Early results of displaced supracondylar fractures of humerus in children treated by closed reduction and percutaneous pinning

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Abstract

Background: Displaced supracondylar fractures are notorious for difficulty in reduction, maintenance of reduction and frequent involvement of neurovascular structures. No general agreement on the treatment is evident with controversy prevailing regarding the ideal timing of surgery, method of maintenance of reduction and configuration of the pin fixation. A crossed pin configuration, though believed by some to be mechanically more stable than the lateral pins alone, has the risk of ulnar nerve injury due to the medial pin. Lateral pins alone impart less rotational stability to the fracture although it has been attributed mainly to technical errors of pin placement. The aim of this study was to assess the efficacy of treatment of this fracture using one lateral and one trans-olecranon K-wires or lateral entry K-wires alone.

Materials and Methods: Ninety cases of displaced supracondylar humerus fractures were included in the study. The mean age of the patients was 6.7 years (range 3–12 years). The male/female ratio was 5:1 and left side was involved in 70% whereas 30% had right sided injuries. The most common mode of trauma was fall from height with elbow in extension. All the 90 consecutively admitted patients had extension type injury with 73.3% fractures being Gartland type III and 26.7% were type II. Posteromedial displacement was noted in 70% whereas 30% fractures were posterolaterally displaced. In 60 cases, lateral entry wires alone were used whereas, in 30 cases, one lateral and another transolecranon transarticular K-wire was used. K-wires were removed at 3 weeks postoperatively and followup was done at 6 weeks and 12 weeks when they were evaluated according to the criteria described by Flynn. Chi-square test was used as a statistical test of significance to compare results among different variables.

Results: Results were graded according to Flynn's criteria. Excellent results were achieved in 12 (13.3%), good in 54 (60%), fair in 15 (16.7%) while in nine patients (10%) poor results were obtained.

Conclusions: Both lateral entry K-wires and lateral-trans-olecranon wire techniques provide stable fixation when observing the guidelines for wire placement and consistently satisfactory results can be obtained, both cosmetically and functionally with both the techniques.

Key words: Percutaneous pinning, supracondylar fracture humerus, transolecranon pinning, lateral pinning

MeSH terms: Pediatrics, humeral fractures, fracture fixation

Introduction

Supracondylar fracture of the humerus is almost exclusively a fracture of the immature skeleton, seen in children and young teenagers.\(^1\) Displaced supracondylar fractures are notorious for difficulty in reduction, maintenance of reduction and frequent involvement of neurovascular structures.\(^2,3\)

No general agreement on the treatment of this fracture is evident.\(^4,5\) In displaced extension type supracondylar fractures, controversy exists regarding ideal timing of surgery, method of maintenance of reduction and configuration of the pin fixation.\(^6-8\) A cross pin configuration is believed to be mechanically more stable than the lateral pins alone. However, the Ulnar nerve can be injured with the use of a medial pin.\(^8\) It has not been proved that added stability of a medial pin is clinically necessary since, in children, pin fixation is always augmented with immobilization in a splint or cast. Lateral pins alone impart less rotational stability to the fracture although it has been attributed mainly to technical errors of pin placement.\(^7\)
The objective of this study was to assess the efficacy of treatment of this fracture using one lateral and one trans-olecranon K-wires or lateral entry K-wires alone.

**Materials and Methods**

This was a prospective interventional study which included 90 consecutively admitted cases of displaced supracondylar fractures of the humerus in children (Gartland grade II and III). Other inclusion criteria were children aged between 2 and 12 years and presenting within 5 days of injury. Criteria for exclusion were open supracondylar fractures with Gustilo–Anderson grade II and III, an irreducible fracture or fracture with vascular injury having pulseless arm with poor perfusion.

