underwent surgery at our hospital were retrospectively reviewed. Patients operated on within 12 hours after the fracture and those operated on later were respectively included in the early and late groups. Early postoperative complications, including neurological deficits, iatrogenic ulnar nerve injury, vascular injury, compartment syndrome, K-wire migration, and unexpected returns to the operating room, were compared between the two groups. We investigated surgical duration, reduction, and perioperative radiographic data.

RESULTS: For modified Gartland type II or type III fractures, there was no significant difference in the incidence of early complications between the early and delayed groups. Additionally, there were no noticeable differences between the two groups in terms of perioperative radiographic data, reduction procedure, or surgical duration.

CONCLUSIONS: Delayed surgery in type II or type III supracondylar humerus fractures was not associated with an increased incidence of early postoperative complications. The difficulty or effectiveness of reduction is not influenced by the timing of surgery.

Key Words:
Supracondylar Humerus Fracture, Surgery, Timing.

Introduction

The majority of pediatric elbow fractures are considered to be pediatric supracondylar humerus fractures (SCHF), which make up between 50 and 70% of all pediatric elbow fractures[1]. After an elbow injury, these fractures require surgery and account for about two-thirds of children's hospital admissions[2]. This fracture often affects children between the ages of 4 and 10 and has the potential to lead to severe morbidity as well as deformity in both acute and chronic settings[3].

To manage fractures of the supracondylar humerus, the modified Gartland classification is now the most widely used system. Gartland has identified three sub-types of the extension type of supracondylar fracture. The first sub-type is undisplaced transverse fractures, which are classified as Gartland extension type I injuries. The second sub-type is moderately posteriorly displaced fractures, which were originally classified as Gartland extension type II injuries and required reduction. The third sub-type is oblique fractures of the Gartland extension type III, which have significant displacement and rotation[4].

When surgery should be performed is still controversial. Previously, it was believed that immediate surgery was necessary for misplaced SCHFs to reduce postoperative problems and the likelihood of an open reduction[5,6]. Other studies[6,7], however, have found no appreciable difference between early and delayed surgical therapies for SCHFs. To ascertain whether the timing of surgery for pediatric SCHFs is related to the occurrence of early postoperative complications and reduction of the fracture, the following research was conducted.

Patients and Methods

Between January 2018 and March 2020, we retrospectively reviewed the records of 54 pediatric patients aged between 2 and 15 who were treated at our hospital for supracondylar

Corresponding Author: Sait Anıl Ulus, MD; e-mail: mdanilulus@gmail.com

humeral fractures (SCHF). The study was conducted in accordance with the guiding principles of the Helsinki Declaration. We obtained data from the medical records of patients who underwent surgery due to modified Gartland type II or III fractures. Patients for whom information was not stored in computerized medical and surgical records until bone union were not included in the study. Patients with neurological deficits, ipsilateral fractures, open fractures, cases where conservative treatment failed, or those in whom the radial artery pulse could not be obtained during the initial examination were also excluded from the research (Figure 1).

The computerized medical data for each patient were used to calculate the interval between injury and reduction. For type II and type III fractures, we designated patients who underwent surgery within 12 hours as the early group (EII for type II and EIII for type III) and those who underwent surgery more than 12 hours after the fracture as the delayed group (DII for type II and DIII for type III) respectively. The surgical delay was caused by the absence of operating room staff, insufficient fasting, and distant consultations with other medical facilities. The incidence of postoperative early complications, including neurological deficits, vascular compromise, compartment syndrome, K-wire migration, and unexpected return to the operating room, were the outcome measures assessed. Using software on our digital imaging system, we also assessed the surgery time, reduction technique, and perioperative radiographic data. In X-ray pictures taken right away after surgery, we assessed the post-

