PERCUTANEOUS FIXATION OF DISPLACED SUPRACONDYLAR FRACTURE IN CHILDREN COMPARING LATERAL WITH MEDIAL AND LATERAL PIN

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Abstract:

Background:
Supracondylar fracture of humerus is one of the most common fracture in the first decade of life. There are various modalities of treatment adviced for the management of type III supracondylar fracture of humerus. At present closed reduction and percutaneous pin fixation is most widely accepted treatment method for displaced supracondylar fracture but controversy persists regarding the optimal pin fixation technique. The purpose of this study was to compare the stability and risk of ulnar nerve injury treated by lateral entry pin fixation with that of medial and lateral pin fixation for Gartland type III supracondylar fracture.

Method:
This prospective randomized controlled study was conducted at the department of Orthopaedics, Asha Hospital (Centre for Orthopaedics and Trauma Care) Bharatpur, Nepal from January 2006 to December 2008. There was totally 66 patients selected for the study between the age three to twelve years. We lost 6 patients for follow up, therefore only 60 patients were included for the study. They were allocated to Group-A (Lateral pin fixation) n = 29, and Group – B (Medial and lateral pin fixation) n=31.
Primary assessment was done for major loss of reduction and iatrogenic ulnar nerve injury. Secondary assessment was done for clinical alignment, elbow range of motion, radiographic measurements, Flynn grade, functions and complications.

Results:
The two groups were evaluated for pre-fracture characteristics and post reduction evaluation at first week, second week, fourth week, sixth week, three months and six months. The mean follow up in group A was 6.2 months and group B was 6.6 months. Both groups were also similar in sex distribution, pre-operative displacement, mode of injury and neurovascular status. No major loss of reduction was observed in both the groups where as there was no significant difference between mild loss of reduction , change in Baumann angle, change in Humerocapitellar angle , Flynn grade, elbow extention and flexion, carrying angle, total range of motion ($p>0.05$). But there was three ulnar nerve injury in group B.

Conclusion:
There was statistically no significant difference between two groups in terms of stability, duration of bone healing and loss of reduction but group B shows three ulnar nerve injuries and none in group A. So we conclude that two or three lateral pin entry, if placed with proper technique, is as stable as medial and lateral pin entry but chances of iatrogenic ulnar nerve injury is low in lateral pin group. So lateral pin group is more safe.

Key words: Child elbow joint ; supracondylar fracture; fracture fixation

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Introduction:

Supracondylar fracture of the humerus in children is one of the most common fracture seen in orthopaedic outpatient department all over the world accounting for 50% to 70% of all elbow fracture in children in the first decade of life[1]. Traditionally this type of fracture is associated with high rate of malunion, nerve injuy, and vascular complications.

Current method of treatment of supracondylar fracture of humerus in children is based on Gartland classification. Flynn et al. reported the incidence of cubitus varus deformity after treatment was 5% where as Arino et al. reported that it was almost 21%, ulnar nerve deficit was found in 15% of patients who were treated with medial and lateral pin as per the report of Chai.[2,3,4]

Various treatment options has been discovered for type III supracondylar fracture such as closed reduction and long arm cast or slab, Dunlop skin traction, olecranon traction, but all of these methods had significantly large complication rate[1,2,5,6,7,8,9,10,11,12,28]. The standard current treatment for displaced supracondylar fracture has been close reduction and percutaneous pin fixation. This method has consistenly given excellent results reported by various authors [10,11,12,13,14,15]. However, controversy persists regarding whether medial and lateral pin fixation or lateral pin fixation is satisfactory technique in terms of stability and iatrogenic ulnar nerve injury[16]. Ideally medial and lateral pin fixation engage medial and lateral column at fracture site whereas lateral pin stabilizes lateral and central column. Medial and lateral pin fixation has been presumed to be more stable but it can cause iatrogenic ulnar nerve injury. Therefore, we conducted this prospective study to compare whether lateral pin construct, if placed properly, can provide the same stability like medial and lateral pin fixation, at the same time avoiding the possibility of iatrogenic ulnar nerve injury[16,17,18].

The null hypothesis was that the lateral pin fixation provides same biomechanical stability like medial and lateral pin fixation but lateral pin group has less possibility of iatrogenic ulnar nerve injury.

Materials and Methods:

A prospective, randomized, single centre, controlled study was conducted at the orthopaedic department of Asha Hospital from January 2006 to December 2008. All the childrens with Gartland type III fracture who presented to the orthopaedic outpatient or casualty were included for the study.