All patients were taken for elective surgery as soon as possible after necessary blood, urine and radiographic preoperative work-up. General anesthesia was used in all cases. One dose of intravenous ceftriaxone was given on induction, appropriate for weight. Patient was positioned supine with ipsilateral shoulder at the edge of the table on a radiolucent side support. Affected elbow, arm and forearm were scrubbed, painted and draped leaving the elbow, lower third of arm and upper third of the forearm exposed. The C-arm image intensifier was positioned adjacent and parallel to the table and covered with a sterile drape. Longitudinal traction was given with elbow in less than full extension and forearm in supination. At the same time, counter-traction was given by an assistant by holding proximal portion of the arm. Continuing traction and counter-traction, medial or lateral displacement was corrected by lateral or medial force respectively at fracture site. A varus angulation was reduced by pronation of the forearm. After that, posterior displacement and angulation were corrected by flexing the elbow and simultaneously applying anteriorly directed force from the posterior aspect of the distal fragment and posteriorly directed force from the anterior aspect of the proximal fragment. Reduction was checked with anteroposterior (AP) view through the fully flexed elbow, and lateral view was taken by rotating the shoulder or by rotating the C-arm in very unstable fractures. A reduction was considered acceptable when Baumann angle was restored on the AP view; medial and lateral columns were observed to be intact, anterior humeral line passed through the capitellum on the lateral view and rotation was minimal. 1.6 mm smooth K-wires were used for maintenance of reduction. In 60 cases, lateral entry wires alone were used [Figure 1], whereas in 30 cases, one lateral and another trans-olecranon transarticular K-wire was used [Figure 2]. In most of the initial cases, maintenance of reduction was achieved using the lateral entry wires alone. Later on, both lateral wires alone and lateral transolecranon wires techniques were utilized randomly in rest of the patients. In the latter technique, after achieving reduction and keeping the elbow in full flexion, a K-wire was inserted through the lateral column, passed across the fracture site and fixed into the medial cortex. The elbow was then extended to 90° and a second K-wire was passed percutaneously through the olecranon, across the elbow joint, into the distal fracture fragment, across the fracture and into the metaphysis of humerus. AP and lateral views were taken in partially flexed elbow in trans-olecranon technique as the trans-olecranon wire did not allow extension at the elbow. A true AP view in maximum possible extension and lateral view of the distal humerus were taken for lateral pinning. K-wires were bent and kept at least 1 cm outside the skin. Sterile dressing was applied, and an above elbow posterior plaster of Paris (POP) splint in 90° elbow flexion and mid-prone position of the forearm was given. Most patients were discharged on 2nd postoperative day with oral antibiotics after check X-rays. At 3 weeks postoperatively, X-rays were done for evidence of healing and K-wires were removed if clinical signs of union were present and POP splint was applied for 1 more week (till 4 weeks postoperatively). In nine patients, the K-wires had to be retained till 4 weeks postoperatively due to lack of clinical union at 3 weeks. In no patient were the wires retained for more than 4 weeks. Patients were encouraged to do intermittent active elbow flexion and extension exercises during this period. At 6 weeks, radiological examination was again done to assess union. Patients were advised all the exercises of the elbow till final followup in outpatient department at 12 weeks when they were evaluated and results graded according to the criteria described by Flynn et al. (loss of movements and change in carrying angle). The obtained results were further categorized according to variables like method of fixation, grade of fracture; time elapsed between injury and surgery and age of the patient and statistical analysis of these results was done using Chi-square test as a test of significance.