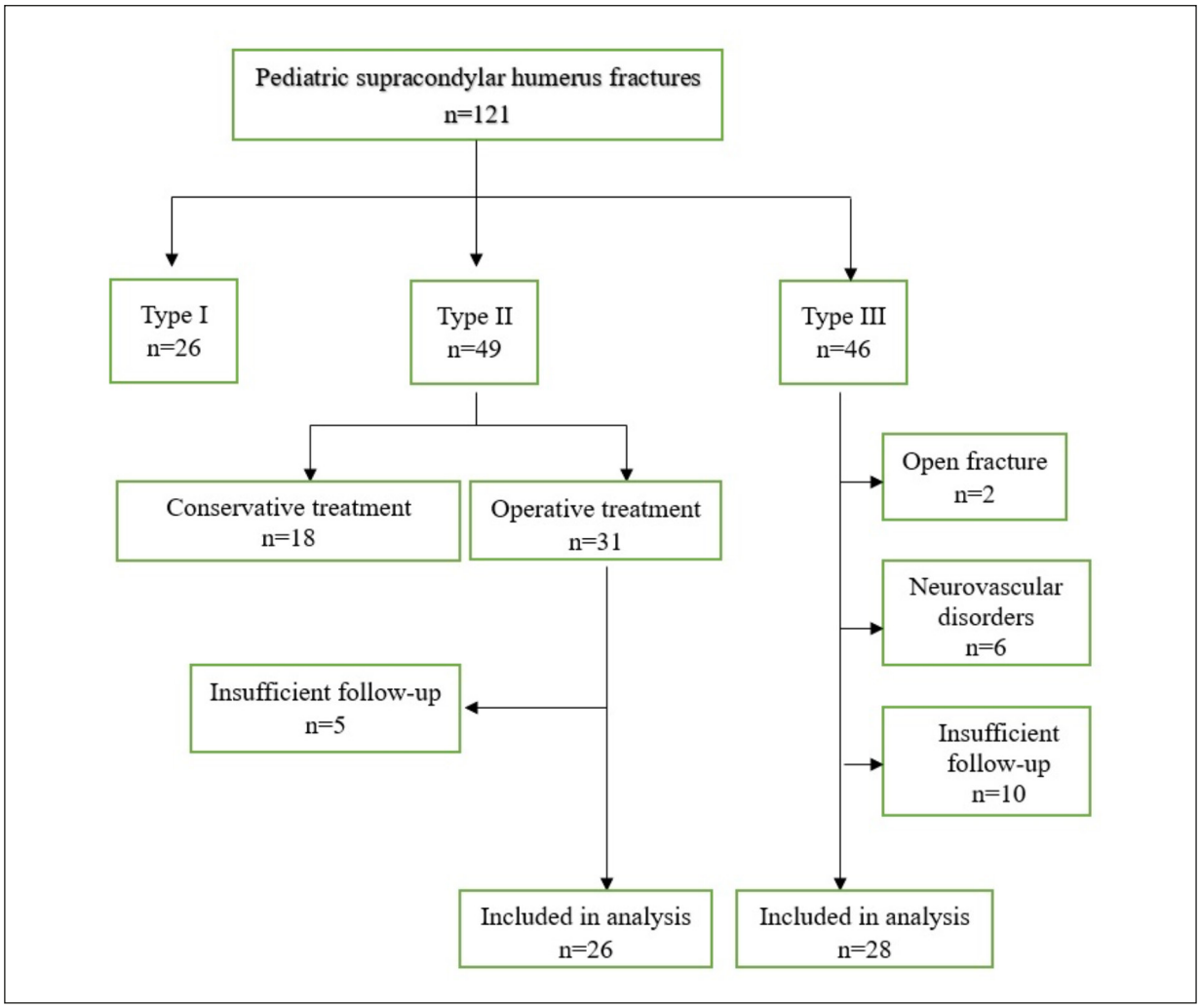

Figure 1. Study patient's inclusion criteria.

operative Bauman's angle (BA) as radiographic characteristics. We measured the patients' carrying angles (CA) after the K-wires were taken out. The approved Baumann angle normal range is 56-86 degrees[8]. We computed the variations among the groups.

Surgical Technique

Before inducing anesthesia, no reduction attempt was made. During surgery, general anesthesia was administered to each patient. Cefazolin sodium was then given at the beginning of the operation at a weight-appropriate dose. The patient was lying on their back with their elbow on a reduction table during the procedure. For all patients, we initially tried closed reduction. When any of the aforementioned two procedures failed to achieve an acceptable reduction or when there was a gap between two fragments that suggested the possibility of soft tissue interposition, we moved to open reduction. To verify reduction under a biplane image intensifier (Ziehm Vision, Nurnberg Germany), we use BA and the anterior humeral line. We generally did cross-pinning for fixation once an acceptable reduction was attained. Each surgeon was free to choose the final pin configuration. For postoperative immobilization, a lengthy arm cast with the elbow bent at 70°-90° was employed for 4-6 weeks. Between 4 and 8 weeks after surgery, the K-wire was taken out when the bones had fused. Between EII and DII, as well as between EIII and DIII, there was no variation in the time it took to remove a pin.

Statistical Analysis

Radiographic measures and demographic information were compared between the two groups. Continuous data is displayed as mean, (SD). The number of cases and percentages are reported for nominal variables. When comparing categorical data between the two groups, either a Fisher's exact test or a Chi-square analysis was used as appropriate. An independent *t*-test was used for between-group comparisons for numerical data, $p \leq 0.05$ was the significance threshold. Statistical analysis was carried out utilizing SPSS software (version 17.0, SPSS Inc., Chicago, IL, USA).

