

Research Article

Functional Outcome Following Closed Reduction and Percutaneous Pinning and Open Reduction and Pinning in Displaced Supracondylar Fractures of the Humerus in Children: A Single Center Study

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Abstract

Objective: The aim of the study was to evaluate the functional outcome of closed reduction and percutaneous pinning (CRPCP) and open reduction and internal fixation (ORIF) after failed closed reduction in displaced supracondylar fractures of the humerus in children.

Methods: It's a prospective study conducted from September 2013 to October 2015. Total of 40 patients who fulfilled the inclusion and exclusion criteria were included in this study. Only one attempt of closed reduction under fluoroscope guidance was done in all the patients. The cases in which reduction was achieved closely were managed with CRPCP and were placed in group A while those cases in which closed reduction was unsuccessful were managed with ORIF via posterior approach and were placed in group B. The fractures were stabilized using cross pinning and was splinted postoperatively in long arm back-slab at 80° of flexion. Patients were followed up for 3 months. Functional assessment was done using Flynn criteria, and carrying angle (CA) for the cosmetic outcome. The time of union was used to assess the radiological outcome.

Results: Twenty-four patients were in group A and 16 patients were in group B. The average age of the patient in group A was 6.17 ± 1.09 years (range 4-8 years) while that in group B was 6.69 ± 1.08 years (range 5-10 years). Male to female ratio in both groups was 1.67. Average time to union was significantly better in group A than group B (5.71 ± 0.69 weeks vs 6.88 ± 0.62 weeks). There was no statistically significant difference in Baumann angle, carrying angle (CA) of affected limb and loss of range of motion (ROM) in both groups. In group A, 22 (92%) patients had excellent result while 2 (8%) patients had good result according to Flynn criteria. In group B, 14 (87.5%) patients had excellent result, 1 (6.25%) patient had good and fair result each. We had 3 cases of ulnar palsy in group A while no ulnar nerve injury was recorded in group B.

Conclusion: The functional outcome was comparable in both groups and thus we recommend low threshold to conversion to open reduction where closed reduction fails to reduce further damage to soft tissue in displaced supracondylar fracture of humerus in children. Earlier union was achieved with CRPCP than with ORIF.

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Key Words: Displaced supracondylar fracture, open reduction, percutaneous pinning, Flynn criteria, carrying angle, Baumann's angle

Introduction:

Supracondylar fracture of the humerus is the most common fractures around elbow in children. Displaced type of these fractures require surgical intervention.⁴ It constitutes approximately 3% of all the fractures. The peak age range at which most supracondylar fractures occur is 5 to 6 years.¹⁻³

It was mostly seen in boys but today the difference of incidence among gender are decreasing.⁴ According to modified Gartland classification⁸, extension type comprise 95% of supracondylar fracture in children.^{5,6} Associated neurovascular injuries are reported in between 5% and 30%.^{7,8}

Type III and type IV have an incidence of 16.7%.⁹⁻¹¹ The aim of treatment of supracondylar fracture of humerus in children is to achieve normal range of motion (ROM) of elbow along with a cosmetically acceptable upper limb.¹² Controversy in the literature regarding the definitive management of severely displaced supracondylar fractures still exists.¹¹ The main difference of opinion exists mainly in term of the treatment provided for the better outcome. The two main treatment option on which the controversy mainly exist is the treatment by either CRPCP¹¹⁻¹³ or ORIF with Kirschner wire (K-wire) under direct vision. The literature supports CRPCP with K-wire as the treatment of choice; however, different complications with CRPCP with K-wire fixation has been observed. The feared complications are neurovascular injury among 5 to 30% of the patient^{14,15}, skin problems, compartment syndrome, and cubitus varus in 60%.^{6,9,16}

Among all the cases of supracondylar fracture, requires open reduction. Various approaches has been described for open reduction.^{11,16,18} The aim of surgical approach used is to provide safe reduction, perfect anatomic alignment, adequate functional and cosmetic outcomes, along with minimal possible complications.¹¹

We aimed to evaluate the outcome of ORIF and compare it with CRPCP after failure to achieve reduction closely.

Methods:

This was a single center Quasi experimental study conducted in Department of Orthopaedic Surgery

and Traumatology, Unit-I of King Edward Medical University/Mayo Hospital, Lahore, Pakistan from September 2013 to October 2015. After ethical approval from institutional review board, all the patient presenting with displaced supracondylar fracture (Gartland type III and IV) within 10 days of injury to Accident and Emergency Department or Outpatient Department (OPD) with age less than 15 years of either gender were included in the study. All the patient with open fracture, neurovascular injury, compartment syndrome and fracture older than 10 days were excluded from this study. All patients underwent closed reduction (CR) under fluoroscopic control. Patient with successful closed reduction were managed with CRPCP and was labelled as group A. while those in whom closed reduction was unsuccessful, was managed with open reduction (OR) and internal fixation (IF) with K-wires and were labelled group B. Triceps sparing posterior approach was used in group B patients.¹⁹ Fractures in both groups were stabilized with crossed K-wires.

