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Treatment of Type III Supracondylar Fracture of Humerus in Children with or without Neurovascular Impairment

—The Most Anatomical Approach—

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Abstract **Purpose** : To review the treatment of paediatric type III (Gartland) supracondylar fracture of humerus in one centre. To study the risk factors for open reduction and the outcome of cases with neurovascular deficit.

Methods : This is a retrospective study of 351 cases of paediatric supracondylar fracture with age ranging from 2 to 15 years old in one hospital between 1998 and 2002. Out of the 124 cases with Gartland's Type III fracture treated operatively, 104 cases were available for detail analysis by a single observer clinically and radiographically.

Results : Overall, excellent and good result (using Flynn's criteria of assessment) was achieved in 96% of the cases treated primarily with close reduction and percutaneous pinning. In 16 (15.4%) cases, conversion to open reduction was necessary with the observed associated risk factors : marked soft tissue swelling and skin bruising clinically ; significant overlapping of the fracture fragments, presence of sharp bone spike and translation/rotation of the distal fragment radiologically. The best surgical approach for open reduction was found to be from the opposite side of the fracture displacement either medially or laterally. 20 (16.4%) cases had neurovascular deficit on presentation, all of which recovered fully without any surgical explora tion in 4 to 12 (median 8) weeks' post op period.

Conclusions : The current study has reaffirmed the high success rate of close reduction and percutaneous pinning in the treatment of paediatric Type III supracondylar fracture of humerus. The clinical, radiological risk factors for open reduction and the recommended approach were presented. Routine exploration of the neurovascular bundle is not necessary following the early anatomical reduction and stabilization of the fracture.

Introduction

Supracondylar fracture is the second most common fracture in paediatric age group according to a local study on near 7000 children fractures in 1995. With the increasingly good result in the treatment of type III supracondylar extension fracture of humerus in children by close reduction and percutaneous pinning, there is a need to redefine the indications of open reduction and fixation. What approaches should be used in open reduction if indicated, medial, lateral, combined medial and lateral, posterior and anterior ? In the current study, we

