



A COMPARATIVE STUDY OF CLOSED REDUCTION AND PERCUTANEOUS CROSSED PINNING VS OPEN REDUCTION AND CROSSED PINNING IN GARTLAND TYPE III SUPRACONDYLAR FRACTURE OF HUMERUS IN CHILDREN.

Orthopaedics

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ABSTRACT

Background: Many methods have been proposed to treat displaced supracondylar fractures of the humerus in children, most are either closed reduction and pinning in different configurations or Open reduction and pinning with different approaches. There remains controversy in the literature with regards to some topics, these topics could be grouped into: method of reduction (open vs. closed), pin configurations, iatrogenic nerve injury and impact of time to surgery in complications. **Methodology:** A total of 70 patients with Type III supracondylar humerus fracture who fulfilled the inclusion criteria were randomly divided into two groups, 35 in each. Group I children were treated with closed reduction and crossed pinning and Group II with open reduction and crossed pinning. Both the groups were followed up for a period of 12 months at regular intervals. Assessment of cosmetic factor & functional factor was done by using Flynn's Criteria. **Results:** All the fractures were found to be united clinically and radiologically by 6 wks. As per Flynn's Criteria 91% cases in closed group showed excellent results whereas 80% cases in open group showed excellent results after 1 year of follow up. 3 cases in closed group had iatrogenic ulnar nerve injury. No cubitus varus deformity encountered in any group. **Conclusion:** Both open and closed reduction with crossed pin configuration provide stable fixation. Restriction of range of motion was more in the open group at 6 months follow up however at 12th month follow up the outcomes were similar. Closed reduction and crossed pinning allows early range of motion but it is technically difficult and satisfactory reduction is difficult to obtain in cases with severe soft tissue swelling.

KEYWORDS

closed reduction, displaced supracondylar fracture, open reduction, percutaneous crossed pinning.

INTRODUCTION

Supracondylar humerus fractures are the most common elbow fractures seen in children and the most common fracture requiring surgery.¹ The peak age range at which most supracondylar fractures occur is 5 to 6 years.² Many methods have been proposed to treat displaced supracondylar fractures of the humerus in children, most are either closed reduction with percutaneous Kirschner wires in different configurations or Open reduction and internal fixation with Kirshner wires from different approaches.⁴

There remains controversy in the literature with regards to some topics in the definitive management of these types of fractures. These topics could be grouped into: method of reduction (open vs. closed), constructs for stabilization of the fractures and impact of time to surgery in complications.⁵

Closed reduction and percutaneous pinning is the most common operative treatment of supracondylar fractures. However there are controversies between percutaneous crossed pinning versus lateral entry pinning. The two main issues are risk of iatrogenic ulnar nerve injury in crossed pinning and risk of loss of reduction in lateral pinning. Open reduction is indicated in cases of failed closed reduction, a loss of pulse or poorly perfused hand following reduction and open fractures. This method allows reduction of the fracture under direct visualization without the help of C-arm and risk of neurovascular complications are essentially low but the most frequent complication appears to be a loss of range of motion.⁶

A number of studies have been conducted earlier in the past comparing the results of closed reduction and percutaneous pinning versus open reduction and pinning. However in most of the studies, in the closed reduction group fixation was done by lateral entry pinning to avoid injury to ulnar nerve but it is mechanically less stable construct than crossed pinning.^{7,8,9}

A very few number of studies have been conducted comparing the outcomes of closed reduction and crossed pinning versus open reduction and crossed pinning with varying results. This variation may be owing to individual surgeon skill or owing to differences in surgical techniques. However in most of these studies the sample size was small and most importantly proper randomization of the cases for each group was not done e.g. cases of failed reduction with closed techniques, open fractures and cases previously manipulated by quacks were deliberately included in the open reduction group.

So the study was done to compare the results of closed reduction and

crossed pinning versus open reduction and crossed pinning in a total sample size of 70 patients, randomly divided into two groups of 35 each in our tertiary setting.

MATERIALS AND METHODS

A prospective, randomized interventional, comparative study was done in 70 cases of Gartland type III supracondylar fracture in RIMS, Imphal a tertiary institute from August 2016 to January 2018. Patients fulfilling the eligibility criteria are included in the study. Restricted randomization is done using block size of 4. Each eligible patient in a block fulfilling recruitment criteria is assigned to either Group 1 or Group 2 using lottery method.

