

Does posterior approach always lead to poor functional and cosmetic outcomes in displaced pediatric supracondylar humeral fractures?

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ABSTRACT

BACKGROUND: Supracondylar humerus fractures (SCHFs) are the most common types of elbow fractures in children. Closed reduction percutaneous pinning (CRPP) is the primary surgical treatment of SCHFs. In cases that cannot be managed with closed reduction, treatment with open reduction and internal fixation (ORIF) is necessary. We aimed to compare CRPP and ORIF through a posterior approach regarding clinical and functional outcomes in pediatric SCHF cases.

METHODS: Patients with Gartland type III SCHF who underwent CRPP or ORIF with posterior approach at our clinic between January 2013 and December 2016 were included in this retrospective study. A total of 60 patients who underwent surgical treatment and had available data on our hospital database and no additional injuries were included in the study. We analyzed their data concerning age, gender, fracture type, neurovascular damage, and surgical treatment. In addition, we inspected the patients' anteroposterior and lateral radiographs at 1-year follow-up visits for Baumann (humero-capitellar) angle (BA) and carrying angle (CA) and checked their goniometer assessments of elbow range of motion (ROM). The cosmetic and functional outcomes were determined using Flynn's criteria.

RESULTS: Demographic, preoperative, and post-operative data of 60 patients between the ages of 2–15 were analyzed. 46 of these patients had CRPP, and 14 had posterior ORIF. CA, Baumann angle, and lateral capitulo-humeral angle were measured for fractured elbow and contralateral elbow and compared statistically. There was no statistically significant difference between the two surgical approaches in terms of CA ($p=0.288$), Baumann's angle ($p=0.951$) and LHCA ($p=0.578$). At the end of 1-year follow-up, elbow ROM was measured, and there was no statistically significant difference between the two groups ($p=0.190$). Furthermore, there is no statistically significant difference between the two surgical approaches in terms of both cosmetic ($p=0.814$) and functional ($p=0.319$) outcomes.

CONCLUSION: A comprehensive literature review of pediatric SCHF shows that surgeons do not frequently prefer posterior incisions in Gartland type III fracture that cannot be managed with closed reduction. However, posterior open reduction is a safe and effective method since it provides more control over the distal humerus, allows for a complete anatomical reduction involving both cortices, reduces the risk of ulnar nerve injury, thanks to the nerve exploration, and yields positive cosmetic and functional outcomes.

Keywords: Pediatric; supracondylar humerus fracture; surgical treatment; the posterior approach.

INTRODUCTION

Supracondylar humerus fractures (SCHFs) are the most com-

mon type of elbow fracture in the pediatric population.^[1] Approximately 16.7% of SCHFs present with severe displacement (Gartland type III); however, there is no consensus on

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the optimal treatment of fractures with severe displacement. Appropriate and effective treatment and close follow-up of these patients are essential to prevent complications such as neurovascular injury, malunion, cubitus varus, and limitations in elbow movement due to stiffness and pain.^[2]

The aim when determining the surgical treatment approach in SCHFs is to achieve the highest functional outcome with the simplest surgical intervention, employing a minimal number of implants and causing only short-term limitations in joint movement. Some surgeons prefer closed reduction and percutaneous pinning (CRPP) due to the advantages of early discharge, less severe limitations in elbow range of motion (ROM), and low risk of infection. In addition, CRPP is cosmetically advantageous due to the absence of incision scars.^[2,3] On the other hand, open reduction and internal fixation (ORIF) may become necessary in cases of irreducible fracture, open fracture, or circulatory disturbance.^[3]

In this study, we compared the impact of CRPP, a more common technique in contemporary orthopedic practice, and ORIF through a posterior approach on clinical and functional outcomes in pediatric SCHF cases.