**Results**

Out of the 90 children in the study (mean age 6.7 years, age range 3-12 years), 75 (83.3%) were boys and 15 (16.7%) were girls. The left side was involved in 63 (70%) and 27 (30%) had right sided injuries. All the 90 consecutively admitted patients were of extension type. 66 (73.3%) fractures were of Gartland type III and 24 (26.7%) were type II with posteromedial displacement in 63 (70%) and 27 (30%) fractures being posterolaterally displaced. We noted three (3.3%) distal radial metaphyseal fractures, and three (3.3%) fractures both bones forearm in association with the supracondylar fracture. These patients were also included in the final analysis. Preoperative complications
included radial nerve palsy in three (3.3%) cases, feeble radial pulse, but adequate distal perfusion in three (3.3%) and grade I open fracture in three (3.3%) patients. Six (6.7%) patients were operated within 12 h of injury; 33 (36.7%) in 12–24 h; 39 (43.3%) in 24–48 h and 12 (13.3%) were operated within 48–72 h of injury (due to late presentation or massive swelling at the elbow) [Table 1]. Maximum percentage of excellent cases was noted in the group operated within 12 h of injury (50%) and highest percentage of poor cases (25%) was observed in the group operated within 48–72 h after injury. The results were analyzed statistically using Chi-square test for significance and it was noted that there is no statistically significant difference in results in patients operated at various durations after injury ($\chi^2 = 11.841; df = 12; P > 0.05$). Early postoperative complications included pin tract infection in 3 (3.3%) and loss of reduction in 9 (10%) cases. Out of these nine cases with postoperative loss of reduction, three fractures were significantly displaced, and rest six were mildly displaced. Although in all these cases satisfactory reduction had been achieved intraoperatively, loss of reduction was seen in X-rays on first postoperative day probably due to technical errors of pin placement. In the three cases with significant loss of reduction, wires were removed and open reduction and stabilization with K-wires was done under GA. In the other six cases, since the displacement was mild and more than 24 h had already elapsed after pinning, we continued with the POP splint fearing the risk of complications from multiple attempts at reduction. At final followup at 12 weeks, 6 (6.67%) patients developed elbow stiffness and six (6.67%) cases of cubitus varus deformity were noted. Results were evaluated according to Flynn et al. criteria. Excellent result was achieved in 12 (13.3%) patients, good in 54 (60%), fair in 15 (16.67%) and poor in 9 (10%) patients. Thus, satisfactory result was obtained in 90% cases and the rest 10% had unsatisfactory results according to Flynn criteria. Poor results were obtained in the cases in which loss of reduction was noted in the immediate postoperative period.

The ratio of satisfactory cases in grade II fractures (100%) were more than those in grade III fracture (86.3%). But after
incidence of the brachial artery reported by Pirone et al. was 10%, Fowles and Kassab 7.27% and Aronson and Prager observed no case of the same in their study of 30 cases. In our study, three cases (3.3% incidence) of preoperative vascular complications was noted (all with postero‑laterally displaced fracture) in the form of feeble radial pulse but adequate distal perfusion. Closed reduction and percutaneous fixation of the fracture was done and capillary filling was sufficient immediately after surgery and the pulse returned to its normal volume within 8 h of surgery in all cases.

Early postoperative complications included loss of reduction in nine (10%) cases. Musa et al. in their study observed a 10% incidence of iatrogenic ulnar nerve injury with crossed percutaneous pinning, whereas Balakumar and Madhuri noted an incidence of iatrogenic nerve injuries of 1.1%, 2.2% and 1.1% for ulnar, median and radial nerves respectively using various techniques of percutaneous pinning. We have not observed any case of iatrogenic nerve injury using lateral pins alone or lateral and trans‑olecranon pins for fixation. In their study, Devkota et al. noted loss of reduction postoperatively in 1.96% cases; Lee et al. observed the same to be 7%, whereas Balakumar and Madhuri in their study observed postoperative loss of reduction in 18.2% cases.

