

## PAPER DETAILS

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# Retrospective Analysis of the Determining Factors for Open Reduction in Pediatric Humerus Supracondylar Fractures: Are Factors Such as Time Until Operation and Surgeon's Experience Effective?

## Pediatric Humerus Suprakondiler Kırıklarında Açık Redüksiyonu Belirleyen Faktörlerin Retrospektif Analizi: Operasyona Kadar Geçen Süre ve Cerrahın Deneyimi Gibi Faktörler Etkili midir?

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### ABSTRACT

**Aim:** Indications for open surgery are very limited in supracondylar humerus fractures (SCHFs).

In our study, we aimed to examine whether the patient's fracture type, waiting time of the patient before the operation, and the experience of the surgeon are effective on the treatment decision for open surgical method in our SCHF patients treated with open reduction.

**Methods:** A group of pediatric patients treated with open reduction for SCHF between the years of 2010 and 2022 were examined for our study. Trauma mechanism, type of fracture, time until operation, neurovascular injuries and years of experience of the surgeons were retrospectively reviewed.

**Results:** A total of 110 patients were included in the study. The mean age was 5.7 years. Nine patients were flexion-type SCHF. According to the Gartland classification, 19 patients were Type II and 82 patients were Type III. Ninety-four patients were operated in the first 24 hours, 16 patients were operated after 24 hours. There was no statistical correlation between the surgeons' experience or time until operation and the type of the fractures. Patients with flexion type fractures were significantly older than the other patients.

**Conclusion:** Supracondylar humerus fractures in children are difficult fractures regardless of the surgeon's experience and the waiting time for surgery. Regardless of the surgeon's years of experience and the type of the fracture, some fractures cannot be treated with closed reduction and require open reduction.

### ÖZ

**Amaç:** Suprakondiler humerus kırıklarında (SKHK) açık cerrahi için kesin endikasyonlar çok sınırlıdır.

Çalışmamızda açık redüksiyon ile tedavi edilen SKHK hastalarımızda, hastanın kırık tipi, operasyon öncesi hastanın bekleme süresi ve cerrahın deneyiminin açık cerrahi yöntem için tedavi kararında etkili olup olmadığını incelemeyi amaçladık.

**Yöntem:** Çalışmamız için 2010-2022 yılları arasında SKHK nedeniyle açık redüksiyon ile tedavi edilen çocuk hasta grubu incelendi. Travma mekanizması, kırık tipi, operasyona kadar geçen süre, nörovasküler yaralanmalar ve cerrahların yıllara dayanan deneyim süreleri retrospektif olarak incelendi.

**Bulgular:** Çalışmaya toplam 110 hasta dahil edildi. Ortalama yaş 5.7 idi. 9 hasta fleksiyon tipi SKHK idi. Gartland sınıflamasına göre 19 hasta Tip II, 82 hasta Tip III idi. 94 hasta ilk 24 saatte, 16 hasta 24 saat sonra ameliyat edildi. Cerrahların deneyimi veya ameliyata kadar geçen süre ile kırık tipi arasında istatistiksel bir ilişki yoktu. Fleksiyon tipi kırığı olan hastalar diğer hastalardan anlamlı olarak daha ileri yaşta idi.

**Sonuç:** Çocuklarda görülen suprakondiler humerus kırıkları, cerrahın tecrübesi ve ameliyat için bekleme süresinden bağımsız zor kırıklardır. Cerrahın tecrübe yılı ve kırığın tipi ne olursa olsun bazı kırıklar kapalı redüksiyonla tedavi edilemez ve açık redüksiyon gerektirir.