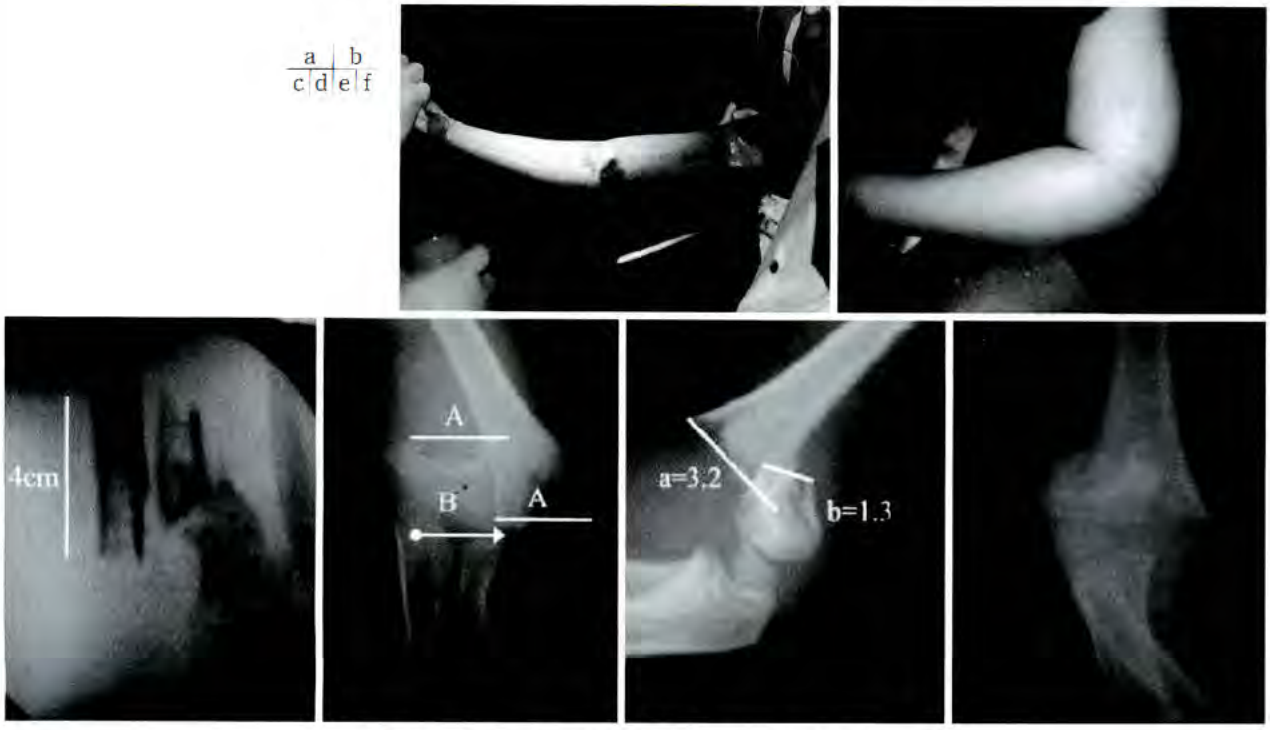

Fig. 1. The six risk factors for open reduction
a : Skin bruises
b : Significant swelling
c : Overapping > 2 cm
d : Translation (A/B > 50%)
e : Assessment of rotation (width differences at fracture ends > 100%)
f : Sharp bone spike

conducted a retrospective study of all patients with Type III supracondylar fractures of humerus in children in one centre over a 5 years period. The pattern and severity of fracture displacement was correlated with the open reduction rates, the risk factors for open reduction and internal fixation and the association with neurovascular deficit and outcome would be analyzed. The most anatomical surgical approach will also be studied.

Materials and Methods

This is a retrospective study of 351 cases of supracondylar fractures of humerus were admitted to Paediatric Orthopaedic ward from January 1998 to December 2002. One hundred and four of them were classified as Gartland's Type III extension type supracondylar fracture and were treated operatively. Complete clinical notes and old radiological films of 113 cases were available for detail analysis.

Preoperative clinical examinations on the following aspects were noted : limbs deformity, skin condition, neurological examination, distal limb circulation by means of presence of radial pulse. Admission radiographs were studied, and distance of overlapping of the fracture fragments, presence of bone spike and translation/rotation of the distal fragment was documented. Cases that necessitate surgical intervention were done under emergency operation and general anesthesia. The close reduction was done with the patient in supine position and injured arm abducted and fixed to a small arm

Table 1. Patient with neurovascular deficits

	No. of patients
Median N.	4 (25%)
PIN	1(6%)
Radial N.	3 (19%)
AIN	6 (38%)
Absence of radial pulse	5 (31%)
Both neurological and vascular deficit	3 (19%) (2 Med. N and 1 AIN)

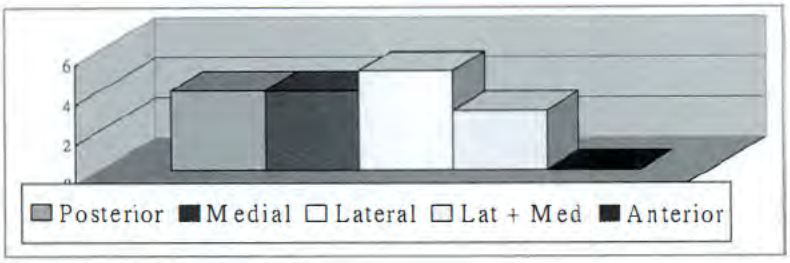

Fig. 2.
Different approaches in our 16 cases of open reduction.

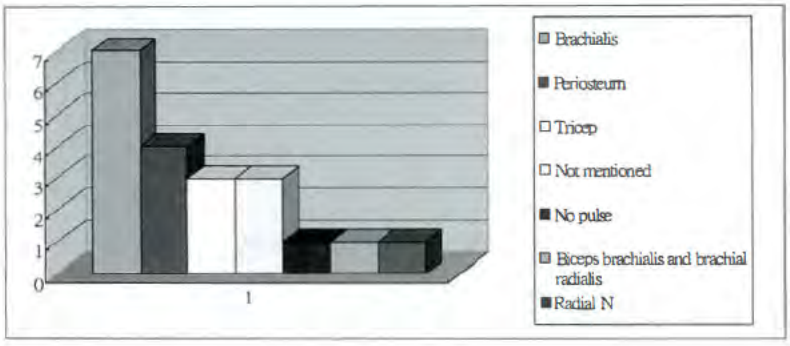

Fig. 3.
Intra operative findings

board by bandaging. Reduction was assessed under x-ray intensifier in anteroposterior and lateral view. Once the satisfactory reduction was achieved, two lateral parallel or cross 1.6 mm K-wires were inserted percutaneously. Long arm casting was then applied with elbow in 90 degrees flexion and forearm in neutral position. For cases failing closed reduction, open reduction with different approaches had been adopted.