**Discussion**

The mean age and sex incidence observed in our study was comparable to the studies of Nacht et al., Wilkins, Fowles and Kassab and Aronson and Prager. Out of the various complications reported, we observed an incidence of 3.3% of nerve injuries (all radial nerve) whereas Fowles and Kassab reported an incidence of 6.36%, Wilkins 7.7% and Aronson and Prager observed it to be 5% in their study. The applying statistical test of significance (chi-square test), it was observed that the difference in results of grade II and III were not statistically significant ($\chi^2 = 4.290; df = 3; P > 0.05$) [Table 2]. Maximum percentage of satisfactory results (100%) was achieved in age group 2–4 years whereas least satisfactory results (66.7%) were noted in age group 9–12 years. However, after applying a statistical test of significance, it was observed that there is no statistically significant difference in results among patients of different age groups ($\chi^2 = 6.981; df = 6; P > 0.05$) [Table 3].
In our study, loss of reduction was noted at the time of first postoperative X-ray (satisfactory reduction was achieved under C-arm in all these cases). Six out of these nine cases belonged to the lateral entry K-wires group and three occurred in lateral-trans-olecranon K-wires group. On examining the postoperative X-rays, it was found that in eight cases, lateral wires were placed too close at the fracture site. In one case, slight withdrawal of a K-wire was noted on the postoperative X-ray and also the POP splint was applied in less flexion (~60°). The incidence of pin tract infections at followup was observed in 90% cases and unsatisfactory in 10% cases. After fixation. In both groups, satisfactory results were obtained in 90% cases and the rest 10% had unsatisfactory results according to the criteria described by Flynn et al., Davis et al. observed 100% satisfactory results in their studies. Hence, the results in our study were similar to the results noted in most other studies [Table 5].

Results were also compared between the two methods of fixation. In both groups, satisfactory results were obtained in 90% cases and unsatisfactory in 10% cases. After statistical analysis, it was found that there was no statistically significant difference in results if either lateral wires or lateral-trans-olecranon wire were used as a method of fixation. (χ² = 0.775; df = 3; P > 0.05) [Table 5].

A probable limitation in our study was a shorter period of followup as compared to most of the other studies. Thus, the results of this study reflect the early outcome of closed reduction and percutaneous pinning in pediatric supracondylar humerus fractures and may vary slightly from the results of other studies with a long followup. Though, we did followup some of our patients as long as till 1-year, this was not incorporated in the study. It was observed that at followup at 1-year, the findings in elder children did not vary much from those at 12 weeks, whereas in younger children, slight changes in the final clinical appearance of the elbow were present, although functional outcome remained more or less the same.

The mean loss of extension, mean loss of flexion and mean change in carrying angle was compared between the two groups and statistical analysis indicated that there was no significant difference in these parameters between patients who had trans-olecranon-lateral pin fixation and those who had lateral pin fixation [Table 4].

We achieved 12 (13.3%) excellent, 54 (60%) good, 15 (16.67%) fair and 9 (10%) poor results. Thus, satisfactory results were obtained in 90% cases and the rest 10% had unsatisfactory results according to the criteria described by Flynn et al., Davis et al. achieved 87.5% satisfactory results; Davis et al., 80% and Aronson and Prager obtained 100% satisfactory results in their studies. Hence, the results in our study were similar to the results noted in most other studies [Table 5].

Majority of patients regained almost full range of motion at 12 weeks. Nine (10%) patients had loss of movements at the elbow more than 15°. Mean loss of flexion was 7.3° and ranged from 0° to 25°. Mean loss of extension was 2.6° and varied from 0° to 18°. In their studies, Maity et al., Musa et al., and Foead et al., observed the mean loss of movements at final followup to be 3.86°, 4.6° and 18.3° respectively. A slightly more loss of movements at final followup was observed in our study which may be attributed to a shorter period of followup. In our study, most of the patients (54 i.e. 60%) had a decrease in carrying angle only up to 5°, including six patients maintaining the normal valgus. Loss of carrying angle ranged from 0° to 18° with a mean decrease of 5.1°. No case of cubitus valgus was observed. Musa et al., observed 2.6° and Foead et al. noted 3.7° mean change in carrying angle in their studies respectively.

