

The Prognostic Value of the Fracture Level in the Treatment of Displaced Supracondylar Humeral Fractures in Children

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ABSTRACT

Background

Supracondylar fractures are subclassified as high and low type depending on whether they are above or below the isthmus of the distal humerus and it play an important role in determining outcome.

Objective

To compare the clinical and radiological outcomes of patients with fractures above and below the distal humeral isthmus treated with closed reduction and percutaneous pinning.

Method

This is a prospective non-randomized analytical study of 40 patients with displaced extension type supracondylar fracture of distal humerus treated by closed reduction and percutaneous pinning. Radiological and functional outcomes was followed up to 6 months postoperatively. The significance of differences between means (baumann angle, carrying angle and time to recovery) were calculated using the independent t-test.

Result

Twenty-four (60%) patients were high type and 16 (40%) patients were low type. According to Flynn grading, there was no statistical significance between the high type and low type ($p = 0.601$). The time to recovery for the high type was 15.58 ± 2.95 weeks and for low type was 18.75 ± 2.18 weeks. Hence, the time to recovery for the low type was longer than high type and it was statistically significant ($p = 0.001$).

Conclusion

Low type supracondylar fractures require a longer period for the gain of elbow range of motion. However, in long term the prognosis of low type is comparable with that of high type fracture. Hence, the prognostic value of fracture level in the treatment of displaced supracondylar fractures is not statistically significant.

KEY WORDS

Flynn's grading, Fracture level, Supracondylar humeral fracture

INTRODUCTION

Closed reduction and pin fixation is generally accepted as the treatment modality of choice for displaced supracondylar fractures.¹ The aim of the treatment of paediatric supracondylar humeral fractures (SCHFs) is to achieve an upper extremity with acceptable cosmetic and functional traits, showing a normal range of motion.²⁻⁴

Although all displaced supracondylar fractures are managed with the same standard technique of closed reduction and percutaneous pinning; some of the patients gain range of motion quickly whereas some children take a prolong time.^{5,6} Studies report that the patient's age and severity of the fracture; identified by the Gartland type, have prognostic value in predicting the final range of motion (ROM) of the elbow. However, these studies do not discriminate between conservative and operative management.^{5,7}

As practically all displaced fractures are managed surgically a more detailed sub classification system is needed to study prognostic indicators for clinical outcomes. Hence supracondylar fractures are subclassified as high and low type depending on whether they are above or below the isthmus of the distal humerus.⁸ Low fracture type was found to be independently associated with the poor prognosis for the restoration of elbow movement. The juxta-articular nature of the low fracture type means more injury to the surrounding tissues such as joint capsules and ligaments. This is recognized as an important cause of joint stiffness.⁸ There are few studies that studies fracture level as the prognostic variable in the treatment of supracondylar humeral fractures. Hence, the purpose of this study was to evaluate the prognostic significance of fracture level in closed reduction and percutaneous pinning in displaced supracondylar fracture of humerus in our population.

METHODS

This was a non-randomized, prospective and analytical study undertaken at Tribhuvan University Teaching Hospital (TUTH), Kathmandu from September 2017 to August 2018. Children with displaced extension type supracondylar fractures of distal humerus presenting to emergency room and orthopaedics OPD who could meet the inclusion criteria were taken up for study. Forty such patients were included in the study. Ethical clearance was taken from the institutional review board of TUTH. All the enrolled cases were explained about the treatment and follow up and a written consent was taken.

Children from 1-15 years of age with Gartland type II and III supracondylar fractures with posterior displacement were included in the study. Gartland type I supracondylar fractures, flexion type injuries, open fractures, patients who required open reduction, compartment syndrome and patients lost to follow up were excluded from the study.

