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A prospective study of surgical management of supracondylar fracture of humerus in children using K-wire fixation

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Abstract

BACKGROUND AND OBJECTIVES: Supracondylar fractures of the humerus are the most common type of elbow fracture in children. Severely displaced supracondylar fractures of the distal humerus in children are a challenging problem. Many treatment methods have been described for the treatment of displaced supracondylar fracture of the humerus; however, it has not been reached a consensus for the choice of treatment. The purpose of this study is to clinically assess the outcome of surgically managed supracondylar fracture of humerus using K-wire fixation.

MATERIALS AND METHODS: Thirty children of supracondylar fracture of humerus treated between June 2018 and February 2020 were included. Out of a total of 30 cases, 24 were treated with closed reduction and internal fixation by K-wire and six were treated with open reduction and internal fixation with K-wire. The average age was 7.1 years. We evaluated the results using Flynn's criteria.

RESULT: According to the results of the study, we obtained 21 excellent, four good, four fair, and one poor results.

CONCLUSION: The data in the current study show that surgically managed displaced supracondylar fracture of humerus in children using K-wire fixation gives excellent outcomes both radiologically and functionally and thus can be deemed as a treatment of choice for the same.

Keywords:

Closed reduction, displaced supracondylar fracture of humerus, open reduction and internal fixation by K-wires

Introduction

Supracondylar fracture of humerus accounts for 60% of all fractures about the elbow in children and represents approximately 3% of all fractures in children. The rate of occurrence increases steadily in the first 5 years of life to peak at 5–7 years of age. It is the fracture of the lower end of the humerus usually involving the thin portion of humerus through the coronoid or olecranon fossae or just above the fossae or through the metaphysis of the humerus.

Undisplaced supracondylar fractures of humerus usually require no more than a simple immobilization for comfort and further protection. The management of displaced supracondylar fracture of the humerus is one of the most difficult of the many fracture seen in children. Pitfalls in the management occur frequently and continue to plague the doctor caring for these patients, especially with respect to displaced supracondylar fractures. Close reduction with splint or cast immobilization has traditionally been recommended for displaced supracondylar fracture, but a loss of reduction and necessity of repeated

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manipulation are likely to go for malunion producing varus or valgus deformity of elbow and elbow stiffness. The aims of the surgical treatment are to maintain an anatomical position and to prevent varus or valgus deformity.

Hence, the study was undertaken to study the efficiency of this method, i.e., internal fixation with K-wire, and to evaluate the clinical outcome.

Materials and Methods

The study was conducted in the Basveshwar Teaching and General Hospital attached to Mahadevappa Rampure Medical College, Kalaburagi.

Source of data

Thirty pediatric patients in the age group of 1–18 years with supracondylar fracture of humerus seeking medical advice in the Department of Orthopaedics of Basveshwar Teaching and General Hospital, Kalaburagi, were taken for the study.

Out of the 30 patients, 24 patients were managed with closed reduction and internal fixation with K-wire and six patients by open reduction and internal fixation (ORIF).

Exclusion criteria

Exclusion criteria are supracondylar fractures of humerus in patients aged above 18 years.

Methodology

First, the history was elicited from the patient and from patients' parents in case of younger children. The nature of the injury, that is, fall on an outstretched hand, direct injury, road traffic accident, was asked. Then time since injury was elicited. After that, a detailed examination of the patient was carried out. The general condition of the patient was assessed. Patients with the associated head injury and fractures of the other long bones were given priority for the emergency department. If there were none of the other injuries, then local examination of the injured elbow was carried out. It consisted of noting down the deformity, swelling around the elbow, tenderness over the distal end of the humerus, and movements of the elbow. The vascular and neurological status of the patient was thoroughly examined. Then x-rays were ordered. The standard anteroposterior and lateral views of the elbow were taken in the emergency radiology room. In the mean time, the patients were given analgesics, and the fractured part was splinted temporarily.

The fracture was then classified according to the fracture patterns in x-rays using Gartland's classification:

- Type 1: not displaced
- Type 2: minimally displaced with intact posterior cortex
- Type 3: completely displaced with no cortical contact
 - (a) posteromedial
 - (b) posterolateral.

The management protocol was then drawn according to the fracture type.

