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Original Research Article

A PROSPECTIVE STUDY OF DISPLACED SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN TREATED BY OPEN REDUCTION AND INTERNAL FIXATION WITH K-WIRES

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ABSTRACT

Background: Supracondylar fracture of the humerus is the most common elbow fracture in children, accounting for approximately 65.4% of all fractures around the elbow. Displaced supracondylar fractures of the humerus are challenging injuries that require accurate anatomical reduction and stable internal fixation to prevent complications and achieve satisfactory functional outcomes. The present study was undertaken to evaluate the functional and radiological outcomes of displaced (Gartland type III) supracondylar fractures of the humerus in children treated by open reduction and internal fixation with K-wires.

Materials and Methods: A prospective study was conducted on 25 children with displaced (Gartland type III) supracondylar fractures of the humerus treated by open reduction and internal fixation with K-wires over a period of 24 months. Patients were evaluated clinically and radiologically during follow-up. Functional outcome was assessed based on loss of carrying angle, range of motion, and complications.

Results: Among the 25 patients included in the study, all had closed Gartland type III fractures. The mean age was 6.3 years. Thirteen patients sustained injury due to falls while playing. The left side was involved in 18 cases. Posteromedial displacement was observed in 16 patients, and 2 patients had associated distal radius fractures. Most patients were operated on the second day after injury and discharged on the third postoperative day. Sixteen patients had a loss of range of motion between 0° and 5°, while 18 patients had a loss of carrying angle between 0° and 5°. Complications included superficial pin tract infection in 4 patients, traumatic median nerve palsy in 2 patients, K-wire migration in 2 patients, cubitus varus deformity in 1 patient, and loss of motion greater than 15° in 1 patient.

Conclusion: Open reduction and internal fixation with K-wires provides accurate anatomical reduction, stable fixation, and satisfactory functional outcomes with minimal complications in displaced supracondylar fractures of the humerus in children. The study supports open reduction and K-wire fixation as an effective and acceptable treatment modality for Gartland type III supracondylar humerus fractures in children.

Keywords: Supracondylar fracture humerus, K-wire, Internal fixation, Gartland's.

INTRODUCTION

There is little controversy regarding the treatment of undisplaced supracondylar fractures, which are generally managed conservatively with immobilization. However, various treatment modalities have been proposed for displaced supracondylar fractures in children. These include closed reduction and plaster immobilization, skin traction, overhead skeletal traction, closed reduction

with percutaneous pin fixation, posterior intrafocal pinning, lateral external fixation, and open reduction with internal fixation using K-wires.[1-4]

Traditionally, displaced supracondylar fractures were managed with closed reduction and cast immobilization or traction methods. Although acceptable results were obtained in some patients, difficulties in maintaining reduction frequently resulted in malunion, loss of carrying angle, and elbow stiffness. In addition, prolonged immobilization and hospital stay associated with traction techniques increased morbidity in children.[5]

During the early part of the twentieth century, there was reluctance to perform open reduction because of concerns regarding infection, stiffness, and myositis ossificans. However, advances in orthopedic trauma care, including improved surgical techniques, better understanding of biomechanics, availability of improved implants, effective antibiotics, and strict aseptic precautions, have significantly improved surgical outcomes. Consequently, open reduction and internal fixation have become accepted methods for managing displaced supracondylar fractures of the humerus in children.[6]

Several studies have demonstrated that open reduction and internal fixation with K-wires provides stable fixation, better anatomical reduction, and satisfactory functional outcomes with minimal complications. K-wire fixation is simple, economical, minimally invasive, and provides adequate stability for fracture healing. Therefore, open reduction and internal fixation with K-wires continues to be a widely accepted treatment modality for displaced Gartland type III supracondylar fractures of the humerus in children.[7]

Objectives

- To study the age, sex, and side incidence of supracondylar fractures of the humerus in children.
- To study the average duration required for fracture union.
- To evaluate the anatomical and functional outcomes of displaced supracondylar fractures of the humerus treated by open reduction and internal fixation with K-wires.
- To study the complications associated with the procedure.