The inclusion criteria were:

1) Age between three to twelve years.
2) Those presented within 0 to 4 days.
3) No previous fracture in the same elbow
4) No associated fracture in the same limb.

The exclusion criteria were:

1) Age less than three years and more then twelve years.
2) Open fractures
3) Fracture requiring open reduction
4) Inability to perform neurological evaluation
5) Floating elbow

All the protocols and procedures applied in this study was approved by administration department of this institution.

All the children with suspected supracondylar fracture of elbow were seen either at casualty or orthopaedic outpatient department by orthopaedic duty doctor or the orthoppaedic surgeon. They were assessed for vascular and neurological status. Anteroposterior and lateral radiographs were done. All displaced supracondylar fractures were admitted and injured elbow was immobilized in crammer splint with elbow in 30 to 45 degree of flexion. Elevation and ice compression given. Pulseless viable limb and nerve injuries were also included for the study. Patients were reassessed in the ward for neurovascular injuries and any other associated injuries. Surgery was planned on the same day or the next day after obtaining written informed consent.

Patients were randomly selected by drawing lots with even number included in group A (Lateral entry) and odd number in group B (medial and lateral entry). Surgical techniques were standardized in terms of pin location, the pin size (weight less than 20.kg size 1.5mm; more than 20 kg 2mm.), stability on table, position of elbow for medial and lateral pin placement and the post operative course.

Surgery was performed by senior orthopaedic surgeon who is well trained for this technique. General anaesthesia was used for all patients with the injured upper limb at the side of the table. The injured elbow was placed on the plate of image intesnsifier which was adequate for the surgery due to the small size of the elbow. Closed reduction was done and confirmed by image intensifier. If acceptable, assistant would clean and drape the limb along with image intensifier and surgeon goes for scrub. Fracture would be reduced again and fixed under image intensifier according to the selected configuration.

For the lateral fixation technique two or three pins were inserted from lateral aspect of elbow across the lateral cortex to engage the medial cortex keeping the elbow in hyperflexion. For the pin construct to be acceptable and biomechanically stable one pin had to be placed in lateral column and another in central column. Pins were placed either in parallel or divergent configuration with the adequate separation at fracture site.

For the medial and lateral fixation technique, first the lateral pin was inserted from lateral cortex across the lateral cortex to engage the medial cortex keeping the elbow in hyperflexion. Then the elbow was extended to less than 90 degree and about 2 to 3 cms. of medial incision was made over the medial epicondyle. Blunt dissection was done to locate the lateral epicondyle and ulnar nerve rolled back with opposite thumb and the medial pin was inserted from the medial cortex to engage the lateral cortex with the elbow in less than 90 degree of flexion. The pin configuration was considered to be acceptable if one pin was placed in lateral column and another pin in central or medial column. Pins were buried under the skin to avoid the pin site local infection. Elbow was immobilized with posterior slab with elbow in 70 to 90 degree of flexion depending upon the swelling and neurovascular status. All patients were given single dose of broad spectrum antibiotics followed by oral antibiotics for three to five days. Neurovascular examination was performed preoperatively and immediate post operatively and at one week follow up. All the patients were evaluated clinically and radiografically at one week, two weeks, four weeks, six weeks, three months and six months. In both the groups K wires were removed in four weeks and active assisted mobilization started

Clinical evaluation was done by senior orthopaedic surgeon which includes passive range of motion, measurement of carrying angle, neurovascular status, superficial and deep infection and necessity to re-operate. Clinical evaluation was graded according to carrying angle and elbow range of motion using the criteria of Flynn et.al.

Radiographic evaluation was performed by anteroposterior and lateral radiographs of the elbow. Satisfactory fixation was confirmed intraoperatively under image intensifier and radiograph taken. Follow up radiographs were taken at one week , two weeks, four weeks, six weeks, three months and six months. Baumann angle and Humerocapitellar angle were calculated on the immediate radiographs and after three months for any loss of Baumann angle and Humerocapitellar angle. At the three months and six months follow up child were evaluated for full function, minor limitation of function and major loss of function.

Iatrogenic ulnar nerve injury was evaluated immediate postoperatively who had normal ulnar nerve function on the preoperative examination. Any patients with immediate post operative ulnar nerve deficit was explored again and the pin was placed in other location.