In Group I thirty five patients are treated with closed reduction and crossed pinning and in group II another thirty five patients are treated with open reduction and crossed pinning.

Inclusion criteria:

- Children aged between 2-15 years
- Gartland's type III closed displaced supracondylar fracture humerus
- Age of the fracture not more than 14 days at presentation

Exclusion Criteria:

- Open fractures
- Associated neurovascular impairment following fracture
- Concomitant ipsilateral fracture of distal humerus or elbow joint
- Patient with flexion type fracture
- Loss of follow-ups

Ethical approval : was taken from Research Ethics Board, RIMS before starting the study. Informed written consent was taken from parents before enlisting the patients in the study.

Surgical technique: Surgical techniques were standardized in terms of pin location, pin size (weight <20 kg size 1.5 mm; >20 kg size 2 mm). Both the operative techniques were performed under general anaesthesia with intra operative monitoring by C-arm. Patient was positioned supine keeping the limb on a radiolucent side table.

Closed reduction and crossed pinning: Closed reduction was done and reduction was maintained with adhesive tape. First longitudinal traction was applied without keeping the elbow in hyperextension and the forearm supinated. While traction was maintained the medial or lateral displacement was first corrected by applying a varus or valgus force at the fracture site. Posterior displacement of the distal fragment

then corrected by applying a force to the posterior aspect while the forearm was pronated and elbow was acutely flexed. Reduction was checked under C-arm and once it was found satisfactory fixation was done with two cross 1.5 or 2 mm K-wire. First K-wire was passed from the lateral side to engage the medial cortex which stabilized the fracture partly then the elbow was slightly extended to 90 degrees so that ulnar nerve remained in its groove. Then the second K-wire was passed through the medial epicondyle to engage the lateral cortex.

Open reduction and crossed pinning: A longitudinal incision of 5 to 7 cm was given 0.5 to 1 cm anterior to the medial epicondyle. Two third of the incision was proximal to the medial epicondyle and one third of it was distal to medial epicondyle. Ulnar nerve was identified and retracted along with the surrounding soft tissues without isolating it. Fracture site was exposed and thoroughly cleaned. Then the distal fragment was exposed and around 5-10 mm of common flexor muscle attachment was elevated from the distal fragment with sharp dissection to visualize the fracture line clearly. Once reduction was achieved it was fixed with two cross 1.5 or 2 mm K-wire and stability was checked. Medial k wire was passed first and it should come out at anterolateral surface of proximal fragment. Wires were cut and bent and left outside the skin. Elevated common flexor origin was sutured by taking the suture around the K-wire instead of drilling into bone. Wound was closed with subcuticular absorbable suture and POP slab was applied.

Post operative management: Patients received parenteral third generation cephalosporin for two days. Anti-inflammatory analgesics and other supportive measures was also be given as per individual requirements. The operated limb was kept elevated. During this time passive and active movements of the fingers were encouraged. Patient was discharged after taking check X-ray on post surgical day 3 or day 4. POP slab was partly broken at the time of discharge on 3rd postoperative day to allow some ROM of elbow. Sutures and slab were removed on day 10 in OPD. Active elbow ROM exercise was started after the removal of pop slab. K-wire removal was done on the 3rd post-operative week during the follow-up in OPD.

Follow ups: The follow-ups were done on 3rd and 6th postoperative weeks and at 3 months, 6 months and finally at 12 months. The radiological evaluation was performed by AP and true lateral views next day after the surgery and at 3 weeks, 6 weeks, 6 months and finally at 12 months. At 6 and 12 months follow-up, the children were evaluated for limitation of range of motion, any neurological deficit, loss in carrying angle.

The final results were graded as excellent, good, fair and poor, according to the loss of range of motion and loss of carrying angle using the criteria of Flynn et al. The overall rating in these patients who had changes both in the carrying angle and in function was made on the basis of the greater clinical loss, that is a good functional rating and a fair cosmetic rating resulted in a fair rating.¹⁰

Table 1: Showing Flynn's criteria and overall rating

| Outcome | Result rating | Functional factor (Loss of motion) | Cosmetic factor (Carrying angle loss) |
|----------------|---------------|------------------------------------|---------------------------------------|
| Satisfactory | Excellent | 0-5° | 0-5° |
| | Good | 5-10° | 5-10° |
| | Fair | 10-15° | 10-15° |
| Unsatisfactory | Poor | ≥15° | ≥15° |