MATERIALS AND METHODS

25 displaced extension type of supracondylar fractures (Gartland's type III) of the humerus in children were treated by open reduction and Internal fixation with K-wires. This study was conducted in Department of Orthopaedics, Navodaya Medical College Hospital, Raichur, Karnataka from September 2010 to August -2012.

Inclusion Criteria

1. Children aged between 5 and 15 years with supracondylar fractures of the humerus.
2. Irreducible fractures following attempted closed reduction.
3. Closed supracondylar fractures associated with neurovascular compromise.

Exclusion Criteria

1. Patients aged more than 15 years.
2. Patients medically unfit for surgery.
3. Open fractures.

Ethical clearance for the study was obtained from the Institutional Ethics Committee prior to commencement of the study. Informed consent was obtained from the parents or legal guardians of all patients included in the study.

All patients selected for the study were admitted and evaluated according to a standard clinical protocol. Detailed history regarding the mode of injury and associated injuries was recorded. General and local examination was performed carefully, with special attention to neurovascular status. Associated injuries, if present, were documented.

Radiological evaluation included anteroposterior and lateral radiographs of the elbow joint. A trial of closed reduction was attempted in selected patients. However, patients presenting with gross swelling or puckering of skin (pucker sign) were planned for early open reduction without repeated attempts at closed reduction in order to avoid further soft tissue injury. In the present study, 7 patients had gross swelling and 4 patients had pucker sign and were therefore taken for elective surgery at the earliest opportunity.

All fractures were classified according to the modified Gartland classification system.[1]

Table 1: Modified Gartland's classification

Type 1	Undisplaced	Fat pad present acutely
Type 2	Hinged posteriorly	Anterior humeral line anterior to capitellum
Type 3	Displaced	No meaningful cortical continuity
Type 4	Displaces in to extension and flexion	Diagnosed with manipulation under image
Medial comminution (not truly separate type)	Collapse of medial column	Loss of baumann angle

Preoperative preparation

Once surgery was planned, the following preoperative procedures were carried out:

1. Written informed consent for anesthesia and surgery was obtained from the parents or attendants.
2. Patients were kept nil per oral for 6 hours prior to surgery.
3. Injection Tetanus Toxoid 0.25 mL intramuscularly was administered stat.
4. Preoperative antibiotics were administered.
5. Preparation of the operative site was performed under aseptic precautions.
6. Patients were evaluated for associated fractures or other injuries.

7. Appropriate size K-wires and surgical implants were selected prior to surgery.

Operative Technique

Anesthesia

All patients were operated under general anesthesia.

Position

The patient was placed in the lateral position with the affected elbow facing the surgeon. Sandbags were placed beneath the arm for support, while the forearm was allowed to hang freely with the elbow flexed. A pneumatic tourniquet was applied in all patients.

Surgical Approach

A standard posterior approach was used in all cases. The ulnar nerve was not routinely explored. The triceps muscle was split vertically to expose the fracture site. Hematoma and interposed soft tissue were removed, and saline irrigation was used to obtain clear visualization of the fracture fragments. Reduction was achieved by carefully manipulating the distal fragment and restoring the alignment of the medial and lateral columns. After satisfactory reduction was confirmed visually and fluoroscopically, fixation was performed using crossed K-wires.

In posteromedial displacement fractures, the medial K-wire was inserted first through the apex of the medial epicondyle. The lateral K-wire was then introduced through the center of the lateral epicondyle and directed obliquely across the fracture site to engage the opposite cortex of the proximal fragment.

K-wires measuring 1.2 mm to 2.0 mm in diameter were used depending on the age and size of the child. The wires were inserted at approximately 30° in the coronal plane to achieve bicortical purchase and stable fixation. Fracture stability was assessed intraoperatively by gentle movement of the elbow. Carrying angle and alignment were compared with the contralateral side.

The K-wires were bent and cut outside the skin to facilitate easy removal in the outpatient department without anesthesia. The wound was closed in layers and sterile dressing applied. After release of the tourniquet, the limb was immobilized in a well-padded posterior plaster splint with the elbow flexed to 90°. The patient was then shifted to the recovery room and later to the ward after recovery from anesthesia.