**Key Words:** Pediatric supracondylar humerus fractures, open reduction, surgeon's experience, time until surgery

**Anahtar Kelimeler:** Çocuk humerus suprakondil kırıkları, açık redüksiyon, cerrahın deneyimi, cerrahiye kadar geçen süre

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## Introduction

Supracondylar humeral fractures (SCHFs) are common and account for 3% of all fractures in the pediatric age group.<sup>1-3</sup> The treatment of these fractures usually depends on the extent of the displacement of the fracture, and the Gartland classification is used for the determination of this extent (degree) and the severity of SCHFs. In Type I fractures, the posterior periosteum is intact without a displacement, so these fractures can be treated with orthopedic immobilization (with a plaster cast); however, severe displaced fractures are treated with surgical (open or closed) reduction and internal fixation with surgical pins.<sup>4-6</sup> Regarding the management of Type II and III fractures, some authors insisted on an operation without a reduction attempt while some others argued that a closed reduction and plaster cast should primarily be given a chance for all degrees of fractures except for those with circulation problems, and surgery should then be performed if appropriate reduction could not be achieved with the help of the aforementioned methods.<sup>7,8</sup> There is no evidence in the current literature showing which method is superior to the others, also, there might be different approaches among the surgeons with different surgical experiences even within the same clinic.

Due to the highly unstable nature of these fractures, a reduction and pin fixation can easily be performed by using proper techniques; however, a minimal varus-valgus angulation may also require open surgery when appropriate techniques are not used. Current literature recommends avoiding open surgery, if possible, in order not to come across with complications such as avascular necrosis, infection, and range of motion limitation. Open surgery may be inevitable in cases in which anatomical reduction cannot be achieved with the closed technique or when the extremity is cyanotic and arterial circulation is impaired.<sup>9</sup>

Definite indications for open surgery are very limited in SCHFs. In literature, there are studies evaluating the effective factors on the decision of the surgery in open surgery patients; however, the factors mostly focused on the type and location of the fracture.<sup>10</sup>

In our study, we aimed to examine whether the patient's fracture type, time until operation, and the amount of experience of the surgeon (regarding expertise in orthopedics and traumatology) are effective on the treatment decision for open surgical method in our SCHF patients treated with open reduction.

## Material and Method

Ethics committee approval was obtained prior to the study (ID:215591851). A total of 130 pediatric patients

(between 2 and 16 years old) treated with open reduction and pin fixation for SCHF between the years of 2010 and 2022 were examined for our study. We excluded the patients who underwent open surgery due to circulatory problems, with Type III open fractures, who did not have adequate medical records, were followed up after having been treated with closed reduction in another center, and whose closed reduction failed during follow-ups and were reoperated for this reason from the study. Patients who did not get any treatment after the occurrence of the fracture were included in the study.

Demographic characteristics such as age, gender, trauma mechanism, type of fracture according to Gartland classification, time until operation, neurovascular injuries and ipsilateral traumas of the patients and years of experience of the surgeons who operated the patients were retrospectively reviewed and scanned via our institution's patient follow-up system; health Information Systems v:5 (HIS). We divided the patients into two groups according to the time spent until their operation: the ones operated in the first 24 hours and those operated after 24 hours. We also examined the experience of the surgeons in two groups: the ones with an experience of less than 5 years and those with an experience of more than 5 years. In total, thirteen surgeons, who have worked at our clinic in different time, participated in the study. The surgical procedures were conducted by the respective surgeons in accordance with their monthly work schedules. The data were analyzed statistically.

A total of 110 patients were included in the study. Standard procedure was applied to all patients. Closed reduction and cast are performed in Type II fractures in SCHF patients during emergency admission if there are no symptoms of a circulatory or neurological problem. If appropriate anatomic reduction cannot be achieved, the patient's plaster is removed, and surgery is planned. If the fracture was a Type III fracture, only minimal alignment is provided with traction to reduce the pressure on the skin and/or neuro-vascular structures in severely displaced fractures, and then the patient is told to fast prior to the surgery and prepared for operation. It depends on the preference of the responsible surgeon when open surgery should be performed in patients, and after how many unsuccessful closed reduction attempts should the surgeon give up pinning and switch to open treatment. In open surgery, medial or lateral approach was preferred according to the experience of the surgeon and the fracture type. The noted time until surgery was calculated from the admittance of the patients to the hospital until the onset time of the surgery. (Figure 1)

**Statistical methods:** The data were analyzed using SPSS Version 26 (IBM, New York, USA). Categorical data were an-



**Figure 1.** A case 7 years old girl, Type 3 supracondylar humerus fracture preop and postop x ray pictures.

alyzed with the Chi-Squared test and Fischer's exact test, and parametric data of the two groups were compared with the Student's t-test. Categorical data were percentage (%), number (n), and frequency while parametric data were mean, standard deviation, minimum, and maximum values. The data were analyzed at a confidence interval (CI) of 95% and a p-value less than 0.005 was considered statistically significant. ( $p < 0.05$ )