All patient underwent closed reduction and percutaneous pinning under c-arm control by author's team. After surgery, the elbow joint was immobilized in neutral rotation and 60°-90° flexion with above elbow plaster of Paris slab. All patients were routinely seen at post-operative weeks one, four, six, and ten. At first week; wound inspection, dressing and check X-ray was done to see any displacement. Loss of reduction was defined as: the change of > 10° of the Baumann angle or, the change of the anterior humeral line during follow-up.^{9,10} At four weeks, slab was taken out and then the patient was sent for check X-ray. The K-wires were removed in the orthopaedics OPD or operating room after the reassurance of clinical and radiological sign of fracture union. Following pin removal; active movement of the elbow was encouraged. Check x-ray was again done on tenth post-operative week to see radiological outcome. If the patient had any functional deficit or limitation of movement at the tenth post-operative week, we continued to review the patient at intervals of four weeks till six months. The passive, painless range of elbow movement was measured with a goniometer at each visit from two weeks after removal of the cast. Restoration of full elbow ROM was defined as greater than (1) 10° of hyperextension and 140° of further flexion or elbow flexion/extension to within 5° of the range displayed by the uninjured elbow, and (2) forearm rotation over 160°.^{5,6}

The data obtained was filled in the master chart created using MS excel 2016. Statistical analysis was carried out using the Statistical Package for Social Sciences (SPSS) version 25 with the help of a statistician. The significance of differences between means (baumann angle, carrying angle and time to recovery) were calculated using the independent t-test. The significance of differences between frequencies (age group, gender, injured side and Flynn grade) were calculated using fisher exact test. P value < 0.05 was regarded as significant.

RESULTS

During the study period 49 displaced supracondylar fractures were encountered, of which 4 patients required open reduction so were excluded from the study. Five patients were lost during the follow up. Hence, 40 patients were enrolled in the study. Twenty-four patients (60%) were of high type and 16 patients (40%) were low type. The demographic details of the participants are mentioned in Table 1. High and low type fractures were both more common in age between 5-10 years (67.5%). Majority of fractures were type III (80%) with 65% male and involving left limb in 52.5%. Twenty-six patients (65%) had excellent outcome according to Flynn grade of which 17 patients (65.38%) had high type fracture. Similarly, 11 patients (27.5%) had good outcome of which 6 patients (54.55%) had high type. Only 3 patients (7.5%) had fair outcome of which 2 patients (66.67%) were low type.

Table 1. The demographics and clinical outcomes of the cohort. Number with percentage as appropriate

Type of fracture	Total (n=40)	High	Low	P value
High	24(60)			
Low	16(40)			
Age (yrs)				0.791
< 5	4(10)	2(50)	2(50)	
≥ 5, < 10	27(67.5)	17(62.96)	10(37.04)	
≥ 10	9(22.5)	5(55.56)	4(44.44)	
Gender				0.685
Male	26(65)	15(57.5)	11(42.3)	
Female	14(35)	9(64.29)	5(35.71)	
Gartland type				0.294
Type II	8(20)	3(37.5)	5(62.5)	
Type III	32(80)	21(65.62)	11(34.38)	
Injured arm				0.366
Right	19(47.5)	10(52.63)	9(47.37)	
Left	21(52.5)	14(66.67)	7(33.33)	
Flynn grade				0.601
Excellent	26(65)	17(65.38)	9(34.62)	
Good	11(27.5)	6(54.55)	5(45.45)	
Fair	3(7.5)	1(33.33)	2(66.67)	
Poor	0(0)	0(0)	0(0)	

There was no statistically significant difference in the Baumann angle between contralateral elbow and injured elbow at 10th post-operative week between high and low type fractures. (p=0.327) (Table 2) Similarly, there was no statistically significant difference in carrying angle between the contralateral elbow and uninjured elbow at last follow up (p=0.619) (Table 3).

Table 2. Baumann angle and type of fracture

Baumann angle	High type (n=24) mean (SD)	Low type (n=16) mean (SD)	p-value
Contralateral	74.46 (7.55)	72.00 (7.48)	0.318
Postoperative (affected)	81.08 (5.90)	80.19 (6.09)	0.645
Mean increase in Baumann angle	6.62	8.19	0.327

Table 3. Carrying angle and type of fracture

Baumann angle	High type (n=24) mean (SD)	Low type (n=16) mean (SD)	p-value
Contralateral	8.46 (3.16)	9.25 (3.49)	0.461
Postoperative (affected)	3.83 (2.63)	4.00 (4.16)	0.877
Mean loss of carrying angle	4.63	5.25	0.619

The mean time to recovery of the full range of elbow movement for the high type fracture was 15.58 weeks (14-26 weeks) and for low type fracture was 18.75 weeks (14-22 weeks). (Table 4) Four patients in low type required 22

weeks to gain full range of motion whereas one patient in high type required 26 weeks to gain full range of motion.

