

Closed Reduction versus Open Reduction and Pin Fixation in Pediatric Type III Supracondylar Humeral Fractures

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Abstract

Background

Supracondylar humeral fractures constitute about 60% and 13% of all pediatric elbow and pediatric skeletal fractures, respectively, with a peak incidence in the 5-7 years age group. The aim of this study was to evaluate and compare closed reduction with open reduction and pin fixation in type III supracondylar humeral fractures in children younger than 12 years.

Materials and Methods: In this retrospective study, all children under 12 years of age with type III supracondylar humeral fractures who referred to two teaching hospitals in Mashhad, Iran, between March 2017 and March 2019 were included. Patients were divided into two groups: open reduction and fixation with pin (OR) (n= 30), and closed reduction and percutaneous pinning (CR) (n=15). The method of surgery for each individual patient was chosen based on the surgeon's preference. For patients who had a follow-up of at least 6 months, subsequent elbow radiographs were requested.

Results: No significant differences were observed between the two groups in terms of range of motion of the fractured limb and radiographic angles at follow-up ($p > 0.05$). However, operation time was significantly shorter in the CR group compared with the OR group ($p < 0.001$). Three patients (6%) had cubitus valgus (all of whom were in the OR group [10%]), and two patients (4%) had cubitus varus (one patient in the OR group [3.33%] and the other in the CR group [5%]). Wound dehiscence was only seen in one patient in the OR group (3.33%).

Conclusion

Based on the results, there was no significant difference between the open and closed reduction methods in type III supracondylar humeral fractures with respect to elbow function and union of the fracture.

Key Words: Fracture, Pediatric, Reduction, Supracondylar humerus.

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1- INTRODUCTION

Supracondylar humeral fractures (SCH) are the most common fractures among the pediatric population that require surgery. It is estimated that SCH fractures account for about 13% of all pediatric fractures and 60% of pediatric elbow fractures (1). The mechanism of fracture generally includes falling down on an outstretched hand, especially from playground equipment. In Modified-Gartland type III fractures there is significant extension-type displacement as well as rotation of the distal fragment with no cortical contact (2). This can be treated either with closed reduction and percutaneous pinning or open reduction and pin fixation. Because of the soft tissue interposition and periosteal disruption, perfect closed reduction, restoration of the anatomy, and correction of the rotation might be difficult to achieve, and thus open reduction may be necessary.

Closed reduction is recommended to be initially used for all SCH fractures. However, some orthopedic surgeons advise open reduction primarily to ensure anatomic reduction (3-5). In this study, we hypothesized that no difference exists in the range of motion and radiographic parameters at 6 months after surgery between closed reduction and open reduction in patients with SCH fractures. It is still controversial which method is the best for type III SCH fractures considering complications, and functional and radiological factors, altogether. Therefore, we aimed to evaluate and compare closed reduction with open reduction and fixation with pin in type III supracondylar humeral fractures in children younger than 12 years.

2- MATERIALS AND METHODS

2-1. Study design and population

In this retrospective cohort study, we used the Health Information System (HIS)

for recruiting patients with SCH fractures, aged 12 years or less, who were referred to two teaching hospitals in Mashhad, Iran (Shahid Kamyab and Imam Reza Hospitals), during March 2017 to March 2019, and who had a follow-up of at least 6 months. Preoperative radiographs were retrospectively reviewed and patients with Modified-Gartland type III fractures were included in the study. We excluded patients with neurovascular impairment as well as patients with other concurrent upper limb fractures. All patients were treated in a similar operating room setting and received similar post-operative care. We considered all patients who were operated regardless of the treating surgeon; however, both methods of surgery were performed in a similar manner by all surgeons, even in different hospitals. Demographic data including gender, age, hospital, operation time and duration of operation were extracted by the researchers using patients' medical records. Any missing information was recollected in the follow-up visits. We divided patients into two groups: open reduction and pin fixation (OR group, n=30), and closed reduction and percutaneous pinning (CR group, n=20).