Statistical analysis was done using SPSS software (version 21.0). The data were compared between the two groups under study by using independent sample t-test. The difference was considered significant when the p value was <0.005



Fig 1: Instruments used for supracondylar fracture fixation

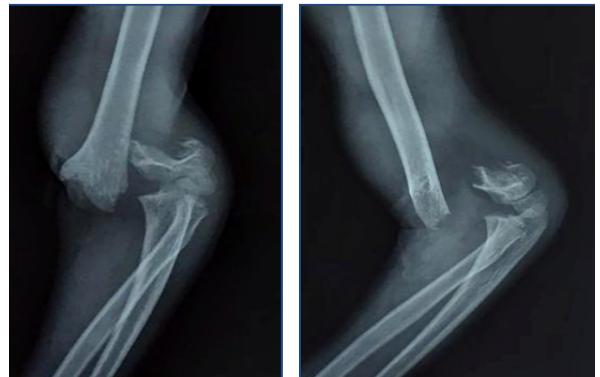


Fig 2: Showing preoperative radiograph of a 10 year old boy with type III supracondylar fracture of left humerus in AP and lateral views planned for closed reduction and crossed pinning.



Fig 3: Showing positioning of the limb following fracture reduction under C-arm

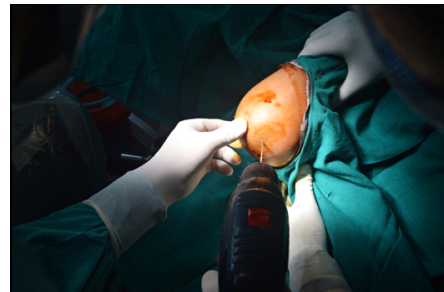


Fig 4: Showing first K-wire being introduced from the lateral side

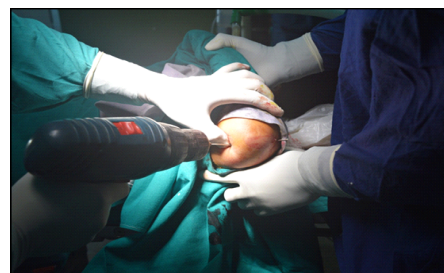


Fig 5 : Showing second k-wire being introduced from the medial side

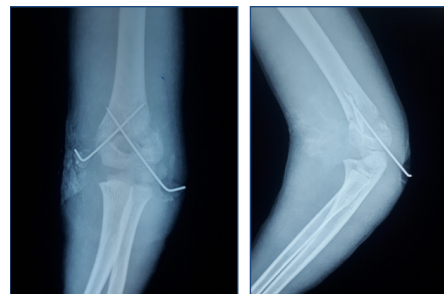


Fig 6 : Showing post operative x-rays of closed reduction and crossed pinning in both AP and Lat views

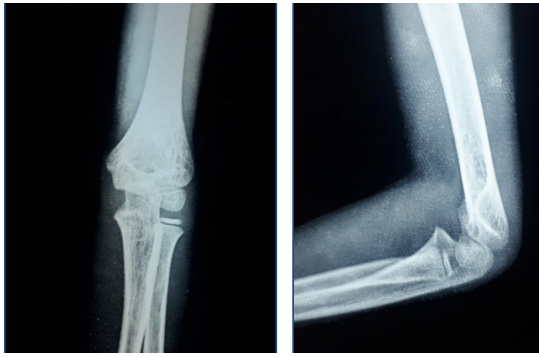


Fig 7 : Showing complete anatomical union of fracture at 12 months follow-up following closed reduction and crossed pinning in both AP and Lateral views of X-ray



Fig 8 : Showing full elbow flexion at 6 months follow up following closed reduction and crossed pinning



Fig 9: Showing full elbow extension at 6 months follow up

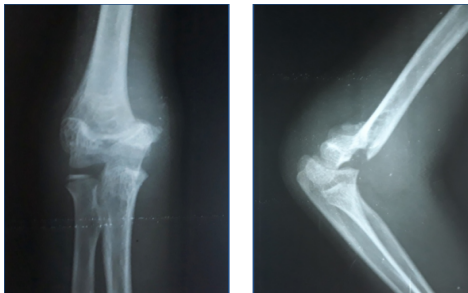


Fig 10: Showing preoperative X-ray of a 9 year old boy with type III supracondylar fracture of right humerus in AP and Lat views planned for open reduction and crossed pinning