Type 1 fractures

The patients' radiographs were thoroughly scrutinized, and the fracture pattern was confirmed. The posterior displacement was ruled out by noting down the anterior humeral line. Then a posterior splint was applied to the limb with elbow at 90° flexion and forearm in the neutral rotation. A cuff and collar sling was given. Then the plaster instructions were given to the patient and were advised to come for review after 2 days. The loosening of the splint if any was corrected, and the patient was advised to come after 3 weeks. At the end of 3 weeks, the posterior splint was removed, and the x-rays were repeated to assess the healing. After seeing the x-rays, the splint was discontinued, and the patient was advised to start active range of motion exercises for the elbow.

Type 2 fractures

Radiographs were analyzed, and the fracture pattern was identified. The anteroposterior x-ray was looked for the coronal displacement and angulation. After confirmation of the type, the patient was admitted, and he was kept nil orally. A splint was applied and affected extremity was elevated to minimize the swelling. In the operation room, general anesthesia was administered. The carrying angle of the normal and affected side was assessed and noted down. Then closed reduction was carried out giving a longitudinal traction of the forearm by the surgeon and counter traction to the proximal arm by the assistant. The elbow was flexed up until resistance was felt usually just above 90° of the elbow flexion. Then the distal fragment was pushed anteriorly. With that, the elbow was flexed up to 120°, and the forearm was brought into full pronation. Then the vascular status was assessed. A posterior splint was applied with the elbow in 120° flexion and the forearm in flexion. A cuff and collar sling was given. Then the patient was observed in the hospital for 24h. Later, the patient was discharged with the instructions regarding the plaster complications and advised to come after 3 weeks. At the end of 3 weeks, the splint was removed and x-rays were repeated. The carrying angle was assessed, and the active range of motion exercises was started. The patient was followed up at periodic intervals, and each time, the carrying angle and functional range of movements were assessed and noted.

Manipulative technique

The patient was hospitalized and advised nil by mouth. The fracture limb was splinted and elevation was done to reduce the swelling. Then the reduction was carried out under general anesthesia with full relaxation in the operating room. The carrying angle was assessed and noted down. First, the longitudinal traction was applied to the forearm with the elbow in extension and forearm in supination. Counter traction to the proximal arm was provided by the assistant. Then with the traction being maintained, the medial or lateral displacement was corrected by applying of valgus or varus force at the fracture site. Once the length was re-established and the edges of the fragments were joined, the displacement and the angulation of the distal fragment were corrected by flexing the elbow. At the same time, a posteriorly directed force was applied to the anterior portion of the arm over the proximal fragment, and the anteriorly directed force was applied posteriorly over the distal fragment. The reduction was achieved, which was confirmed by full flexion of the elbow. Then the elbow was kept in 120° of flexion and forearm in full pronation in a posterior splint. Cuff and collar sling was applied. The distal vascularity was checked. The patient was discharged on the second day and reviewed after 2 days and then after 1 week to see whether reduction was stable clinically and radiologically, then after 3 weeks. Postoperative management as per type 2 fracture was carried out. The results were noted down.

Type 3 fractures

The type 3 fractures were diagnosed with the help of x-rays. These cases were taken up for ORIF immediately once other emergencies of head injuries and of long bones were ruled out. Finally, the end result of these fractures' management were analyzed according to the carrying angle and functional range of movements.

Open reduction and internal fixation with K-wires

Out of the 30 patients, six patients were subjected to ORIF with K-wires. In majority of the cases, posterior Campbell's approach was used. In one case with brachial artery injury, we have used the anteromedial approach. In one case having radial nerve injury, we used anterolateral approach.

Posterior approach

With the patient under general anesthesia and in prone position with the elbow supported on the sand bag, extremity was prepared from axilla to wrist and draped. With a posterior Campbell's approach,^[1] ulnar nerve was isolated, and inverted tongue-shaped incision was made over the triceps. All the blood clots and debris were removed from the fracture site. Fracture was reduced and internally fixed with two or three smooth crossed K-wires of diameter 1.5–2.5mm. The pins were introduced with

the help of a hand drill. The lateral wire was introduced through the anterior side of the lateral condyle and directed posteriorly into the posteromedial side of the opposite cortex. The medial wire was started through the posteromedial side of medial condyle and engaged into the anterolateral side of opposite cortex. While introducing the medial wire, greater care was taken to avoid ulnar nerve. By this method, the wires were laid high above the fracture site. The pins were cut percutaneously for easy removal later. After the pins are placed, the elbow is extended, and the carrying angle is measured and compared to that on the nonaffected side. The stability of the fracture was checked. Then the wound was closed and a drain was kept, and a posterior splint was applied with the elbow in 90° flexion and forearm in the neutral rotation.