Neurovascular status of injured hand was reassessed before discharge. All the patients were followed up regularly for up to 4 years postoperatively. X-ray distal humerus AP and lateral were taken at 1 and 4 weeks post-operatively and then regularly during subsequent follow up. The cast and K wires were removed during the forth to sixth weeks in the clinic. Patient's elbow function was assessed on each visit using Flynn's criteria

We proposed 6 predicting factors for open reduction and internal fixation including clinically : significant soft tissue swelling, skin bruises. And radiologically : overlapping of the fracture fragments more than 2 cm, presence of sharp bone spike, more than fifty percent of translation and significant rotation evidenced by 2 times difference in appearance length at the fracture ends. The presences of these 6 risk factors in close reduction group were compared with those in open reduction group (Fig. 1)

Operative findings and approaches in open

Table 2. Flynn criteria of assessment

	Loss in carrying angle (degrees)	Loss in elbow motion (degrees)	Number of patient in the series(%)
Excellent	0-5	0-5	62 59.6%
Good	6-10	6-10	38 36.5%
Fair	11 15	11-15	4 3.8%
Poor	>15	>15	0 0%

reduction cases were documented.

Results

For the 104 operated cases, there were 69 boys and 35 girls with age ranging from 2 to 15 years old. All the demographic data and data on timing of emergency operation, operation time, approaches, hospital stay, related complications, follow up period were analyzed by a single observer, N. Y. H. twenty cases with neurovascular deficit and the 16 cases who had open reduction were invited back for detailed outcome assessment.

The ages of the children were between 2 to 15 years old with a mean age of 6.6 years old. Twenty of the 104 cases had neurovascular deficit. Two open fractures and 6 co-injuries of fracture forearms. There were 5 cases with anterior interosseous nerve (AIN) palsy, 3 cases with median nerve palsy, 4 cases with radial nerve palsy and 3 PIN palsy cases. Five cases absented radial pulse pre-operatively (Table 1). Three AIN palsy cases were recorded as complication after prolonged manipulation. We had to convert to open reduction in 16 cases. Only one open reduction was done because of absence of radial pulse after gentle close reduction. Intra-operative Doppler was used to detect the radial pulse. The radial pulse was absence even after exploration. However it spontaneously returned on day one post-op. All other cases with neurovascular deficits recovered completely within 4 to 12 weeks post-op period.

The emergency operations were done within 1 hour to 26 hours after patient's admission, with a mean of 6 hours. The mean general anaesthesia time for a standard close reduction and percutaneous K-wire fixation was 53 minutes. For cases that necessitate open reduction the mean general anaesthesia time was 136 minutes. Three cases of post-operative anterior interosseous nerve palsy and one superficial wound infection were recorded. On average patients stayed in hospital for 3 days. Our patients were followed up in out patient clinic for 2 to 54 months with a mean of 9 months. We do not have any case of cubital varus deformity or myositis ossificans at the time of latest follow up.

In the open reduction group, different approaches had been adopted according to surgeon's preference (Fig. 2). There were 4 posterior approaches, 4 medial approaches, 5 lateral approaches and 3 combined medial and lateral approaches. The most frequent obstacles to reduction was brachialis, followed by periosteum, triceps etc (Fig. 3).