Results

The current study collected data from 54 participants (Table I). 26 type II fractures and 28 type III fractures were present in the 44 boys and 10 girls, with a mean age of 5.8 (SD, 2.3) years. In 34 cases, the left elbow and, in 20 cases, the right elbow, were implicated. The majority of fractures resulted from simple falls (77.8%), height falls (14.8%), or traffic accidents, including bicycle accidents (7.8%). The average follow-up duration was 7.1 months (SD, 1.3).

Patients with type II fractures had one (3.8%) complication. A patient experienced ulnar nerve palsy but made a full recovery during follow-up. There were two (7.8%) complications within the patients with type III fractures. The migration of K-wires was one of them. K-wire migration was found in this case two weeks after surgery. The K-wire was taken down earlier than anticipated. The patient was followed up on, and there was

Table I. Patients' demographics.

	Type II	Type III	Total
N	26	28	54
Age, mean (SD), years	5.9 (2.8)	5.8 (2.9)	5.8 (2.3)
Sex			
Male	24	20	44 (81.8%)
Female	2	8	10 (18.2%)
Injured side			
Left	17	11	28 (51.8%)
Right	9	17	26 (48.1%)
Trauma type			
Simple fall	24	18	42 (77.8%)
Fallen from height	2	6	8 (14.8%)
Traffic accident		4	4 (7.8%)
Surgical group			
Early group (≤ 12)	13	15	28
Delay group (> 12)	13	13	26

Table II. Post-operative complications.

	Type II		Type III		
	EII	DII	EIII	DIII	Total
Neurological deficit	0	1	0	1	2
K-wire migration	0	0	0	1	1
Compartment syndrome	0	0	0	0	
Vascular compromise	0	0	0	0	
Unplanned return to the operating room	0	0	0	0	

no loss or reduction. In the second instance, the patient experienced drop hand syndrome after an open reduction, but it resolved later. EII and DII did not differ significantly from one another (p = 0.30), nor did EIII and DIII (p = 0.11). Patients with type II or type III fractures did not experience postoperative vascular compromise, compartment syndrome, or unexpected reoperation (Table II).

For type II fractures, the mean surgery time was 75.9 minutes (SD, 30.3), while for type III fractures, it was 68 minutes (SD, 21.4). Between EII and DII, there was not a significant difference (p = 0.88). EIII and DIII did not differ significantly from one another either (p = 0.56). All patients with type II fractures underwent closed reduction. In contrast, one patient in EIII (6.6%) and two in DIII (15.3%) required conversion to open reduction. Between EIII and DIII, there was no discernible difference in the reduction strategy (p = 0.58).

EII and DII had average Baumann angles of 67.6 (SD, 1.6) and 69.2 (SD, 3.2), respectively. EIII and DIII both had average BAs of 67.5 (SD, 8.7) and 68.1 (SD, 9.2), respectively. Between EII and DII (p = 0.13) and EIII and DIII (p = 0.85), there was no significant difference. EII and DII both had average CAs of 17.8 (SD, 5.8) and 14.2 (SD, 6.8), respectively. EIII and DIII both had average CA values of 14.5 (SD, 7.5) and 18 (SD, 8.4), respectively. EII and DII (p = 0.16) and EIII and DIII (p = 0.26) did not differ significantly from one another. In addition, there were three cases of type III malrotation and one case of type II malrotation. Between EII and DII (p = 0.30) and EIII and DIII (p = 0.58), there was no significant difference (Table III).

Discussion

Many supracondylar humerus fractures (SCHFs) occur post-school hours due to sports or playground activities. Consequently, a significant number of patients reach healthcare facilities during the early evening, requiring surgical interventions in the evening or at night. However, due to the limited availability of medical resources, it might occasionally be challenging to carry out emergency surgery throughout the night. Additionally, limiting the number of procedures carried out after hours can lessen worker tiredness and thereby enhance the standard of care[9]. Thus, one of the most frequently discussed issues has been whether to do emergency surgery on SCHFs. Emergency surgical intervention has been promoted throughout the past few decades. In Gartland type III SCHFs run later than 8 hours, Walmsley et al[10] showed higher open reduction rates. According to a systematic study by Loizou et al[11] open reduction rates were higher in patients who were not operated on within the first 12 hours. There has not been any conclusive evidence to support these perspectives[5,11], even though an emergency procedure can be justified to prevent swelling, which could, at least theo-

Table III. The averages of surgical durations and measured angles are as follows.