Postoperative course

Full-arm posterior slab was used, cuff and collar was given, and the limb was elevated. The preoperative antibiotics were continued on the day of operation. It was continued for 5 days after the surgery. Regular dressings were done, and routine check x-rays were taken. The sutures were removed on the 12th day and the patient was discharged. Patients were called at the third week for K-wire removal. After the K-wires were removed, the posterior slab was discarded, and active movements of the elbow were started. All these cases were advised to attend the outpatient department at regular intervals of 3 weeks, 6 weeks, 3 months, 6 months, and 12 months for check-up and to note down the progress of union, the range of movements at the elbow, and the onset of any deformity. We have measured range of movements and carrying angle using goniometer [Table 1].

Results

The following observations were made from the data collected during the study.

In Table 2, most of the patients in the present study were in the age group between 5 and 8 years, around 53.3%. The youngest was 2 years of old, and the eldest was 15 years old. The mean age incidence of supracondylar fractures in the study was 7.1 years.

In Table 3 the present study, 60% of the cases were boys and 40% of our cases were girls. The male to female ratio was 1.5:1. The left elbow was involved in 19 (63%) of the cases, and the right side was involved in 11 (37%) of the cases in the present study.

In table 4, right side affected were 37% and left side 63%. In Table 5, the present study, 86.6% of the cases were due to indirect injury, that is, fall on an outstretched hand; 13.3% of the cases were due to direct injury to the elbow joint, which mostly comprise the vehicular accidents.

Table 1: Flynn's grading system

Results	Ratings	Loss of carrying angle (degrees)	Loss of range of movements
Satisfactory	Excellent	0–5	0–5
	Good	6–10	6–10
Unsatisfactory	Fair	11–15	11–15
	Poor	Over 15	Over 15

Table 2: Age distribution

Age group (years)	No. of cases	Percentage
0–2	1	3.3
3–4	3	10
5–6	10	33.3
7–8	6	20
9–10	6	20
11–12	4	13.4
12–14	-	-
Total	30	100.00

Table 3: Sex distribution of supracondylar fracture cases

Sex	No. of cases	Percentage
Male	18	60
Female	12	40
Total	30	100

Table 4: Side affected

Side	No. of cases	Percentage
Right	11	37
Left	19	63
Total	30	100

Table 5: Mode of injury

Mode of injury	No. of cases	Percentage
Fall on an outstretched hand	26	86.6
Direct injury	4	13.4
Total	30	100.0

Table 6: Type of fracture

Type of fracture	No. of cases	Percentage
Closed	28	93.3
Open	2	6.7
Total	30	100.00

Table 7: Type of supracondylar fracture

Type of fracture	No. of cases	Percentage
Extension type	29	96.6
Flexion type	1	3.4
Total	30	100.0

Table 8: Classification of fractures (Gartland's)

Gartland's type	No. of cases	Percentage
Type 1	3	10
Type 2	12	40
Type 3	15	50
Total	30	100

The minimum reporting time for hospital since injury was 1 h. The maximum time since injury was 8 days. The average time of reporting was 1 day. In the present study, the percentage of the closed fractures was 93.3% and of the open fractures was 6.6%. All of the open fractures were high-velocity injuries due to vehicular accidents. We had two open fractures, which included one case of grade 1 and another case of grade 2 Gustilo and Anderson's classification of open fractures.

In table 6, Type of fracture, closed were 93.3% and open were 6.7%. In Table 7 the study, we have 29 extension type and one flexion type of supracondylar fracture.

In Table 8, 50% of the cases were of type 3 fractures, 40% were type 2, and 10% were type 1 fracture. According to Gartland's classification, out of the 15 patients with type 3 fractures, we had eight patients with posteromedial displacement and seven patients with posterolateral displacement pattern. Out of the 30 cases of supracondylar fractures, 24 cases were treated with closed reduction and internal fixation and six cases were treated with ORIF by K-wires.

In table 9, Fracture pattern such as Type 3A posteromedial were 53.3% and posterolateral were 46.7%. The final results of the operative management of the supracondylar fracture of humerus were evaluated using Flynn's criteria based on the loss of movements and loss of carrying angle [Table 10].

Complications

In Table 11 the present study, we had one case of brachial injury, one case of radial nerve injury, two cases of elbow stiffness, three cases of cubitus varus, one case of the cubitus valgus, and one case of superficial pin tract infection. The total percentage of associated complication was found to be 30%. The most common complication in the study was cubitus varus accounting for 1/3 of the complications.