Fig 11: Showing medial skin incision to the distal humerus of right elbow



Fig 12: Showing exposure of the ulnar nerve and the fracture site

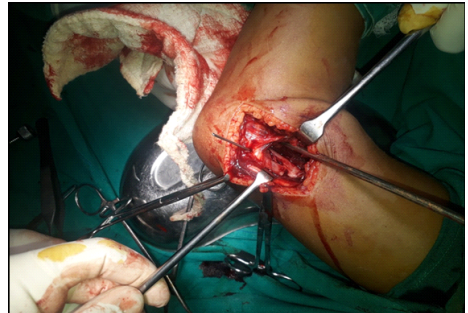


Fig 13: Showing placement of the medial pin following fracture reduction



Fig 14: Showing introduction of the lateral pin



Fig 15: Showing post operative X-ray of open reduction and crossed pinning in Lat and AP views



Fig 16 : Showing complete anatomical union of fracture at 12

months follow-up following open reduction and crossed pinning in both AP and Lat views of x-ray



Fig 17 : Showing full elbow flexion at 12 months follow up following open reduction and crossed pinning



Fig 18 : Showing full elbow extension at 12 months follow up



Fig 19: Showing clawing of 4th and 5th finger due to iatrogenic ulnar nerve injury in a patient following closed reduction and crossed pinning

RESULTS

The average age in group I is 7.86 ± 2.51 and the average age in group II is 7.49 ± 2.25 and the difference between them is statistically not significant (p-value 0.5171).

In our study fall while playing was the most common mode of injury accounting for 47 (67.14%) cases. There was male predominance (64%) with left hand being involved most commonly. The average time interval between trauma and surgery in group I was 3.54 ± 1.01 days and in case of group II was 3.74 ± 1.40 days and the difference between them was statistically not significant (p-value 0.495). The average duration of surgery in group I was 49.29 ± 7.59 minutes and in group II was 43 ± 41 minutes. The difference between them was statistically significant (p-value 0.0001). The average duration of hospital stay in case of group I was 3.23 ± 0.60 days and in case of group II was 4.49 ± 0.74 days. The difference between them was statistically significant (p-value 0.0001). All the fractures in both the groups were found to be united when X-rays were taken at 6 weeks.

In our study at 6 months follow up average elbow motion loss in group I was $5.77 \pm 2.37^\circ$ and in group II was $8.43 \pm 3.08^\circ$. The difference between them was statistically significant. However at 12 months follow up average elbow motion loss in group I was $3.49 \pm 2.06^\circ$ and in group II was $4.43 \pm 2.82^\circ$ and the difference between them was statistically not significant (p-value 0.1241).

The average change in carrying angle at final follow up in group I was $4.89 \pm 2^\circ$ and in group II was $3.77 \pm 1.80^\circ$. The difference between them

was statistically significant (p-value 0.0168).

The average change in Baumann's angle in group I was $5.03 \pm 2.24^\circ$ and in group II was $3.89 \pm 1.68^\circ$. The difference between them was statistically significant (p-value 0.0184).

Overall assessment by Flynn's criteria: Overall assessment by Flynn's criteria showed satisfactory results in all patients of both the groups. No patient had unsatisfactory results in terms of loss of motion or carrying angle loss of more than 15 degrees. 32 patients in the group I had excellent results whereas 28 patients in the group II had excellent results. Statistical analysis failed to show any clear benefit of an operative techniques over another

Table 2: Showing overall assessment by Flynn's criteria

| Outcome | Rating | Group I (n=35) | | Group II (n=35) | |
|----------------|-----------|----------------|-------------|-----------------|-------------|
| | | No of cases | Percentages | No of cases | Percentages |
| Satisfactory | Excellent | 32 | 91.42 | 28 | 80 |
| | Good | 3 | 8.57 | 5 | 14.29 |
| | Fair | 0 | 0 | 2 | 5.71 |
| Unsatisfactory | Poor | 0 | 0 | 0 | 0 |

Complications: There were 3 cases of iatrogenic ulnar nerve injury in group I which recovered over a period of 6 months. 1 case of superficial pin tract infection in group I and 2 cases of superficial pin tract infection in group II which was cured with regular dressings and antibiotic therapy. No patients had myositis ossificans.