Postoperative management

1. The operated limb was kept elevated.
2. Blood pressure, pulse rate, temperature, and respiratory rate were monitored regularly.
3. Neurovascular status of the limb was carefully assessed at regular intervals.
4. Appropriate intravenous antibiotics were administered for 3 days, and analgesics were given for 10 days.
5. Immediate postoperative radiographs were obtained to confirm maintenance of reduction and implant position.
6. Patients were discharged with advice to return on the 10th postoperative day for wound inspection and suture removal.

Sutures were removed on the 10th postoperative day under sterile precautions.

Follow-up

- Patients were reviewed after 4 weeks, and the plaster splint was removed.
- K-wires were removed at 4 weeks postoperatively.
- Active range of motion exercises of the elbow were encouraged following removal of immobilization.
- Parents were specifically advised to avoid massage and passive stretching exercises around the elbow joint.
- Further follow-up evaluations were conducted at 12 weeks and 24 weeks postoperatively.

At each follow-up visit, patients were assessed clinically and radiologically for fracture union, range of motion, carrying angle, and complications.

Functional assessment

Final functional outcome was evaluated using Flynn's criteria.[9] The results were graded as excellent, good, fair, or poor based on the loss of carrying angle and loss of range of motion compared to the normal side.

Table 2: Flynn's Grading System

Result	Rating	Cosmetic factor: Carrying angle loss (degrees)	Functional factor: motion loss (degrees)
Satisfactory	Excellent	0-5	0-5
	Good	6-10	6-10
	Fair	11-15	11-15
Unsatisfactory	Poor	>15	>15

Instruments

K-Wire,
Man-Man drill, Chuckey, Hand drill,
K-wire cutter, Suture material,
Right angled retractors, Artery forceps, Scalpel.

RESULTS

This study was done to find out the age incidence in our Indian setup and to know the type of fracture incidence.

Table 3: Distribution of patients by age category

Age category	No of patients	percentage
5-6	8	32
7-9	10	40

10-12	5	20
13-15	2	8
Total	25	100

Majority of the patients i.e. 18 (72%) were from 4-9 years age group, followed by 5(20%) patients in 10-12 years age group. The average age of patient was 6.3 years.

Majority of the patients were males i.e., 17 (68%) and 8 (32%) patients were females.

Table 4: Mode of injury

Nature of trauma	No of patients	Percentage
Fall from bicycle	8	32
Fall while playing	13	52
Fall from tree	4	16
Total	25	100

The major cause of fracture in our study was fall while playing in 13 patients (52%), followed by fall from bicycle in 8 patients (32%) and in 4(16%) patients was due to fall from tree.

The fracture occurred on the left side in 18 patients (72%) and on the right in 7 (28%) patients.

Table 5: Classification of fracture pattern

Fracture pattern	No of patients	Percentage
Type3posteromedial	16	64
Type3posterolateral	9	36
Total	25	100

In our study, we had 16 (64%) patients with posteromedial displacement and 9 (36%) patients with posterolateral displacement.

Table 6: distribution of associated injuries among patients

Associated injuries	No of patients	Treatment method
Fracture distal radius	2	Conservative

In this series 8% had associated injuries.

Table 7: distribution of patients by time of surgery after fracture time of surgery

Time of surgery (days)	No of patients	percentage
2nd day	13	52
3rd day	7	28
4th day	2	8
5th day	3	12

All cases included in this study group were fresh fractures who underwent surgery at the earliest possible time after admission to hospital. The average interval between fracture and surgery was 3.1 days. Majority of the patients i.e., 16(64%) patients were discharged on 2ndpostoperative.

Table 8: Complications

Complications	No of patients	percentage
Traumatic median nerve palsy	2	8
Superficial pin tract infection	4	16
Iatrogenic ulnar nerve palsy	0	0
Migration of K-wires	2	8
Restriction of movements	1	4
Operative wound infection	0	0
Cubitusvarus	1	4

We had 4 cases of superficial pin tract infection which are treated by appropriate antibiotics. There are two cases of k-wire outward migration for which reinsertion of k-wire was done. No cases of iatrogenic ulnar nerve palsy.