## Results

We examined a total of 130 supracondylar humerus fractures treated with open reduction pin fixation. Twenty patients were excluded from the study because they did not meet the inclusion criteria, and the remaining 110 patients were included in the study. The mean age was 5.7 years (between 1 and 11 years). Nine patients were flexion-type SCHF. According to the Gartland classification, 19 patients were Type II and 82 patients were Type III. Ninety-four patients (85.5%) were operated in the first 24 hours, and 16 patients (14.5%) were operated after 24 hours (Table 1). While surgeons with less than 5 years of experience operated 38 of the cases, surgeons with more than 5 years of experience operated 72 patients.

**Table 1.** Type of fractures and time until operation

	<24 hours	>24 hours
Flexion Type	8 (88.9%)	1 (11.1%)
Type 2	19 (100%)	0 (0%)
Type 3	67 (81.7%)	15 (18.3%)

Of the cases operated in the first 24 hours, 8.5%, 20.2%, and 71.3% were flexion type, Type II, and Type III fractures, respectively. Of the cases operated after 24 hours, 6.3% were flexion type and 93.7% were Type III fractures.

While 81.6% of the surgeons with less than 5 years of experience operated their patients in the first 24 hours, surgeons with more than 5 years of experience operated

87.5% of their cases in the first 24 hours. All Type II fractures were operated in the first 24 hours regardless of the surgeon's experience. Regarding the fracture types, 33.3% of flexion type fractures, 26.3% of Type II fractures, and 36.6% of Type III fractures were operated by surgeons with less than 5 years of experience. Surgeons with more than 5 years of experience operated 66.7% of flexion fractures, 73.7% of Type II fractures, and 63.4% of Type III fractures.

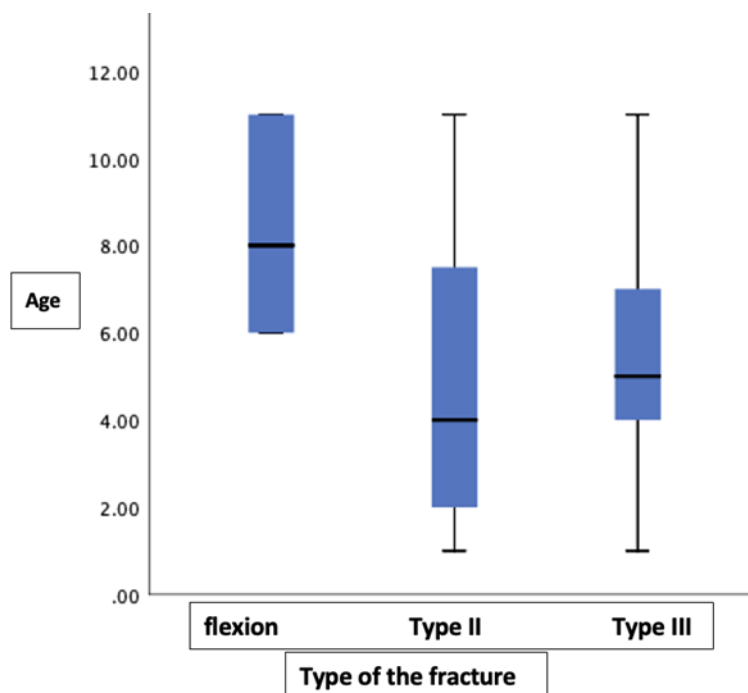
There was no statistical correlation between the surgeon's experience and the Gartland type of fracture that underwent open surgery ( $p = 0.609$ ). In other words, inexperienced surgeons did not need to switch to open reduction in Type II fractures more than the experienced ones or experienced surgeons did not prone to perform open reduction in Type III fractures more than the inexperienced ones.

Patients with flexion type fractures were statistically significantly older than the other patients who underwent open surgery ( $p = 0.008$ ) (Figure 2). While younger children are likely to suffer more extension-type fractures due to falling on their wrists or elbows in extension from sofas and chairs, older children are more likely to fall on the elbow and suffer flexion-type fractures because they can be injured in activities.