DISCUSSION

Displaced supracondylar fracture humerus has always been one of the most common and challenging fractures among the paediatric age groups. The surgeon's goal is to achieve anatomical reduction, stable fixation and return to normal range of motion as early as possible. Unstable fixation in spite of good anatomical reduction at the time of operation leads to loss of reduction in future. 11,12,13

Open reduction and crossed pinning has been employed for a long time in the treatment for displaced supracondylar fracture humerus. Technically it requires less clinical expertise, provides anatomical reduction of the fracture under vision and good mechanical stability but the disadvantages as documented in many studies are delay in return to normal range of motion, loss of some degrees of normal flexion extension arch even on longer follow up and scar related complications. 13,14,15,16,17 Now a days open reduction is indicated in cases of failed closed reduction, a loss of pulse or poorly perfused hand following reduction and in open fractures.

Closed reduction and percutaneous pinning is the most common operative treatment for displaced type III supracondylar fractures. However there are controversies between percutaneous crossed pinning versus lateral entry pinning. The two main issues are risk of iatrogenic ulnar nerve injury in crossed pinning and risk of loss of reduction in lateral pinning. 6 Though lateral entry pinning avoids the risk of iatrogenic ulnar nerve injury, the construct may be less stable biomechanically. 18,19,20

In our study 3 (8.57%) patients in closed reduction group suffered from iatrogenic ulnar nerve injury because of the medially placed pin. Slobogean et al 21 in their study reported on 32 trials with 2639 patients and found that there is an iatrogenic ulnar nerve injury for every 28 patients treated with crossed pinning. Babel et al 22 in their systematic review of 35 articles found that the incidence of iatrogenic ulnar nerve injury in cases of crossed pinning is 3.4%. The relative high incidence of ulnar nerve injury in our study may be due to small sample size and previous attempted manipulations by local quack.

The mean age of the patients in the present study was found to be 7.6 years which was comparable to other studies by Yaokreh JB et al 23 and Teja BR et al 24. Male gender predominance was also observed in the present study which was also seen by Pavone et al 25 and Boparai et al 26.

In our study series of 70 patients majority of our patients 47 (67.14%) sustained fractures due to fall while playing, remaining due to fall from bicycle, fall from tree and fall from stairs. Gowda PM et al 27 and Fransworth et al 28 in their study also found most common mode of

injury is fall in the ground while playing which is similar to our study.

There was a statistically significant difference noted in the present study in terms of operative time with longer time required in patients with closed reduction and crossed pinning group because fracture reduction and pin placement was done under C-arm guidance.

The mean duration of hospital stay in group I was 3.23 days and in group II was 4.49 days which is similar to study conducted by Yaokreh JB et al¹⁵ 3.03 days in closed reduction and percutaneous group and 4.08 days in open reduction group

In the present study at 6 months follow up average elbow motion loss in closed reduction and crossed pinning group was $5.77 \pm 2.37^\circ$ and in open reduction group was $8.43 \pm 3.08^\circ$ and the difference between them was statistically significant. However at 12 months follow up the difference between them was statistically found to be not significant. In the literature in most of the studies closed reduction group had a better range of motion as compared to the open reduction group at final follow up which may be due to lack of randomization; cases with failed closed reduction were deliberately put on open reduction group, followed up of only 6 months and lack of proper rehabilitation.^{29,30,31,32}

The average change in carrying angle in group I was $4.89 \pm 2^\circ$ and in group II was $3.77 \pm 1.80^\circ$. The difference between them was statistically significant. No patient in our study had cubitus varus deformity in the form of negative carrying angle.

Overall assessment by Flynn's criteria showed satisfactory results in all patients of both the groups. No patient had unsatisfactory results in terms loss of motion or carrying angle loss of more than 15 degrees. 32 patients in the group I had excellent results whereas 28 patients in the group II had excellent results. Statistical analysis failed to show any significant difference between them. Similar results were shown by Yaokreh JB et al²³, Turhan E³², Cramer K³³ and Keskin D³⁴.

CONCLUSION

In view of these results, we conclude that closed reduction and crossed pinning allows early return to normal range of motion, gives cosmetic outcomes more or less similar to the open group in most of the cases but this procedure requires expert surgical skill and C-arm guidance. We suggest to minimise the high risks of iatrogenic ulnar nerve injury, closed reduction and crossed pinning should be avoided in cases with previous manipulations by quacks, and in fractures with severe soft tissue swelling. Whereas open reduction with crossed k-wire fixation is a safe and convenient method as it gives better anatomical reduction and stable fixation restoring the humerus supracondylar region anatomy. It takes less time, less surgical expertise and doesn't require C-arm. The only disadvantage being delay in return to normal range of motion and scar mark.

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