Table 4. Time to recovery and type of fracture

Type of fracture	Number	Mean time to recovery (range)	SD	p-value
High	24	15.58 weeks (14-26)	2.95	0.001
Low	16	18.75 weeks (14-22)	2.18	

DISCUSSION

Most of the patients with supracondylar fractures treated with closed reduction and percutaneous pinning show excellent outcome. However, there is poor outcome in some patients.^{5,6} In 2015, study by Kang et al. showed the level of fracture has prognostic value in the treatment of type III supracondylar fractures.⁸ Hence, we did this study in our population to assess the significance of fracture level in the treatment of displaced supracondylar fractures in our population.

There were altogether 40 patients enrolled in our study. Twenty four (60%) patients were of high type and 16 (40%) were low type. The mean age in high type was 7 years and in low type was 7.18 years. In the study by Kang et al. in 230 Korean children the mean age was 6 ± 2.6 years. The mean age for high type was 5.9 ± 2.3 years and for low type was 6.6 ± 3.9 years.⁸ Similarly, Abott et al. studied 297 children from 2004 to 2011 with closed type III supracondylar fractures in USA where the mean age was 5.8 ± 2.2 years.¹¹ Garg et al. in the University of Colorado from 2004 to 2007, studied 1296 children with displaced SCHFs with an average age of 5.45 years.¹² Schmid et al. in Inselspital University of Bern, Switzerland retrospectively reviewed 343 displaced supracondylar humeral fractures who underwent surgery between 2000 and 2009. The average age was 6.3 ± 2.4 years.¹³ Hence, in most studies the average age of the child is from 5-10 years which is similar to our study (67.5%).

In our study, 26 out of 40 patients (65%) were male patients of which 15 patients (57.70%) had high type fracture and 11 patients (42.30%) had low type fractures. Similarly, 14 patients (35%) were female of which 9 patients (64.29%) had high type and 5 patients (35.71%) had low type fracture. Similarly, in the study by Kang et al. 144 out of 230 patients (62.6%) were male of which 122 patients (84.72%) had high type fracture and 22 patients (15.28%) had low type fractures.⁸ Eighty six patients (37.4%) were female of which 76 patients (88.37%) had high type and 10 patients (11.63%) had low type fractures.⁸ It is similar to our study, where there was male predominance in both high and low type fracture, however it was not statistically significant.

In the study by Spencer et al. 216 patients (57.60%) of 375 patients were male and 159 patients (42.40%) were female.⁵ In the study by Garg et al. 476 patients (54.59%)

of 872 were male and 396 patients (45.41%) were female.¹² Schmid et al. in his study found 194 patients (56.56%) of 343 were male and 149 patients (43.44%) were female.¹³

Thus, in most studies male patients are more susceptible to supracondylar fractures which is also found in our study. This reflects that boys are more active and engage more in outdoor activities, thus resulting in higher incidence of supracondylar fractures.¹⁴

In our study 21 out of 40 patients (52.50%) had left side and 19 patients (47.50%) had right side involvement. In the study by Kang et al. 146 patients (63.5%) of 230 patients had left side involvement and in the study done in Turkish people by Ozkoc et al. 73.73% of 99 patients had left sided involvement.^{8,15} Left limb predominance may be due to comparatively weak musculature in the non-dominant hand or because of its use as a defensive action when falling with outstretched hand.¹⁶

In our study 32 out of 40 patients (80%) had type III supracondylar fracture of which 21 (65.62%) had high type and 11 patients (34.38%) had low type of fractures. Similarly, 8 patients (20%) had type II supracondylar fracture of which 3 patients (37.50%) had high type and 5 patients (62.50%) had low type fracture. In the study by Schmid et al. 144 patients (41.98%) of 343 had type II supracondylar fractures and 199 patients (58.02%) had type III supracondylar fractures.¹³