Table 9: Fracture pattern (type 3 fractures)

Fracture pattern	No. of cases	Percentage
Type 3A posteromedial	8	53.3
Type 3B posterolateral	7	46.7
Total	15	100.0

Table 10: Final results of operative management according to Flynn's criteria

Result	Rating	Loss of range of motion	Loss of carrying angle	No. of cases	Percentage
Satisfactory	Excellent	0–5	0–5	21	70
	Good	6–10	6–10	4	13.3
	Fair	11–15	11–15	4	13.3
Unsatisfactory	Poor	>15	>15	1	3.3
	Total			30	

Table 11: Distribution of complications

Complications	No. of cases	Percentage
Vascular injury	1	3.3
Volkma's ischemic contracture		
Nerve injury	1	3.3
(a) Radial		
(b) Median		
(c) Ulnar		
Myositis ossificans		
Elbow stiffness	2	6.6
Cubitus varus	3	9
Cubitus valgus	1	1
Superficial pin tract infection	1	1
Total	9	30

Discussion

The study was conducted between June 2018 and February 2020 in the Basveshwar Teaching and General Hospital attached to Mahadevappa Rampure Medical College Kalaburagi. The aim of this clinical study was to study the epidemiology of the supracondylar fractures of humerus in children, the mechanism of injury, associated complication, and the role of operative management of these fractures. Many methods have been proposed for the treatment of displaced supracondylar fractures of the humerus in children such as closed reduction and the plaster of Paris slab application, skin traction, overhead skeletal traction, ORIF and closed reduction, and percutaneous pin fixation.

The present study was conducted to establish that surgical management with K-wires with slab application can be considered as the treatment of choice in supracondylar fractures of humerus based on the evaluation of results and functional outcome. During the study period, we treated 30 patients of supracondylar fracture of humerus. A majority of the patients reported to the hospital within 12h of injury; the average reporting time was 24h. Most of the children were initially taken to bone setters in their village. After an increase in pain and swelling, they reported to our hospital. Few cases were reported from the primary health centers.

In the present study, 53.3% (16) of the patients were from 5 to 8 years age group with the average age being 7.1 years. Fowles and Kasab have reported an average age incidence of 7.2 years.^[2] Minkowitz and Busch have found peak incidence between 5 and 7 years of age.^[3] The average age in Pirone *et al.* study was 6.4 years.^[4] Mulhall *et al.* reported a mean age of 5.9 years in the study.^[5] This may be explained by the weak bony architecture and other anatomical factors, which have been explained previously. The sex incidence in the present study was found to be 60% (18) in males and

40% (12) in females. The same has been observed by Fowles and Kasab.^[2] D'Ambrosia has observed an incidence of 69% in males and 31% in females.^[6] Pirone *et al.* reported an incidence of 52% of males and 48% of females.^[4] This male dominance can be explained as boys are more active and more prone to falls. The most common mode of injury in the present study was due to fall on an outstretched hand accounting for 86.6% (26) of the cases, and 13.3% (4) of the patients had a direct injury, that is, fall on the point of the elbow. Our observation is in the concurrence with that of Wright *et al.*, that is, when a child loses its balance, he or she tries to save themselves with an outstretched hand.^[7] McDonnell and Wilson reporting are also coinciding with that of our study.^[8] In the present study, 29 (96.6%) cases were of extension type, and one (3.3%) case was of flexion type. Fowles and Kasab have reported 90% of the extension type and 10% of the flexion type.^[2] Celiker *et al.* reported an incidence of 79.5% of extension type and 20.5% of flexion type in their study.^[9] A majority of the cases were of type 3 (0%) fractures, and the rest of them were of type 2 (40%) and type 1 (10%) fracture. Fracture patterns in the present study were 53.3% (8) of the posteromedial displacement and 46.6% (7) of the posterolateral displacement. Aronson and Prager noted 15 (75%) patients of the posteromedial displacement and five (25%) patients of the posterolateral displacement in the study of 20 cases.^[10] Of the 30 patients in the study, the complications we encountered were one (3.3%) patient having absent radial pulse on presentation. That case was of type 3 fracture with posterolateral displacement. Closed reduction was tried first under general anesthesia. But the radial pulse did not return. Hence, the fracture was explored and brachial artery was found to be compressed by the proximal fragment. Fracture fragments were reduced, the compression was relieved, and the pulse returned. Fracture was stabilized with K-wires. Fowles and Kassab^[2] has reported cases in which the brachial artery flow was resumed often by simple reduction of the fracture under general anesthesia. Ottolenghi^[11] has reported an incidence of 5% of vascular injuries among 830 cases of supracondylar fractures studied. Campbell *et al.* have reported that 38% of the cases had evidence of injury to the brachial artery.^[1] The low incidence in the present study has been explained due to the smaller sample size. Moreover, in this study, we have used only static and dynamic assessment tests clinically. In the present study, only one (3.3%) patient presented with radial nerve injury. It was operated using anterolateral approach. The injury was of neuropraxia type and recovered completely within 8 weeks. McGraw *et al.*^[12] have reported an incidence of nerve injuries up to 12% of all supracondylar fractures. Ogunlade *et al.* observed neurological complications in 12 of the 131