MATERIALS AND METHODS

Pediatric patients aged 0–15 years who presented to the orthopedics and traumatology department and emergency service of our university hospital were retrospectively evaluated. Patients with Gartland type III SCHFs who underwent CRPP or ORIF with a posterior approach at our clinic between January 2013 and December 2016 were included in this study. Patients were excluded if they met any of the following criteria: different operative approach, open fracture, associated neurovascular injury, concomitant ipsilateral limb injury, prior fracture of the same elbow, and flexion-type SCHF. Two patients who had open fractures, seven patients who were lost to follow-up, three patients with impaired neurovascular status, two patients with ipsilateral limb injury, and 11 patients who underwent a different operative approach were excluded from the study. Thus, a total of 60 patients (32 males, 28 females; mean age: 5.8 years; range: 2–11 years) were included

in the final analysis. The institutional review board of our university approved the study protocol (no: 148548/2017), and the parents or legal guardians of the children granted their written consent for inclusion. The patients' data from the patient database and medical records concerning demographics (age, gender, fracture side, time to operative procedure, and operation time), surgical treatment, and complications were retrospectively reviewed by one investigator.

Surgical Technique

Under general anesthesia, the application of traction to the patient's arm and countertraction to the forearm was performed during the reduction. Rotational and coronal-plane deformities were corrected beforehand under fluoroscopic control. The surgeon then positioned the thumb of one hand on the posterior distal arm and the other four fingers on the anterior proximal arm while using the other hand to move the forearm into pronation for posteromedial displacement and supination for posterolateral displacement. Subsequently, the surgeon performed the reduction by pushing the distal arm downward and forward with the thumb and the proximal arm backward with the other four fingers (Fig. 1). Fixation was achieved using two percutaneous bicortical K-wires, one over the medial epicondyle and one from the lateral epicondyle, under fluoroscopy. In cases where the ulnar nerve and groove could not be palpated from the medial side, both K-wires were applied over the lateral epicondyle to prevent nerve damage.

The surgeon shifted to an open reduction in cases in which a proper reduction was not revealed in fluoroscopy despite several reduction maneuvers. Following the exploration of the ulnar nerve through a posterior incision, the reduction was achieved with a paratricipital approach. Definite fixation was achieved with medial and lateral K-wires (Fig. 2).

At the end of the surgery, after vascular and elbow joint ROM examinations, the wound was irrigated with saline and the skin and subcutaneous tissues were sutured. After the outer ends of the K-wires were bent, the arm was placed in a long-arm splint at 90° of elbow flexion. If callus tissue was evident on the radiographs taken at the 3rd-or 4th-week follow-up visits, the splint was promptly removed. If the fracture line had



Figure 1. Closed reduction of supracondylar humerus fracture. (a) Extending the elbow to correct the displacement in the coronal plane, (b) Correction of sagittal plane displacement with elbow flexion, (c) Stabilization of reduction with elbow flexion and forearm pronation.

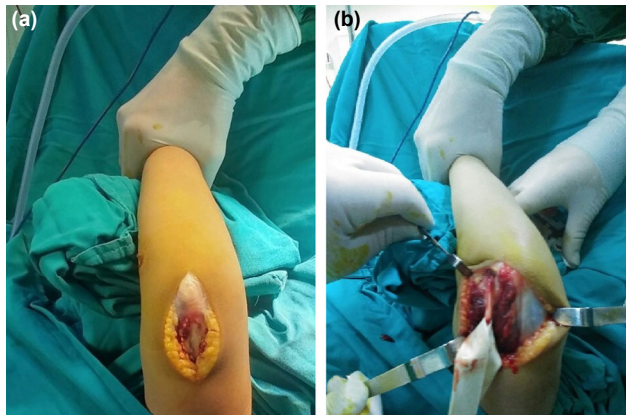


Figure 2. Open reduction of supracondylar humerus fracture. (a) Posterior skin incision, (b) Ulnar nerve exploration.

blurred a week after removal of the splint, the K-wires were also removed. After pin removal, as noted in other studies in the literature, physical therapy is not routinely recommended.^[3] Patients who had stiffness and loss of function 3 weeks after pin removal were referred to physical therapy. Patients with insufficient bone union were reassessed 2 weeks after pin removal.

Radiological and Clinical Assessment

In the pre-operative radiological examination, the patients' anteroposterior and lateral radiographs were evaluated to determine the fracture direction (flexion/extension) and type according to the Gartland classification.^[3] In addition, the direction of displacement (posterolateral/posteromedial) in extension-type Gartland type III fractures was ascertained. In the post-operative radiological examination, radiographs were examined on the 1st post-operative day, at the early follow-up visits (third and 6th weeks), and at the final follow-up visit (1 year).