2-2. Surgical Technique

Patients were placed in the lateral decubitus position. In the OR group, after applying a tourniquet, the upper extremity was prepped and draped in a standard manner, then with a paratricipital approach, we exposed the distal humerus. The fracture was reduced and fixed using two 1.8 mm Kirshner wires (K-wires), one from the medial epicondyle and the other from the lateral epicondyle, with an angle of 30 to 40 degrees relative to the humeral shaft axis, preferably crossing each other above the fracture site. In the CR group, the fracture was reduced through a full extension maneuver, either varus or valgus maneuvers depending on the fracture, and then full elbow flexion in pronation was

performed. After reduction was confirmed by C-arm, percutaneous pinning was done using two or three 1.5 or 1.8 mm K-wires, depending on the patient's age, in either a parallel or divergent fashion on the lateral side under C-arm guidance. Postoperatively, based on the extent of swelling and neurovascular condition, the arm was immobilized in a long forearm splint in 70-90° of elbow flexion. Preoperative prophylactic antibiotic as well as a 2-day long postoperative oral antibiotic therapy was administered to all patients. The two previously mentioned methods are the routine surgical techniques performed in Imam Reza Hospital and Shahid Kamyab Hospital. Patients in both groups were usually discharged the day after surgery unless the development of compartment syndrome or other complications was suspected. All patients were recommended to visit the out-patient clinics for regular follow-up at one, three and six weeks after surgery. The last follow-up was at least 6 months after surgery, at which time patients' clinical

and radiological observations were recorded.

2-3. Clinical evaluation

All of the included patients were advised to participate in regular follow-up visits. On physical examination, clinical union, range of motion of both elbows, and the presence of possible fracture complications such as pin tract infection, Volkmann ischemic contracture syndrome, clinical cubitus varus or valgus, wound dehiscence, and malformed scars were evaluated. Additionally, patients were informed about the appropriate time for pin removal and the need for subsequent physiotherapy, when necessary.

2-4. Radiological evaluation

At the last follow-up visit, standard anteroposterior (AP), and lateral radiographic views were taken to assess radiological union, and radiographic angles including Baumann's angle, condylar-shaft, lateral capitohumeral, and carrying angles (**Figure 1**).

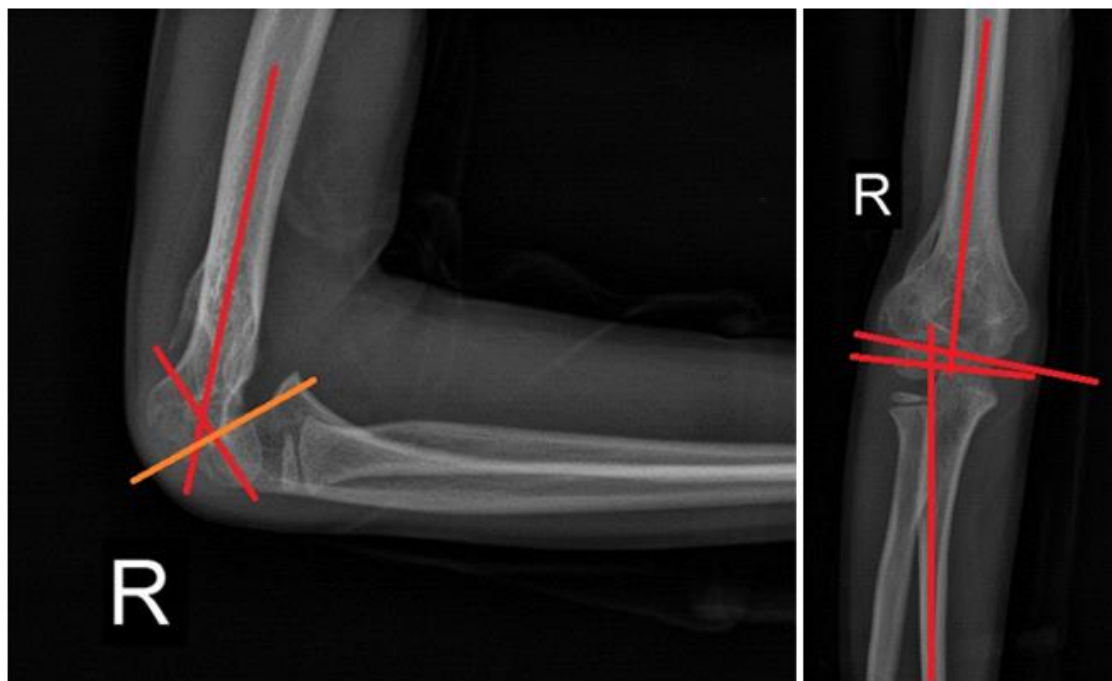


Fig1: AP (Left), and lateral (Right) radiographs of left elbow of a patient at follow-up, for angular measurement and radiological union evaluation.