K-wire of stainless steel of 1.5- 2.0 mm were used.

Closed reduction was labelled as successful if there was intact medial and lateral columns on oblique views, and the anterior humeral line (AHL) was passing through the middle third of the capitulum on the lateral view.¹

Postoperatively, long arm back slab was applied in all the patient with elbow in 80° of flexion. The patients were followed up at 2nd week to look for loss of reduction, at 4th week when back slab was removed and range of motion of elbow was started. The patients were then followed-up every 4 weeks for 3 months until the union was achieved which was evident by disappearance of fracture line with callus formation on anteroposterior and lateral roentgenogram along with absence of tenderness on palpation. At this stage K-wires were removed.

The functional outcome of the treatment was assessed by using the Flynn criteria, and the cosmetic outcome by measuring the carrying angle. The time to union was used to assess the radiological outcome. Also Baumann angle and AHL were measured pre and post-operatively to check for maintenance of

reduction of fracture. Complications recorded were compartment syndrome, non-union, neurovascular injury, pin tract infection, loss of reduction and wound problem.

The outcome was analyzed using SPSS 20. The mean, standard deviation (SD) and P-value were calculated for quantitative data and percentage was calculated for qualitative data.

Results:

There were total 40 patients with 24 supracondylar fracture in group A who were managed with CRPCP and 16 patients in group B who were managed with ORIF with K-wire. The mean age of the patient in group A was 6.17 ± 1.09 years (range 4-8 years) while that in group B was 6.69 ± 1.08 years (range 5-10 years). There were total of 15 males and 9 females with male to female ratio of 1.67 in group A while 10 male and 6 females with male to female ratio of 1.67 in group B.

Six patients have left upper limb involvement while 18 has dominant limb involvement (right) in group A. There were 3 patients with left and 13 patients with right upper limb involvement in group B.

In group A, 17 patients were injured while playing at home, 3 while playing in play-ground, 3 following fall on outstretched hand at school while 1 patient sustained fracture after fall from bike. In group B, 9 patients were injured while playing at home, 2 while playing in play-ground, 3 at school and 2 following fall from bike.

Mean time to union, mean preoperative Baumann

angle, mean postoperative Baumann angle, mean carrying angle at the end of study, mean ROM at the end of the study and mean loss of ROM are summarized in table 2. Here p-value > 0.05 was considered statically insignificant.

Outcome of both the groups according to Flynn criteria is displayed in Table 3

There was statically significant improvement in postoperative Baumann angle in comparison to preoperative Baumann's angle with p-value less than 0.001 both in group A and B.

Interposition of soft-tissue was the main cause of failure of close reduction in all the cases with failed closed reduction. No case of interposition of neurovascular structure in fracture was observed.

We had 3 cases (12.5%) of ulnar nerve palsy in group A in which 2 recovered spontaneously at the end of one month while one at the end of 3 months. Two patients (8.33%) in this group had pin-tract infection which was managed with dressing and antibiotic according to culture and sensitivity. No case of ulnar palsy or pin-tract infection was seen in group B while it had 3 cases (18.75%) of superficial infection which was managed with dressing and antibiotic according to culture and sensitivity. We had over all complication rate of 21% in group A while 18.75% in group B. No case with loss of reduction, compartment syndrome, deep infection was seen.

Table 1: Variable Assessment at each follow-up

Sr.	Variables	Follow-up				
		2 nd week	4 th week	6 th week	8 th week	12 th week
1.	Loss of reduction (Bauman Angle and AHL)	No	No	No	No	No
2.	Union	No	No	Yes	Yes	Yes
3.	ROM	NA	Started	Continued	Continued	Measured
4.	Carrying angle	Normal	Normal	Normal	Normal	Normal
5.	Flynn Criteria	NA	NA	NA	NA	Evaluated

Table 2: Summary of outcome of the study

Variables	CRPCP	ORIF+ K-wire	p-Value
Mean Time to union	5.71± 0.69 weeks (range 5-7 weeks)	6.88±0.62 weeks (range 6-8 weeks)	< 0.0001
Mean Preoperative Baumann angle	7.83°± 0.87 (range 6°-9°)	7.88°± 0.89 (range 6°-9°)	> 0.05
Mean Postoperative Baumann angle	13.33°± 1.63 (range 10°-16°)	13.13°± 1.89 (range 10°-16°)	0.72
Mean Carrying angle at the end of study	7.29°± 0.95 (range 6°-9°)	7.69°±1.08 (range 6-10)	0.22
Mean ROM at the end of the study	137.50°±4.89 (range 130°-145°)	136.56°± 6.76 (range 120°-145°)	0.61
Mean Loss of ROM	3.96°±2.55 (range 0°-10°)	4.69°±3.86 (range 0°-15°)	0.47