The operative extremity was compared with the intact extremity using Baumann (humero capitellar) angle (BA), carrying (humero ulnar) angle (CA), and lateral capitellohumeral angle (LCHA). In addition, elbow ROM (extension/flexion) was assessed in all patients at the final follow-up using a goniometer. The degree of loss of ROM in the treated elbow was calculated using the intact elbow as the reference. Furthermore, the cosmetic and functional outcomes were determined using Flynn's criteria (Table 1).^[4]

Statistical Analysis

We used the IBM SPSS 11.5 software package for statistical analysis and considered $p < 0.05$ significant. Descriptive statistics were performed using mean (\pm standard deviation), median, minimum, and maximum values for continuous data and percentage values for discrete data. We conducted the Mann-Whitney U test to compare the cosmetic and functional outcomes determined by Flynn's criteria with the nominal variables (gender, fracture side, and surgery).

RESULTS

Of the sample of patients included in this study, 32 (53.3%) patients were male and 28 (46.7%) patients were female. The mean age was 5.83 (2–11) years for all patients, 5.1 (2–11) years for female patients, and 6.43 (2–10) years for male patients. The fracture was located on the left side in 44 (73.3%) patients and the right side in 16 (26.7%) patients. CRPP was performed on 46 (76.7%) patients and ORIF was performed on 14 (23.3%) patients. A posterior incision was performed for all ORIF patients. The average time to the operative procedure was 1.1 days (range: 0–3 days) in the CRPP group and 1.2 days (range: 0–4 days) in the ORIF group ($p=0.49$). When the operation times were assessed and compared between the two groups, the average surgery time was 145.84 ± 48.72 minutes for ORIF and 76.28 ± 35.72 minutes for CRPP ($p < 0.001$).

Elbow alignment was evaluated radiologically at the postsurgical 1-year follow-up. CA, BA, and LCHA were measured for both the operative elbow and the intact elbow and compared. The statistical comparison of the differences between the operative and intact limbs' radiological measurements based on the surgical approach is summarized in Table 2. There were no statistically significant differences between the two sur-

Table 1. Flynn's criteria

	Functional	Cosmetic
	Loss of range of motion (degrees)	Loss of carrying angle (degrees)
Excellent	0–5 °	0–5 °
Good	6–10 °	6–10 °
Fair	11–15°	11–15°
Poor	>15°	> 15°

Table 2. Statistical comparison of the differences between radiological and clinical measurements obtained from the operated limb after surgery

	Posterior approach	CRPP	p-value
	Median (IQR)	Median (IQR)	
CA	3 (2)	4 (5)	0.288
Elbow ROM	5 (5)	5 (5)	0.190
	Mean \pm SD	Mean \pm SD	p-value
BA	0 \pm 5.41	0.17 \pm 6.75	0.951
LCHA	2.28 \pm 4.46	1.17 \pm 4.59	0.578

CRPP: Close reduction and percutaneous pinning; CA: Carrying angle; ROM: Range of motion; BA: Baumann's angle; LCHA: Lateral capitellohumeral angle; SD: Standard deviation.

Table 3. Cosmetic and functional outcome according to Flynn's criteria

	Cosmetic factor Loss of carrying angle (degrees)			Functional factor Loss of range of motion (degrees)		
	CRPP (n=46)	Posterior (n=14)	p-value	CRPP (n=46)	Posterior (n=14)	p-value
Excellent, n (%)	32 (70)	12 (86)	0.814	34 (74)	14 (100)	0.319
Good, n (%)	10 (22)	2 (14)		8 (17)	–	
Fair, n (%)	2 (4)	–		4 (9)	–	
Poor, n (%)	2 (4)	–		–	–	

CRPP: Close reduction and percutaneous pinning.

gical approaches in CA ($p=0.288$), BA ($p=0.951$), or LHCA ($p=0.578$). In addition, at the 1-year follow-up, elbow ROM was measured and the loss of ROM was calculated by comparing the operative and intact elbows. The statistical comparison of elbow ROM values based on the surgical approach is summarized in Table 2; there was no statistically significant difference in elbow ROM between the two groups ($p=0.190$).