2-5. Data collection

Data was analyzed using SPSS software version 20.0 with appropriate statistical tests. Kolmogorov-Smirnov test was used to check the normal distribution of data. Continuous data were expressed as mean \pm standard deviation (SD). For comparative analysis of data, independent t-test was used for normally-distributed data and Mann-Whitney test was used as a non-parametric test. Chi-square test and Fisher's exact test were used to compare qualitative variables. P-values less than 0.05 were considered statistically significant.

2-6. Ethical approval

Written informed consent was obtained from all parents prior to enrollment of children in the study. This research was approved by the ethical committee of our institution (Ethics code: IR.MUMS.MEDICAL.REC.1398.598).

3- RESULTS

Based on the inclusion and exclusion criteria, 50 patients with type III SCH fractures were included in this study. Overall, 35 (70%) patients were operated in Shahid Kamyab Hospital and 15 (30%) in Imam Reza Hospital. Also, 31 (62%) patients were male. In 19 (38%) patients, fracture was on the right side, and the right arm was the dominant side in 41 (82%) patients. Overall, 20 (40%) cases underwent percutaneous pinning (PCP), and 30 (60%) patients received open reduction internal fixation (ORIF) with pin for treatment. The fracture mechanism was completely elongated, caused by a fall on the upper extremity, in 41 (82%) patients

and only one (2%) patient had a heavy body fall on the upper limb. The remaining cases were unaware of the fracture mechanism. Patients' demographic data, elbow function and radiographic angles are provided in detail in **Table 1**. As shown, there was no significant difference in range of motion between the ipsilateral and contralateral fracture side as well as the radiographic angles of the fractured limbs at follow-up. Elbow extension was complete in all patients except for one patient who had extension deficit. The duration of operation was significantly shorter in patients treated with PCP than in those treated with ORIF ($p = 0.002$).

In terms of complications, no nonunion/malunion, Volkmann ischemic contracture, and infection was found in any of the patients after surgery. There were three patients with clinical cubitus valgus (all of whom had undergone ORIF), and two patients with clinical cubitus varus (one patient had undergone ORIF and the other patient was treated with PCP).

Additionally, wound dehiscence was observed in only one patient in the ORIF group after pin removal. Wound dehiscence occurred in this patient despite refreshing the wound edges and sealing them again after removing the pins. In one patient who had not referred to the outpatient clinics for follow-up after surgery, the pins had remained in the distal humerus; however, no signs of infection, nonunion/malunion, clinical or radiological deformity or limitation in range of motion of the elbow were observed one year after fixation of the SCH fracture.

Table-1: Baseline characteristics, elbow function and radiographic angles in two groups of OR and CR (n=50).

Variables	Operation method		P-value
	ORIF (n=30)	PCP (n=20)	
Age (years)	6.94±3.12	5.79±3.08	0.212
Sex (male)	19 (63.33%)	12 (60%)	1.0
Side of fracture (Right)	11 (36.67%)	8 (40%)	1.0
Dominant side (Right)	25 (83.33%)	16 (84.21%)	1.0
Hospital (Shahid Kamyab/Imam Reza)	23/17 (76.67%/24.33%)	12/8 (60%/40%)	0.228
Mechanism	Falling down	26 (86.7%)	15 (75%)
	Falling a heavy thing on the elbow	1 (3.3%)	0
	unknown	3 (10%)	5 (25%)
Elbow range of motion in fractured upper limb (Degrees)	Flexion	141.75±5.86	141.75±5.86
	Extension	0	0.5±2.23
	Supination	67.86±6.61	68.1±4.97
	Pronation	66.72±6.94	66.75±4.22
Elbow range of motion in unfractured upper limb (Degrees)	Flexion	139.27±7.85	144.2±4.23
	Extension	0	0
	Supination	71.10±4.51	69.55±5.18
	Pronation	69.66±5.37	68.65±3.98
Radiographic degrees in fractured upper limb (Degrees)	Baumann's	17.65±8.99	19.16±10.26
	Carrying	9.54±6.33	10.84±6.80
	Condylar shaft	39.27±7.85	43.11±15.84
	Lateral Humerocapitalar	55.5±15.85	51.0±16.81
Operation time (minutes)	150.36±49.65	73.16±37.20	<0.001
Physiotherapy sessions (number)	3.42±4.87	7.0±8.66	0.245
Operation to pin removal (days)	45.43±16.80	38.5±16.8	0.347

ORIF: Open reduction internal fixation, PCP: Percutaneous pinning, OR: Open reduction and fixation with pin, CR: Closed reduction and percutaneous pinning.