The distribution of Type II and Type III fractures that underwent open surgery was homogeneous ( $p = 0.134$ ). There was no statistically significant relationship between the time until operation and fracture type ( $p = 0.120$ ).

## Discussion

Closed reduction and percutaneous fixation are the most frequently preferred methods of surgical treatment, especially in patients with displaced SCHFs. Open reduction is required in fractures that cannot be adequately reduced by closed methods, fractures with arterial injury, or open fractures.<sup>4,5,9,11-12</sup> The rate of the requirement of open reduction has been reported to be between 3% and 46% in the literature.<sup>13-16</sup>



**Figure 2.** Type of fractures and age.

Many factors, including fracture type and direction, time to surgery, and surgeon experience, influence the decision to open reduction.<sup>9,17,18</sup> A study published in 2017 emphasized the importance of the years of experience of surgeons in having more patience and obtaining the necessary skills to achieve a closed reduction.<sup>19</sup> Open reduction may result in unpleasant skin scars, longer operative time, and sometimes poor functional outcomes.<sup>9,19-21</sup> Mehlman et al. described “a delayed surgery” as an 8-hour-delay in their study and this delay was reported not to increase pin infection, nerve damage, compartment syndrome, or the requirement for open reduction in Gartland Type II and III fractures.<sup>16</sup> Iyengar et al. indicated that a delay of more than 8 hours did not cause an increase in open reduction rates in Type III fractures.<sup>22</sup> Leet et al. found that a mean surgery delay of 21.3 hours in Type III fractures did not increase the need for open reduction or unsatisfactory outcomes.<sup>23</sup> In addition, they did not detect any adverse effects such as prolonged operative time and hospital stay due to the delay of the surgery. In our study, no complication was reported in our patients related to the waiting time that passed until surgery. In the literature, there are many studies on the safety of operating the Gartland Type IIA and Type IIB fracture patients that were admitted at night in the next business day.<sup>22-24</sup> However, in their study, Walmsley et al. found that the requirement for open reduction due to a delay of more than 8 hours in Gartland Type III fractures increased from 11.2% to 33% and the results were significant.<sup>25</sup>

In our cases, the reason why we delayed the surgeries for more than 24 hours was the patients’ health conditions

such as multitrauma or upper respiratory tract infection. We aim to begin the surgery in the first 24 hours when there is no clinical obstacle to the operation. However, when the surgery time is going to past midnight, we operate the patient next day. In the literature, this decision was not reported as a disadvantage for the patient, and we did not also detect any negative outcomes. Of the patients we treated with open reduction, 74.5% had Type III fractures. We believe that the more displaced the fracture is, the more probable the open reduction is. We also think that as the surgeon’s years of experience increase, the probability of performing a successful closed reduction increase, and we also believe that the type of fracture, the age of the patient, and the time until the operation are also effective in a successful closed reduction.

Our study undoubtedly had several limitations. First of all, since the patients included in the study were only open surgery patients, it was impossible to discuss the number of the patients that underwent open surgery, yet this was not the main focus of the study. In addition, the relationship between the duration of the surgeries and the surgeons’ experiences as well as the relationship between the surgeons’ experience and possible complications could not be examined because the duration of the surgeries was not properly recorded. Furthermore, the patients included and examined in this study were exclusively those who underwent open surgery for all humerus supracondylar fractures. However, considering that the results were obtained based on the resources of a single clinic, we are cognizant of the need for broader-scale studies that en-

compass various clinics to assess different clinical conditions. This understanding underscores the necessity for more comprehensive research initiatives.

**Conclusion:** Supracondylar humerus fractures in children are difficult fractures regardless of the surgeon's experience and the waiting time for surgery. Regardless of the surgeon's years of experience and the type of the fracture, some fractures cannot be treated with closed reduction and require open reduction.

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**ORCID and Author contribution:** *M.T.* (0000-0001-5391-7662): Concept, Design, Supervision, Writing and Critical Review. *B.K.* (0000-0002-4795-4309): Literature Search, Resources, analysis and/or interpretation. *M.E.K.* (0000-0003-0995-0953): Materials, Data Collection and/or Processing, Writing Manuscript.

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