Functional and cosmetic outcomes according to Flynn's criteria are presented in Table 3. There were no statistically significant differences between the two surgical approaches in cosmetic ($p=0.814$) or functional ($p=0.319$) outcomes.

Complications, such as early and late vascular and neurological damage, nonunion, compartment syndrome, pin tract and wound infection, and avascular necrosis, were not observed in any of the cases included in this study.

DISCUSSION

SCHFs are common elbow injuries that affect children. Due to its potential to cause serious complications and morbidity, this injury often causes concern for the patient, family, and surgeon. The primary goal when treating pediatric SCHF is to recover full elbow ROM functionally and restore normal elbow anatomy cosmetically.^[3,5] Today, countries such as the United Kingdom are attempting to standardize the treatment of SCHFs, as there is still debate regarding the optimal management method.^[2,6]

SCHFs are most common in children aged 5–6 years old.^[7,8] While most studies have reported that males comprise the majority of cases,^[2,5,8–11] no significant difference was found between males and females, though the number of male patients was higher; in the cohort study conducted by Holt et al.^[12] in 2018, in which more than 63,000 cases were examined. In addition, while SCHFs have been found to be more common in the non-dominant extremity (often the left elbow) due to its protective role during injury,^[3,9] some studies have reported the dominant extremity to be more frequently affected.^[2,13] In our study, the mean age and gender distri-

bution of the patients were similar to the previous studies in the literature. In addition, similar to the previous studies, 73.3% of the fractures were to the left elbow and 75% of the fractures were to the non-dominant extremity.

A wide variety of treatment modalities has been described in the literature for the treatment of pediatric SCHF. Although CRPP is the most-used method in clinical practice in the treatment of Gartland type III fractures, it is not always possible to achieve an anatomical reduction.^[14] Open reduction is thus required in patients with irreducible fractures, instability, neurovascular deficits, and open fractures.^[3,6,7,15] Open reduction can be performed with a lateral, medial, anterior, or posterior approach, and each approach has advantages and disadvantages.^[5,6] There is still debate regarding which approach should be used to achieve an anatomical reduction safely and appropriately. Thus, many comparative studies in the literature have examined the impact of different surgical approaches on the functional and cosmetic outcomes of displaced pediatric SCHFs.^[14–18] Compared to the other approaches, the posterior approach is less studied due to the claim that this approach causes more damage to the posterior muscles and periosteum of the elbow, results in more functional loss due to adhesions that develop after surgery, and increases the risk of avascular necrosis of the trochlea.^[15,17,19]

Uzer et al., in their study published in 2017 evaluating functional and cosmetic results according to Flynn's criteria, assessed 47 patients with Gartland type III-IV SCHFs. The posterior approach was performed on 22 patients and the lateral approach was performed on 25 patients. There was no significant difference between the two groups in functional scores ($p=0.187$) or cosmetic scores ($p=0.222$). In two different studies published in recent years,^[16,20] the effects of medial and posterior approaches in the surgical treatment of displaced SCHF on functional and cosmetic results were compared. In the study by Sahin et al.,^[16] of the sample of 67 patients, the medial approach was performed on 33 patients and the posterior approach was performed on 34 patients. No significant differences were found between the two groups in functional and cosmetic scores. In the study published in