4- DISCUSSION

The aim of this study was to compare the results of open versus closed reduction in the treatment of type III supracondylar humeral fractures in children younger than 12 years. Both clinical and radiological union of fractures was observed in all patients undergoing surgery with either of the two treatment methods. There was also no significant difference between the two groups in terms of radiographic angles of the elbow at follow-up. In terms of complications, only a small percentage of patients developed complications and there was no significant difference between the two groups in this regard. Similar to our results, some studies have reported no

significant difference in range of motion of the elbow between patients treated with open reduction and those treated with closed reduction (6-10). However, a meta-analysis by Gou et al. (11) indicated that the results of five studies evaluating patients' satisfaction based on Flynn's criteria showed that patients in the CR treatment group were significantly more satisfied with surgery than patients treated with OR (p = 0.03). Consistent with our results, Shrestha et al. (12) found no significant difference in Baumann's angle values between patients treated with ORIF and PCP (p = 0.142). Similarly, Yaokreh et al. (6) found that the mean Baumann's angle value between the ORIF and PCP groups was not significantly different

immediately and one year after surgery ($p= 0.84$ and $p = 0.51$, respectively). However, in a study by Tomori et al. (10) in Japan, Baumann's angle was significantly higher in the PCP group than in the ORIF group after a follow-up period of 8-10 months ($p = 0.006$). Results of this study showed that in the PCP group, Baumann's angle in the fractured elbow was significantly higher than that in the normal elbow ($p = 0.003$). Also, in the PCP group, the carrying angle in the fractured elbow was lower than that in the normal elbow ($p = 0.016$). In our study, surgical site infection, Volkmann ischemic contracture syndrome, or articular artery ischemia were not observed in either group. Only 3/50 patients (6%) had clinical cubitus valgus and 2/50 patients (4%) had clinical cubitus varus. Similar results were seen in a study by al- Algawy et al. (9), which showed no significant difference between patients treated with ORIF and PCP according to Flynn's criteria.

In our study, we observed no patient with iatrogenic nerve injury or the need for reoperation due to inadequate reduction. Consistent with our results, Keskin and Sen (7) reported that pin infection occurred in 10% of patients in both groups. In their study, cubitus varus was identified in two patients in the PCP group and one patient in the ORIF group ($p = 0.8$). In 6% of patients in the ORIF group, ulnar nerve injury occurred; after 3 months, however, spontaneous recovery was achieved in all cases. In line with the observations of our study, a meta-analysis by Gou et al. (11) showed that the total rate of complications associated with surgery was not significantly different between the open and closed reduction treatment groups among patients with SCH fractures ($p = 0.5$). We found significantly shorter operation times in the CR group as compared to the OR group ($p < 0.001$), similar to the findings of the study by

Keskin and Sen (7); nevertheless, in a prospective study, Waikhom and Ray (13) found that operation time was significantly longer in the PCP group compared with the ORIF group (49.29 ± 7.59 vs. 43 ± 41 minutes, $p < 0.001$).

4-1. Study Limitations

The retrospective design of this study limited our clinical judgement, but we tried our best to reduce the effect of confounder variables. However, the most important barrier to reaching more favorable results was the very poor level of parents' cooperation during the follow-up visits, which limited our sample size.

5- CONCLUSION

Based on the results, there was no significant difference between the OR and CR groups in terms of range of motion of the elbow, radiologic findings, and bone union. In the open reduction method, we found slightly higher rates of complications as well as significantly longer operation times. Therefore, we recommend the use of closed reduction for any uncomplicated type III SCH fracture. Also, should closed reduction prove unsuccessful, open reduction could be used since the post-operative results are similar to those of the closed reduction method.

6- CONFLICT OF INTEREST: None.

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