Table 9: Loss of range of motion

Loss of range of motion	No of patients	percentage
0-50	16	64
6-100	6	24
11-150	2	8
>150	1	4

Table 10: Carrying angle loss

Carrying angle loss	No of patients	Percentage
0-5	18	72
6-10	5	20
11-15	1	4
>15	1	4
Total	25	100

At the final follow up, 0-5 degree carrying angle loss of the affected extremity was noted in 18 (72%) patients. 11-15 degrees carrying angle loss was noted in only one (4%) patient and. Gross loss of carrying angle i.e., more than 15 degrees is observed in 1 our study.

Table 11: Functional results based on Flynn's grading system

Results	Rating	No of patients	Percentage
Satisfactory	Excellent	18	72
	Good	5	20
	Fair	1	4
Unsatisfactory	Poor	1	4
Total		25	100

In our study,24(96%) patients had satisfactory results. Of these 24 patients, 18(72%) patients were rated as excellent,5(20%) patients were rated as good & 1 patient as fair and 1 (4%)patient was rated as poor.

Figure 1: A. Pre operative. B. Immediate post-operative .C. 4 weeks follow . D. After K-wire removal

Figure 2: A. Preop X ray. B. immediate post op. C. 4 weeks follow up. D. Final follow up.

DISCUSSION

Supracondylar fracture of the humerus is the most common injury around the elbow in children and constitutes the majority of pediatric elbow fractures.[1] These fractures require careful management because improper treatment may lead to complications such as neurovascular compromise, Volkmann's ischemic contracture, malunion, cubitus varus deformity, and stiffness of the elbow joint.[2] Various treatment modalities have been described for displaced supracondylar fractures of the humerus, including closed reduction with plaster immobilization, skeletal traction, closed reduction with percutaneous pinning, and open reduction with internal fixation using K-wires.[4] The primary goal of treatment is to achieve satisfactory cosmetic and functional outcomes with minimal complications and early restoration of elbow function.

Open reduction and internal fixation with K-wires provides stable fixation, accurate anatomical reduction, and early mobilization with minimal complications.[8] Therefore, it continues to be one of the most widely accepted treatment methods for displaced supracondylar fractures of the humerus in children.

The present study was undertaken to evaluate the effectiveness of open reduction and internal fixation with K-wires in displaced supracondylar fractures of the humerus in children and to compare the results with those reported in previous studies.

In the present study, the majority of patients, 18 (72%), were between 5 and 9 years of age, with a mean age of 6.3 years. This finding is comparable with earlier studies, which reported peak incidence between 5 and 7 years of age.[1] The higher incidence in this age group may be attributed to increased outdoor activity and vulnerability to falls during play. Male predominance was observed in the present study, with 60% males and 40% females. Similar male predominance has been reported in several previous studies due to increased physical activity among boys.

The most common mode of injury in the present study was fall while playing, accounting for 52% of cases. Edward E. Palmer et al,[9] reported that 69 out of 78 patients sustained injury following falls while

playing. Similarly, Fransworth C. L. et al,[10] reported falls as the most common mechanism of injury in approximately 70% of cases.

In the present series, 18 patients (72%) sustained fractures on the left side, while 7 patients (28%) had right-sided injuries. Similar predominance of left-sided involvement has been reported in earlier studies and may be related to the non-dominant upper limb being more commonly used to break a fall.

Regarding fracture displacement, 16 patients (64%) had posteromedial displacement and 9 patients (36%) had posterolateral displacement. Posteromedial displacement has been reported more frequently in extension-type supracondylar fractures because of the typical mechanism of injury.

Associated injuries were uncommon in the present study, with 2 patients sustaining ipsilateral distal radius fractures. Mazda K. et al,[11] reported ipsilateral forearm fractures in 7 out of 116 patients. Similarly, Pirone A. M. et al,[5] noted 20 associated ipsilateral forearm injuries in their series of 230 patients. Millis M. B. et al,[12] reported associated fractures in 8.33% of patients.

In the present study, 14 patients (56%) underwent surgery on the second day of hospitalization. Ramsey R. H. et al,[13] reported that all patients in their series underwent surgery within 24 hours of injury. David L. Skaggs et al. reported a mean interval of 1.4 days between injury and surgery. Similarly, Andrew J. Weiland et al,[15] reported that 51 out of 58 patients underwent surgery within 24 hours. Delay in surgery in the present study was mainly due to delayed presentation to the hospital.