2021 by Rokaya et al.,^[20] although there was no significant difference between the medial approach and posterior approach in cosmetic scores ($p=0.198$), it was reported that the medial approach caused worse functional results. While excellent-good results were obtained in 83% of patients who underwent the medial approach, only 25% of patients who underwent the posterior approach achieved these results. The authors associated this result with surgical trauma caused by the posterior approach and poor patient compliance after surgery. Kizilay et al.^[14] conducted a study in 2017 evaluating 70 patients who were operated on for Gartland type III SCHFs. Of these patients, 19 were treated with CRPP, 11 with the medial approach, 11 with the lateral approach, 11 with the posterior approach, and 18 with the posterior approach combined with triceps transection. While there was no significant difference between the groups in cosmetic scores, patients who underwent the posterior approach had significantly worse functional outcomes and only 61.1% of patients who underwent triceps transection with the posterior approach had excellent-good results. In the study of Turkmen et al.,^[18] 38 patients who were operated for Gartland type 3 supracondylar humerus fracture and followed up for an average of 4.2 years were evaluated. While the posterior approach was applied in 30 of these patients, the lateral approach was applied in 8 patients. There was no significant difference between the groups in terms of clinical and radiological results of the patients and Flynn Scores. On the other hand, in the study of Bombaci et al.,^[21] 27 patients (17 lateral approaches and 10 posterior approaches) with Gartland type 2–3 fractures which followed for an average of 19.4 months were evaluated. In terms of functional and cosmetic results, except for the significantly longer surgery time with the posterior approach, there was no difference between the groups. In this study, despite the short term follow-up, we found no significant differences between the CRPP and ORIF patient groups in functional and cosmetic outcomes ($p>0.05$). When the results of our study are evaluated together with other studies published in the literature, it reveals that the short-term results of both surgical approaches are similar.^[15,16,18,20,21]

Although there is still controversy regarding the optimal method of surgically treating displaced SCHFs, one of the most important criteria used to evaluate the superiority of one method over the other is undoubtedly the possible complications. In the study by Uzer et al.,^[15] while no complications were observed during the follow-up in any of the patients who underwent the posterior approach, one case of cubitus varus and one case of avascular necrosis were observed in patients who were treated with the lateral approach. In addition, the cubitus varus complication was thought to be associated with avascular necrosis of the trochlea. In the study by Sahin et al.^[16] comparing the results of the medial and posterior approaches, no complications were reported at the 3-year follow-up for all patients. Another study comparing the results of the medial and posterior approaches reported wound infection in two patients who underwent

the posterior approach and radial nerve neuropraxia in one patient who underwent the medial approach.^[20] In a study evaluating patients treated with CRPP and four different surgical approaches (medial, lateral, posterior, and posterior plus triceps transection), the loss of extension ROM and loss of triceps strength in patients treated with the posterior approaches were significantly less compared to the other methods.^[14] This is contrary to the findings of this study, as there was no significant difference in elbow ROM in this study between the patients with CRPP and the patients with the posterior approach. Interestingly, while cubitus varus is a common complication reported in the literature, cubitus valgus developed in four patients with CRPP at 1-year follow-up in our study. The absence of malalignment in the measurements performed immediately post-surgery in these patients suggests that the cubitus valgus occurred as a result of epiphyseal damage sustained during the trauma.

Conventionally, Gartland type 3 fractures have been considered to require emergency surgery regardless of the time of admission. It is believed that the intervention without the development of hematoma and swelling in the fracture area reduces the need for open reduction.^[6] Aktekin et al.^[19] reported that the mean time from fracture formation to surgery was 1.2 days. It was reported that there was no significant difference between the groups performed with the posterior approach and CRPP. The effect of this period on the results was not evaluated. In another study, Kizilay et al.^[14] reported that the average time to surgery was 13.85 h and did not affect the results. Uzer et al.^[15] In their study, it was reported that the mean time to surgery was 21.2 h in the posterior approach group, and 16 h in the lateral approach group. In our study, while the mean time to surgery was 1.1 days in the posterior approach group, it was 1.2 days in the closed approach group. In the latest guidelines, it has been reported that emergency surgery is not required in patients without neurovascular disorders.^[6] On the other hand, Gupta et al.^[22] reported that more than 12 h before surgery did not increase the need for open reduction and complications.

Our study has some limitations. The primary limitation is its retrospective design and unequal sample size, which may cause bias. The cosmetic result was based solely on Flynn's criteria, and parent and patient satisfaction with the post-operative scar was not assessed. In addition, this study included a small number of patients and had a short follow-up duration, particularly considering that complications such as avascular necrosis may occur over a longer postoperative period. We also did not evaluate postsurgical triceps strength in our study.

Conclusion

A comprehensive literature review of pediatric SCHF indicates that surgeons do not frequently prefer posterior approaches in Gartland type III fractures that cannot be managed with

closed reduction. However, posterior open reduction is a safe and effective method, as it provides more control over the distal humerus, allows for a complete anatomical reduction involving both cortices, reduces the risk of ulnar nerve injury, and yields positive cosmetic and functional outcomes.