### Table 1: Results according to time elapsed between injury and surgery

| Time between injury and surgery | Excellent (%) | Good (%) | Fair (%) | Poor (%) | Total |
|---------------------------------|---------------|----------|----------|----------|-------|
| <12                             | 3 (50)        | 3 (50)   | 0        | 0        | 6     |
| 12-24                           | 6 (18.2)      | 18 (54.5)| 9 (27.3) | 0        | 33    |
| 24-48                           | 3 (7.7)       | 27 (69.2)| 3 (7.7)  | 6 (15.4) | 39    |
| 48-72                           | 0             | 6 (50)   | 3 (25)   | 3 (25)   | 12    |
| Total                           | 12            | 54       | 15       | 9        | 90    |

### Table 2: Results according to grade of fracture

| Garstland grade | Excellent (%) | Good (%) | Fair (%) | Poor (%) | Total |
|-----------------|---------------|----------|----------|----------|-------|
| II (%)          | 3 (12.5)      | 21 (87.5)| 0        | 0        | 24 (100)|
| III (%)         | 9 (13.7)      | 33 (50)  | 15 (22.6)| 9 (13.7)| 66 (100)|
| Total           | 12            | 54       | 15       | 9        | 90    |

### Table 3: Results according to age group

| Age (in years) | Excellent (%) | Good (%) | Fair (%) | Poor (%) | Total |
|----------------|---------------|----------|----------|----------|-------|
| 2-4            | 3 (16.7)      | 9 (50)   | 6 (33.3) | 0        | 18    |
| 5-8            | 6 (11.1)      | 39 (40.2)| 11 (11.1)| 3 (5.6)  | 54    |
| 9-12           | 3 (16.7)      | 6 (33.3) | 3 (16.7) | 6 (33.3)| 18    |
| Total          | 12            | 54       | 15       | 9        | 90    |
Table 4: Analysis of loss of extension, flexion and carrying angle between the two methods of fixation

| Clinical parameter (in degrees) | 2 lateral wires (%) | 1 lateral and 1 trans-olecranon (%) | P (using student’s t-test) |
|--------------------------------|---------------------|-------------------------------------|--------------------------|
| Mean loss of extension         | 2.1±4.35            | 3.70±4.19                           | 0.11                     |
| Mean loss of flexion           | 7.5±5.25            | 6.90±6.26                           | 0.63                     |
| Mean change in carrying angle  | 5.5±7.2             | 4.90±2.85                           | 0.52                     |

Table 5: Results according to method of fixation

| Garland grade | Result | Total |
|---------------|--------|-------|
| Excellent     | Good   | Fair  | Poor |       |
| 2 lateral wires (%) | 9 (15) | 33 (55) | 12 (20) | 6 (10) | 60 (100) |
| 1 lateral and 1 trans-olecranon (%) | 3 (10) | 21 (70) | 3 (10) | 3 (10) | 30 (100) |
| Total         | 12     | 54    | 15    | 9      | 90     |

Though many studies have been done so far to analyze the outcome of various treatment modalities for fixation of pediatric supracondylar fractures humerus, none of them has been done to evaluate the outcome of lateral-trans-olecranon percutaneous pinning technique. Thus, our study provides a comparison between the already established lateral entry pinning technique and the novel lateral-trans-olecranon pinning technique.

**Conclusion**

Both lateral entry K-wires and lateral-trans-olecranon wire techniques provide stable fixation when observing the guidelines for wire placement. Although the trans-olecranon wire has the disadvantage of limiting the flexion and extension of the elbow, this does not influence the final outcome much as the elbow is fixed in a POP splint for minimum 3 weeks in all patients postoperatively. With the use of smooth pins for the trans-olecranon transarticular fixation of the fracture, no feature of articular damage is noted in followup X-rays. Although a theoretical risk of septic arthritis persists with the trans-olecranon wire, its incidence is negligible when diligent aseptic precautions are observed intra and postoperatively. With both the techniques, consistently satisfactory results can be obtained both cosmetically and functionally.

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