patients.^[13] The deficit was transient in 10 patients. Radial nerve was involved in five patients.

Elbow stiffness was also seen in two cases in the present study. We defined elbow stiffness as a loss of more than 25° of flexion or extension or both. The incidence of the elbow stiffness in our study was 6.6%. The mean loss of flexion and extension was found to be 7.3°. Coventry and Henderson have analyzed in detail regarding the follow-up of the range of motion of the elbow. They have reported that for fractures treated by closed method, the average loss of flexion was 4°, and loss of flexion with open reduction was found to be 6.5°. The greater loss of elbow motion in the study may be attributed to the shorter follow-up period when compared with other studies. One case of elbow stiffness was found in patient treated by conservative method. Ogunlade *et al.* reported that 10.7% had 15° of extension lag at the elbow joint at 6 months.^[13]

The incidence of cubitus varus deformity in the current study was found to be three cases (9%). All of these cases were seen in cases treated with close reduction. We feel that varus deformity was the result of the residual displacement of distal fragment in the medial direction and also incomplete correction of internal rotation. This concept is widely accepted by various authors. Ippolito *et al.* in a long-term follow-up study of 131 patients reported an incidence of 7.5% of cubitus varus.^[14] The incidence of cubitus varus in the closed reduction group of the study was 30%, and in the open reduction was nil. Pirone *et al.*^[4] have reported that an incidence of cubitus varus was 14% with closed reduction and cast immobilization and 11% in open reduction and K-wire fixation. We came across one case of cubitus valgus (2.5%) in the study; it was a type 3 fracture with posterolateral displacement treated by closed reduction. We feel that valgus was the result of residual displacement of distal fragment in the lateral direction. Ippolito *et al.* reported an incidence of 5.6% of the cubitus valgus treated by conservative method in the long-term follow-up study.^[14] Langenskiöld and Kivilaakso in a study of 14 cases of elbow deformities have reported cubitus valgus in three patients.^[15] We had one case of superficial pin tract infection, which was treated by appropriate antibiotics. The average period of immobilization in the study was 3.2 weeks. In two patients, K-wire was removed after 5 weeks, because they did not turn up for follow-up after 4 weeks. The average period of follow-up in the study was 8.6 months.

Change in the carrying angle

The mean change in the carrying angle following operative management was 5.8°.

Change in the range of motion

The mean change in the range of motion following operative management was 7.3°.

From the above-mentioned prospective study, we found that surgical management with K-wire fixation for displaced supracondylar fracture in children results in a good functional and cosmetic outcome than treated by conservative approach.

Conclusions

From our study, we conclude that open/closed reduction and internal fixation with K-wire fixation is an effective and safe method of treatment for supracondylar fracture of humerus in children compared with conservative method with slab application.

Supracondylar fracture of humerus is a common injury in children and is common in 5–8 years of age group. Boys are predominantly affected. A male to female ratio is 1.5:1. The right is involved more often than the left. Indirect injury due to fall on an outstretched hand is the most common mode of injury. Extension type is the most common type of supracondylar fracture. Results of closed reduction and external immobilization give uncertain results. Conservative management in type 3 fractures shows a high failure rate because of difficulty in reduction, lost of reduction postoperatively, or during follow-up. All cases of the displaced supracondylar fracture of humerus in children must be treated as an emergency and should be admitted and observed for at least 24h following open reduction.

Surgical management with internal fixation with K-wire offers more advantage with fewer complication, more stable fixation, and better anatomical reduction with minimal complications.

ORIF with K-wire offers better functional and cosmetic results compared with conservative methods.

Hence, we conclude that K-wire osteosynthesis is associated with a low complication rate and continues to be a safe standard procedure for stabilization and can be advocated as the treatment of choice in supracondylar humerus fractures in children.

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Conflicts of interest

There are no conflicts of interest.

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