	EII	DII	p	EIII	DIII	p
Surgery time	76.8 (SD, 28.7)	75 (SD, 32.9)	0.88	65.8 (SD, 17.6)	70.5 (SD, 25.5)	0.56
Baumann angle	67.6 (SD, 1.6)	69.2 (SD, 3.2)	0.13	67.5 (SD, 8.7)	68.1 (SD, 9.2)	0.85
Carrying angle	17.8 (SD, 5.8)	14.2 (SD, 6.8)	0.16	14.5 (SD, 7.5)	18 (SD, 8.4)	0.26

retically, reduce the number of open reductions and lessen consequences like compartment syndromes and nerve damage. However, numerous studies[12,13] have claimed that there is no distinction between early and delayed surgery in terms of postoperative complications or the requirement for open reduction. To see if early *vs.* delayed procedures had different perioperative outcomes, Farrow et al[14] recently conducted a systematic review and meta-analysis. They concluded that there was no appreciable difference between early and delayed procedures in terms of the need for an open reduction or the incidence of complications. We argue that there are some problems with the aforementioned studies[5,10-16]. First, two research[15,16] looked into a combination of type II and III fractures that might be a source of bias. Therefore, we looked at type II and type III fractures separately. Second, the reduction quality was evaluated infrequently or not at all in these investigations[6,10,14]. They almost all focused solely on the open reduction requirement. However, we believe it is crucial to evaluate both the reduction process and the reduction itself. To appropriately assess the reduction's quality, we looked into the surgical duration and open reduction required, as well as BA and CA.

In the current study, early (≤ 12 hours) or late (> 12 hours) surgical scheduling options for SCHFs of Gartland type II and type III were studied. The time of surgery has little impact on reduction, as there is no correlation between delayed surgery and a higher likelihood of early postoperative problems in type II or type III fractures. Only a few studies[6,17], as far as we are aware, have looked at whether type II fractures require urgent surgical intervention. An increase in significant complications after closed reduction and percutaneous pinning of type II fractures was not seen in some investigations[6,17]. We have obtained results that are consistent with the information presented by these studies. Additionally, we discovered that the difficulty and effectiveness of reduction were unrelated to the time of the surgical procedure for type II fractures. Contrarily, there has been debate regarding whether delaying surgery for type II fractures is prudent. Certain individuals should receive treatment as soon as possible if they exhibit warning indications such as neurological deficiency[18], reduced or non-existent radial artery pulse[19], and/or pucker sign[20-22]. Attempting to treat type III fractures without problems in elective situations may not always be useful, despite studies suggesting that it is possible. Patients and their parents may become anxious if they have to wait longer to have surgery. Therefore, if surgery is delayed until the next day, a comprehensive clinical assessment of neurovascular findings and proper preoperative pain management must be carried out repeatedly. As a regional hospital, our facility sees a lot of patients from outlying regions. As a result, we sometimes see supracondylar humerus fractures that appear later than expected. According to our study, delayed fracture cases can also benefit from conventional treatment algorithms.

Limitations

The current study has some limitations, starting from the retrospective design. Due to follow-up loss, data collection was initially constrained. Therefore, there may not be any randomization of the patients into periods. Third, different surgeons carried out the procedures, which would have resulted in a variety of surgical approaches. However, throughout the study, we conducted regular meetings and case discussions among the surgical team to address any questions or concerns and to ensure that the surgical technique was consistently applied. We primarily focused on objective outcome measures, such as radiological assessments and clinical scores, to evaluate the results. This approach helped mitigate potential bias arising from differences in surgical methods. By implementing these measures, we aimed to minimize the influence of variations in surgical techniques on our study outcomes. However, we acknowledge that despite these efforts, some degree of variability may still exist due to individual surgeon preferences and experiences. As a fourth point, it can be mentioned that the number of patients is relatively low. Additionally, several uncontrollable factors could affect whether a patient received prompt or delayed treatment. Prospective organization of such clinical studies with more current data collection would render the study's results more reliable and generalizable.

Conclusions

If a patient has a supracondylar humerus fracture that does not require immediate medical attention, such as in cases of open fractures, neurovascular compromise, or compartment syndrome, it may be better to postpone the surgery until the morning instead of performing it late at night.

Although this may seem to delay the surgery, it is unlikely to result in any negative outcomes. Close monitoring during the postponed period is essential. The clinical investigations would be more reliable and applicable if they were prospectively organized with up-to-date data collection.

Conflict of Interest
The authors declare that they have no conflict of interests.

Funding
None.

Ethics Approval
Ethical approval for this study was obtained from the Ethics Committee of the Medical Faculty of Dicle University (Number 233-2023).

Informed Consent
The protocol was performed in accordance with the Declaration of Helsinki, and the participants or their families provided written informed consent.

Authors' Contribution
Sait Anıl Ulus and Mehmet Sait Akar designed, analyzed, and wrote the article. Mehmet Sait Akar and Sait Anıl Ulus collected and performed the studies. All authors contributed to and approved the final version of the paper.

Data Availability
All data associated with this paper are available from the corresponding author upon reasonable request.

ORCID ID
Sait Anıl Ulus: 0000-0003-3270-1648
Mehmet Sait Akar: 0000-0002-2999-2141

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