Using Flynn's criteria of elbow assessment for outcome, 62 of our cases achieved excellent result, another 38 achieved good result. There were 4 fair results. No poor result recorded. (Table 2)

In the close reduction group, patients had 2.53 risk factors and in open reduction group, patient had 4.06 risk factors on average. If we take 4 risk factors as the critical number, then, there were 11 out of 16 (68.75%) patients had 4

Table 3. Presences of risk factors in different groups

	Close reduction		Open reduction	
Significant swelling	66/88	75%	16/16	100%
Bruises	12/88	14%	7/16	44%
Translation>50%	24/88	27%	8/16	50%
Rotation a : b>2 1	29/88	33%	6/16	38%
Overlapping>2 cm	34/88	29%	13/16	81%
Sharp bone spike	24/88	26%	5/16	31%

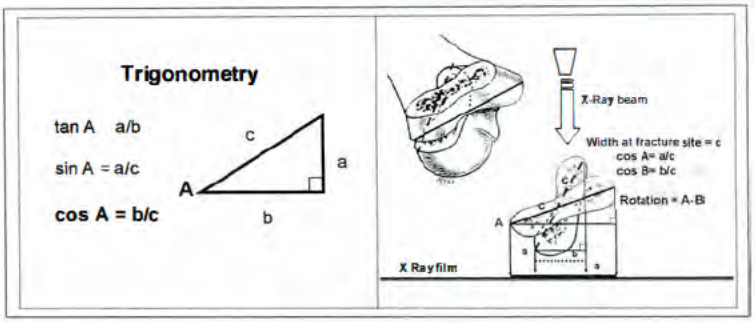

Fig. 4.
Tilting of each fragment can be calculated using the cosine rule.

or more risk factors. The percentage of patients with 4 or more risk factors in close reduction group was 24/88(27.3%) which is much less than the open reduction group(Table 3).

Discussion

Using Flynn's assessment, the overall results of this study on type III supracondylar extension fracture of humerus in children were good. Complications like cubitus varus deformity, myositis ossificans and Volkman's contracture were not seen. The open reduction rate of 15.5% is comparable with other major reported series.

The 6 risk factors utilized in the current study : significant swelling, bruises, overlapping for the 2 cm, translation more than fifty percent, sharp bone spike and significant rotation provide useful documentation of the severity of fracture displacement and predicts the probability of requiring open reduction. In this study, significant swelling means in comparison with the circumference of contralateral arm. Skin bruise indicates soft tissue penetrative damage, tissue blockage at the fracture ends, which will make close reduction difficult. Translation, overlapping and sharp bone spike are easy to understand. The degree of rotational deformity is based on two assumptions : first, x-ray beam is linear, second, identical bone size of both upper limbs. What we have on the x-ray film is the apparent width of the bone fragments. The shorter the apparent bone fragment the greater is the tilting. The greater the difference in apparent width the larger is the rotation. Using the cosine rule of trigonometry, we can calculate the angle tilting of the fracture ends. The rotation is the difference between these two angles(Fig. 4). The average number of risk factors in open reduction group and close reduction group differs significantly, 2.53 vs 4.06 respectively. In cases with 4 or more risk factors, serious consideration of directly go to open reduction is suggested. This is important because we can prevent unnecessary neurovascular damage caused by prolonged close manipulation.

Too comminuted fracture was not commonly

seen in both open reduction and close reduction groups. Thus, it is not considered as a risk factor in this study.

Different approaches for open reduction had been mentioned in the literature, anterior, posterior, lateral, medial and combined approach. Posterior approach is becoming less favorable as it causing further damage to the relatively uninvolved posterior soft tissue. The fracture displacement is more severe during the injury, neurovascular bundles at two sides are in danger. Anatomical reduction is blocked by the soft tissue interposing at the fracture ends. After reanalysis on the fracture patterns of our open reduction cases, we would suggest medial and lateral approach initially. A combined medial and lateral approach can be used for difficult cases.

Conclusion

This study reaffirmed close reduction and percutaneous pinning as the standard of treatment in type III supracondylar fracture of humerus in children. The six risk factors for open reduction offers a guideline in managing severely displaced type III supracondylar fractures. Four or more risk factors deserve open reduction in order to achieve anatomical reduction and stable fixation. From patho-anatomical consideration, we think open reduction should be approached through the disrupted soft tissue, so that the stability and vascularization will not be impaired. Our suggestion for open reduction is to approach through opposite site of the fracture displacement, that is through either medially or laterally or a combination of medial and lateral approaches. Routine exploration of the neurovascular bundle is not necessary follow a satisfactory anatomical reduction and stabilization of fracture.

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