Table 3: Outcome according to Flynn Criteria in both group

Group	Excellent	Good	Flynn Criteria Fair	Poor	P-value
CRPCP	22 (92%)	2 (8%)	0	0	< 0.001
ORIF + K-wire	14 (87.5%)	1 (6.25%)	1 (6.25%)	0	

Discussion:

The main goal of treating severely displaced supracondylar fracture of humerus is to achieve a functionally and cosmetically satisfactory upper extremity, without any deformity or residual neurovascular insufficiency. Although CRPCP has been labelled as the primary treatment in the management of displaced supracondylar humerus fracture^{17, 20}. This procedure requires experience and has risk of neurovascular compromise or non-anatomical reduction. The main indication of open reduction in majority of these fractures is inability to reduce the fracture closely. Failed closed reduction may be secondary to unstable fracture pattern and / or soft tissue interposition in the fracture leading to failure of closed reduction.²¹ Conversion rate from CRPCP to ORIF with K-wire ranges from 3 to 46%.^{11,22}

In our study, we found that statistically significant more time for union was required in group managed with open reduction than in those managed with closed reduction and percutaneous pinning (6.88 weeks vs 5.71 week with P value < 0.0001). Early union achieved with CRPCP than with ORIF was due to preservation of fracture hematoma and conser-

vation of soft tissue attachment of bone in group A. Reduction in ROM in our study was however not significant between two groups (P = 0.47). The cosmetic value (CA) was also same in both group. Baumann angle were also comparable in both groups (P = 0.72). We had 92% excellent result in group A and 87.5% excellent in group B patients that was statistically non-significant (P > 0.05)

In a study by Naseer et al, where 48 patients were included in the study for open reduction and internal fixation after failed closed reduction were evaluated using Flynn's criteria. They managed this case using lateral approach. They had 30 from 33 patients (90.09%) with excellent result, 2 patients (6.1%) with good and one case (3%) with fair cosmetic results on Flynn's criteria. They observed 31 patients (93.9%) with excellent and 2 patients (6.1%) with good functional result at the completion of follow-up.⁽²³⁾ The results in this study was slightly better than our result in group B based on functional outcome on Flynn's criteria.

Holgado et al in their study of open reduction and internal fixation after failed closed reduction of

supracondylar fractures of humerus in children observed satisfactory functional and cosmetic results according to Flynn's criteria in 85.5% of cases.²⁴ These results were comparable to our group B result.

Hussain et al in a study in 2012 involving 42 children with displaced supracondylar fractures of humerus and managing them using open reduction and internal fixation via medial approach found 88.09% with satisfactory result as per Flynn's criteria.²⁵ Our results were comparable in group B with 87.5% having excellent result, 6.25% having good result and 6.25% having fair result.

Keskin et al in their comparative study of open versus closed reduction and internal fixation of displaced supracondylar humerus fracture observed 96% of excellent or good cosmetic result and 94% and 90% excellent or good functional result in CRPCP and ORIF group respectively according to Flynn's criteria. These results were comparable to our result with 100% excellent and good result and 93.75% excellent and good result according to Flynn's criteria in CRPCP and ORIF group respectively.

Though no significant difference was found between closed reduction and percutaneous pinning when compared with open reduction, the time to union is significantly less in CRPCP.

Short follow-up was the main drawback of this study.

Conclusion:

The functional outcome was comparable in both group and thus we recommend low threshold to conversion to open reduction where closed reduction fails to reduce further damage to soft tissue in displaced supracondylar fracture of humerus in children. Earlier union was achieved with CRPCP than with ORIF.

Ethical Approval: Given

Conflict of Interest: The authors declare no conflict of interest

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References:

1. Flynn JM. Supracondylar Fractures of the Distal Humerus. In: Flynn JM, editor. Rockwood and

2. Wilkins' Fractures in Children. Eight ed. Philadelphia: Wolters Kluwer Health; 2015. p. 581-628.
2. Abzug JM, Herman MJ. Management of supracondylar humerus fractures in children: current concepts. *Journal of the American Academy of Orthopaedic Surgeons*. 2012;20(2):69-77.
3. Cheng JC, Lam TP, Maffulli N. Epidemiological features of supracondylar fractures of the humerus in Chinese children. *Journal of Pediatric Orthopaedics B*. 2001;10(1):63-7.
4. Omid R, Choi PD, Skaggs DL. Supracondylar humeral fractures in children. *J Bone Joint Surg Am*. 2008;90(5):1121-32.
5. Barlas K, George B, Hashmi F, Bagga T. Open medial placement of Kirschner wires for supracondylar humeral fractures in children. *Journal of Orthopaedic Surgery*. 2006;14(1):53.
6. Chen R, Liu C, Lin X, Feng X, Zhu J, Ye F. Supracondylar extension fracture of the humerus in children MANIPULATIVE REDUCTION, IMMOBILISATION AND FIXATION USING A U-SHAPED PLASTER SLAB WITH THE ELBOW IN FULL EXTENSION. *Journal of Bone & Joint Surgery, British Volume*. 2001;83(6):883-7.
7. Mangwani J, Nadarajah R, Paterson J. Supracondylar humeral fractures in children TEN YEARS' EXPERIENCE IN A TEACHING HOSPITAL. *Journal of Bone & Joint Surgery, British Volume*. 2006;88(3):362-5.
8. Campbell CC, Waters PM, Emans JB, Kasser JR, Millis MB. Neurovascular injury and displacement in type III supracondylar humerus fractures. *Journal of Pediatric Orthopaedics*. 1995;15(1):47-52.
9. Sadiq M, Syed T, Travlos J. Management of grade III supracondylar fracture of the humerus by straight-arm lateral traction. *International orthopaedics*. 2007;31(2):155-8.
10. Houshian S, Mehdi B, Larsen MS. The epidemiology of elbow fracture in children: analysis of 355 fractures, with special reference to supracondylar humerus fractures. *Journal of orthopaedic science*. 2001;6(4):312-5.
11. Mazzini JP, Martin JR, Esteban EMA. Surgical approaches for open reduction and pinning in severely displaced supracondylar humerus fractures in children: a systematic review. *Journal of children's orthopaedics*. 2010;4(2):143-52.
12. O'hara L, Barlow J, Clarke NM. Displaced supracondylar fractures of the humerus in children AUDIT CHANGES PRACTICE. *Journal of Bone*

- & Joint Surgery, British Volume. 2000;82(2):204-10.
13. Kazimoglu C, Çetin M, ?ener M, Agu? H, Kalandarer Ö. Operative management of type III extension supracondylar fractures in children. *International orthopaedics*. 2009;33(4):1089-94.
 14. Reitman RD, Waters P, Millis M. Open reduction and internal fixation for supracondylar humerus fractures in children. *Journal of Pediatric Orthopaedics*. 2001;21(2):157-61.
 15. Schoenecker PL, Delgado E, Rotman M, Sicard GA, Capelli AM. Pulseless arm in association with totally displaced supracondylar fracture. *Journal of orthopaedic trauma*. 1996;10(6):410-5.
 16. Ababneh M, Shannak A, Agabi S, Hadidi S. The treatment of displaced supracondylar fractures of the humerus in children. *International orthopaedics*. 1998;22(4):263-5.
 17. Pirone A, Graham H, Krajbich JI. Management of displaced extension-type supracondylar fractures of the humerus in children. *J Bone Joint Surg Am*. 1988;70(5):641-50.
 18. Rasool M, Naidoo K. Supracondylar fractures: posterolateral type with brachialis muscle penetration and neurovascular injury. *Journal of Pediatric Orthopaedics*. 1999;19(4):518-22.
 19. Rizk AS. Triceps-sparing approach for open reduction and internal fixation of neglected displaced supracondylar and distal humeral fractures in children. *Journal of Orthopaedics and Traumatology*. 2015;16(2):105-16.
 20. Kurer M, Regan M. Completely Displaced Supracondylar Fracture of the Humerus in Children: A Review of 1708 Comparable Cases. *Clinical orthopaedics and related research*. 1990;256:205-14.
 21. Oh C-W, Park B-C, Kim P-T, Park I-H, Kyung H-S, Ihn J-C. Completely displaced supracondylar humerus fractures in children: results of open reduction versus closed reduction. *Journal of orthopaedic science*. 2003;8(2):137-41.
 22. Gupta N, Kay RM, Leitch K, Femino JD, Tolo VT, Skaggs DL. Effect of surgical delay on perioperative complications and need for open reduction in supracondylar humerus fractures in children. *Journal of Pediatric Orthopaedics*. 2004;24(3):245-8.
 23. Sarrafan N, Nasab SAM, Ghalami T. Treatment of displaced supracondylar fracture of the humerus in children by open pinning from lateral approach: An investigation of clinical and radiographical results. *Pakistan journal of medical sciences*. 2015;31(4):930.
 24. Holgado ME, Tomé-Bermejo F, Ruiz MN. Open reduction and internal fixation of supracondylar fractures of the humerus in children. Analysis of results at ten-year of follow-up. *Revista espanola de cirugia ortopedica y traumatologia*. 2012;56(5):361-8.
 25. Hussain S, Dhar S, Qayoom A. Open Reduction and Internal Fixation of displaced Supracondylar Fractures of Humerus with Crossed K-wires via Medial Approach. *Malaysian Orthopaedic Journal*. 2014;8(2):29.