Most patients in the present study were discharged within 3 days following surgery. Early discharge was possible because of stable fixation, adequate pain control, and absence of major postoperative complications.

Neurovascular complications are important concerns in displaced supracondylar fractures. In the present series, 2 patients had traumatic median nerve palsy associated with posterolateral displacement. Both patients recovered completely within 4 to 6 weeks postoperatively. Andrew J. Weiland et al. reported 5 preoperative neurological deficits in their study, including combined radial and median nerve injuries. Srivastava P. et al,[14] reported nerve injuries in 42.2% of patients.

Pin tract infection is a recognized complication of K-wire fixation. In the present study, 3 patients developed superficial pin tract infection, which resolved with antibiotic therapy and local care. One patient required early K-wire removal. No deep infection or osteomyelitis was encountered. Srivastava P.14 reported superficial pin tract infection in 14% of cases, while Ramsey R. H. et al,[13] reported one case of pin tract infection that healed after treatment.

In the present study, one patient developed cubitus varus deformity and one patient had proximal migration of K-wire due to inadequate bicortical fixation. The migrated wire was subsequently removed under general anesthesia. The patient with cubitus varus deformity was advised corrective osteotomy but declined surgery because elbow function remained satisfactory and the deformity was primarily cosmetic.

Loss of range of motion was minimal in most patients. Sixteen patients had loss of motion between 0° and 5°, six patients had loss between 6° and 10°, two patients had loss between 11° and 15°, and only one patient had loss greater than 15°. Andrew J. Weiland et al. reported moderate restriction of elbow motion in five patients, with most having less than 10° loss of flexion or extension.

Loss of carrying angle in the present study was also minimal. At final follow-up, 18 patients (72%) had carrying angle loss between 0° and 5°, whereas only one patient had more than 15° loss. Ramsey R. H. et al,[13] reported essentially normal carrying angle in most patients, while Andrew J. Weiland et al. observed varying degrees of varus deformity in a small number of patients.

All fractures in the present study showed radiological union by 4 weeks. K-wires were removed at 4 weeks, following which active elbow mobilization exercises were initiated. Stable fixation achieved by open reduction and K-wire fixation enabled early mobilization and satisfactory functional recovery. According to Flynn's criteria, the present study demonstrated 96% satisfactory results, which is comparable with previously published studies on open reduction and internal fixation using K-wires for displaced supracondylar fractures of the humerus in children.[14,15]

Therefore, the findings of the present study support that open reduction and internal fixation with K-wires provides stable fixation, accurate anatomical reduction, early union, and satisfactory functional outcomes with minimal complications in displaced supracondylar fractures of the humerus in children.

CONCLUSION

In the present study of 25 children with displaced extension-type supracondylar fractures of the humerus treated by open reduction and internal fixation with K-wires, the following conclusions were drawn:

- Open reduction and internal fixation with K-wires provides stable fixation, accurate anatomical reduction, and satisfactory functional outcomes with minimal complications. It is a safe and effective method of treatment, particularly in fractures associated with neurovascular compromise.
- Supracondylar fractures of the humerus were most commonly observed in children between 4 and 6 years of age, with a predominance among male patients.
- The most common mode of injury was fall on an outstretched hand while playing.

- Posteromedial displacement was the most common pattern of fracture displacement observed in the study.
- The duration of hospital stay was relatively short, thereby reducing the overall cost of treatment and facilitating early recovery.
- The incidence of cubitus varus deformity was low compared to conservative treatment methods because of better anatomical reduction and stable fixation achieved by open reduction and K-wire fixation.
- Elbow stiffness was minimal due to stable fixation and early initiation of mobilization exercises.
- Open reduction is particularly indicated in cases of irreducible fractures, fractures associated with neurovascular injury, and open fractures.
- Open reduction and internal fixation with K-wires provides excellent cosmetic and functional results when performed at an appropriate time in displaced supracondylar fractures of the humerus in children.

In conclusion, open reduction and internal fixation with K-wires is a reliable, safe, and effective treatment modality for displaced supracondylar fractures of the humerus in children, especially in cases associated with neurovascular injury and failed closed reduction.

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