In our study, the mean Baumann angle in the contralateral elbow in the high and low fracture type was $74.46^{\circ} \pm 7.55$ and $72^{\circ} \pm 7.48$ respectively. Similarly, the mean Baumann angle at 10th postoperative week was $81.08^{\circ} \pm 5.90$ and $80.19^{\circ} \pm 6.09$ in the high and low fracture type respectively. Therefore, the increase in Baumann angle for high type fracture was 6.62° and for low type fracture was 8.19° . In the study of Kang et al. the mean Baumann angle in the contralateral elbow in the high and low fracture type was $71.80^{\circ} \pm 6.7$ and $73.6^{\circ} \pm 7.7$ respectively.⁸ Similarly, the mean Baumann angle at 10th postoperative week was $76.2^{\circ} \pm 6.3$ and $80.0^{\circ} \pm 8.5$ in the high and low fracture type respectively. Therefore, the increase in Baumann angle for high type fracture was $4.4^{\circ} \pm 6.5$ and for low type fracture was $6.4^{\circ} \pm 6.4$.⁸ The greater increase in Baumann angle in low type fracture may be due to unstable fixation of the small distal fragment risking the loss of reduction.

Similarly, in our study the mean carrying angle in the contralateral elbow in the high and low fracture type was $8.46^{\circ} \pm 3.16$ and $9.25^{\circ} \pm 3.49$ respectively. Similarly, the mean carrying angle at last follow up was $3.83^{\circ} \pm 2.63$ and $4.00^{\circ} \pm 4.16$ in the high and low fracture type respectively. Therefore, the loss of carrying angle for high type fracture was 4.63° and for low type fracture was 5.25° . In Kang et al. study the mean carrying angle in the contralateral elbow in the high and low fracture type was $12.0^{\circ} \pm 4.4$ and $11.0^{\circ} \pm 5.6$ respectively.⁸ Similarly, the mean carrying angle at last

follow up was $9.3^{\circ} \pm 5.5$ and $9.6^{\circ} \pm 6.4$ in the high and low fracture type respectively. Therefore, the loss of carrying angle for high type fracture was $2.7^{\circ} \pm 5.4$ and for low type fracture was $1.5^{\circ} \pm 7.1$. However, there was no statistically significant difference in fracture type and loss of carrying angle.⁸

Twenty-six patients of 40 (65%) had excellent outcome according to Flynn grade of which 17 patients (65.38%) had high type fracture and 9 patients (34.62%) had low type fracture. Similarly, 11 patients (27.5%) had good outcome of which 6 patients (54.55%) had high type and 5 patients (45.45%) had low type fracture. Only 3 patients (7.5%) had fair outcome of which 1 patient (33.33%) was high type and 2 other patients (66.67%) were low type. In the study by Kang et al. 153 patients (66.5%) had excellent outcome of which 135 patients (88.24%) had high type fracture and 18 patients (11.76%) had low type fracture.⁸ Similarly, 62 patients (27%) had good outcome of which 54 patients (87.10%) had high type and 8 patients (12.90%) had low type fracture. Twelve patients (5.2%) had fair outcome of which 9 patients (75%) was high type and 3 patients (25%) were low type. Only 3 patients (1.3%) had poor outcome and all of them were of low type fracture.⁸

Hence, it is seen that low fracture type is associated more with the poorer prognosis in terms of Flynn grade. However, this finding is not statistically significant in our study. The most likely explanation for the poorer outcome in low fracture types is the small distal fragment. This makes accurate closed reduction difficult. The small fragment also predisposes the fixation to be dynamically unstable, risking loss of reduction in the low fracture type group.

In our study the mean time to recovery of the full range of elbow movement for the high type fracture was 15.58 ± 2.95 weeks and for low type fracture was 18.75 ± 2.18 weeks. In the study by Kang et al. mean time to recovery of the full range of elbow movement for the high type fracture was 16.1 ± 10 weeks and for low type fracture was 25.7 ± 12.2 weeks.⁸ Both these studies show that the time to recovery for the low type fracture was longer than for high type fracture and it was statistically significant.

The juxta-articular nature of the low fracture types means surrounding tissues such as joint capsules and ligaments are more likely to be injured which is recognized as an important cause of joint stiffness.

This study was done in a single center so the sample size was small. Similarly, two groups had unequal number of participants making their comparison difficult. The principal investigator was unblinded so it could have led to observer bias. Hence, a large multicentric study with comparable number of participants in each group may yield results that is applicable to larger population.

CONCLUSION

Low type supracondylar fractures require a longer period for the gain of elbow range of motion. However, in long term the prognosis of low type is comparable with that of

high type fracture because all patients eventually attained full range of motion within 6 months. Hence, the prognostic value of fracture level in the treatment of displaced supracondylar fractures is not statistically significant.

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