Ethics Committee Approval: This study was approved by the Süleyman Demirel University Faculty of Medicine Clinical Research Ethics Committee (Date: 16.08.2017, Decision No: 127).

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ORIJİNAL ÇALIŞMA - ÖZ

Deplase pediatrik suprakondiler humerus kırıklarında posterior yaklaşım her zaman kötü fonksiyonel ve kozmetik sonuçlara neden olur mu?

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AMAÇ: Suprakondiler humerus kırıkları (SKHK), çocuklarda en sık görülen dirsek kırığı tipidir. Kapalı redüksiyon perkütan tespit (KRPT), SKHK tedavisinde ilk olarak tercih edilen yöntemdir. Kapalı redüksiyon ile tedavi edilemeyen durumlarda açık redüksiyon ve internal fiksasyon (ARIF) ile tedavi gereklidir. Bu çalışmanın amacı, pediatrik SKHK olgularında posterior yaklaşımla yapılan ARIF ile KRPT sonuçlarını klinik ve fonksiyonel açıdan karşılaştırmaktır.

GEREÇ VE YÖNTEM: Bu geriye dönük çalışmaya Ocak 2013 ile Aralık 2016 tarihleri arasında kliniğimizde posterior yaklaşımla ARIF veya KRPT uygulanan Gartland tip III SKHK olan hastalar dahil edildi. Cerrahi tedavi uygulanan, hastane veri tabanımızda verileri mevcut olan ve ek yaralanması olmayan toplam 60 hasta çalışmaya dahil edildi. Hastaların yaş, cinsiyet, kırık tipi gibi demografik verileri ile nörovasküler hasar varlığı ve cerrahi tedavi ilişkili verileri analiz edildi. Ek olarak, hastaların 1 yıllık takiplerinde ön-arka ve yan grafleri incelenerek Baumann (humerokapitellar) açısı (BA) ve taşıma açısı (TA) ölçüldü. Gonyometre değerlendirmesi ile dirsek hareket açıklığı (ROM) kontrol edildi. Kozmetik ve fonksiyonel sonuçlar, Flynn kriterleri kullanılarak belirlendi.

BULGULAR: Yaşları 2–15 arasında değişen 60 hastanın demografik, ameliyat öncesi ve sonrası verileri analiz edildi. Bu hastaların 46'sına KRPT ve 14'üne posterior ARIF yapılmıştı. Kırık dirsek ve kontralateral dirsek için TA, Baumann açısı ve lateral kapitellohumeral açı (LKHA) ölçüldü ve elde edilen veriler istatistiksel olarak karşılaştırıldı. TA ($p=0.288$), Baumann açısı ($p=0.951$) ve LKHA ($p=0.578$) açısından iki cerrahi yaklaşım arasında istatistiksel olarak anlamlı fark yoktu. Bir yıllık takip sonunda dirsek EHA ölçüldü ve iki grup arasında istatistiksel olarak anlamlı fark bulunmadı ($p=0.190$). Ayrıca iki cerrahi yaklaşım arasında hem kozmetik ($p=0.814$) hem de fonksiyonel ($p=0.319$) sonuçlar açısından istatistiksel olarak anlamlı bir fark yoktu.

TARTIŞMA: Pediatrik SKHK ile ilgili kapsamlı bir literatür taraması, cerrahların kapalı redüksiyon ile tedavi edilemeyen Gartland tip III kırıklarında posterior insizyonları sıklıkla tercih etmediğini göstermektedir. Ancak posterior açık redüksiyon, distal humerus üzerinde daha fazla kontrol sağladığı, her iki korteksi de içeren tam bir anatomik redüksiyona olanak sağladığı, sinir eksplorasyonu sayesinde ulnar sinir yaralanması riskini azalttığı, kozmetik ve fonksiyonel sonuçlar üzerinde olumsuz etkisi olmadığı için tercih edilebilecek güvenli ve etkili bir yöntemdir.

Anahtar sözcükler: Cerrahi tedavi; çocuk; posterior yaklaşım; suprakondiler humerus kırığı.

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