All data were compiled and calculated by Epi-info 2000 software. Significance of difference was measures by determining ‘P’ value and value less than <0.05 was considered significant.

Results:

Both group A and group B were comparable in terms of pre-fracture characteristics, fracture patterns, post reduction radiographic measurements showing satisfactory randomization. During this study period 66 patients were treated for completely displaced type III supracondylar fracture in humerus. Six patients were excluded from the study due to loss of follow up and sixty patients were included for the study.

The group A comprised twenty-nine patients. The mean age was 5.8 years. Among which twenty-one patients (72%) were males. In fourteen patients injury occurred due to fall from height, eleven patients were injured while playing whereas three due to road traffic accident and one due to some other cause. Twelve patients had right elbow and seventeen had left elbow fracture. Four patients had pulseless viable hand, one had median nerve palsy two had radial nerve palsy. In majority of patients (86%) primary splintage was done in crammer splint and ice compression and elevation given. Displacement was posteromedial in twenty-four patients, three had posterolateral and two had direct posterior displacement. No iatrogenic ulnar nerve injury was found in this group. The mean Baumann angle loss, Capitohumeral angle loss and carrying loss was 5.30^0, 6.1^0 and 3.70^0 respectively. Total range of motion was 129^0. Flynn grade showed excellent result in 25 patients, good in 3 and fair in 1 patients. Only one patient had superficial pin tract infection. No re-operation was needed in this group. The mean hospital- treatment duration was 5.6 hours. Finally 28 patients had full return to function and only one had minor limitation.

The group B comprised thirty-one patients. The mean age was 6.2 years. Among which seventeen patients (54.8%) were males. In eighteen patients injury occurred due to fall from height, ten patients were injured while playing whereas three due to road traffic accident. Fourteen patients had right elbow and seventeen had left elbow fracture. Three patients had pulse less viable hand and one had radial nerve palsy. In majority of patients (90%) primary splintage was done in crammer splint and ice compression and elevation given. Displacement was posteromedial in twenty-three patients, seven had posterolateral and one had direct posterior displacement. Three children had postoperative iatrogenic ulnar nerve injury in this group. The mean Baumann angle loss, Capitohumeral angle loss and carrying loss was 5.96^0, 6.30^0 and 3.57^0 degree respectively. Total range of motion was 127^0. Flynn grade showed excellent result in 24 patients, good in 5 and fair in 2 patients. Only two patients had superficial pin tract infection. Three patients needed immediate re-exploration among which two had tenting of ulnar nerve over the pin and in one case pin was causing constriction of cubital tunnel since no direct compression over the nerve was found . The mean hospital- treatment duration was 6.1 hours. Finally 29 patients had full return to function and only two had minor limitation. Both the groups were compared in terms parameter

given in the table-III. There were no significant differences (p> 0.05) between groups with regard to any of these variables except three cases had iatrogenic ulnar nerve palsy which needed re-operation.

Table : I
Modified Flynn's criteria and overall rating

Result	Rating	Carrying angle loss(◦)	Flexion loss(◦)	Extension loss(◦)
Satisfactory	Excellent Good Fair	0-4.9 5.9.9 10-14.9	0-4.9 5.9.9 10-14.9	0-4.9 5.9.9 10-14.9
Unsatisfactory	Poor	≥15	≥15	≥15

Table : II
Modified Gartland Classification of supracondylar humeral fracture

Type I	• Non displaced or minimally displaced(by <2mm), • Intact anterior humeral line • Posterior fat pad ± • Periostium intact circumferentially
Type II	• Displacement >2mm • Posterior cortex presumably intact but hinged • Anterior humeral line does not pass through middle third of capitellum • No rotational deformity
Type III	• Displaced with no meaningful cortical contact • Extension in sagittal and rotation in frontal plane • Periostium extensively torn • May me associated with soft tissue and neurovascular injury • Collapse of medial column
Type IV	• Multidirectional instability • Incompitent periosteal hinge Circumferentially • Unstable both in flexion and extension

Table :III

Data on the patients	Group - A	Group - B	P value
No of patients	29	31	
Age* (yrs)	5.8±3.4	6.2±2.2	0.473
Sex @			
Male	21	17	0.226
female	8	14	
Mode of Injury @			
Fall from height	14	18	
While Playing	11	10	0.357
Road Traffic accident	3	3	
Other	1	0	
Affected side @			
Right	12	14	0.794
Left	17	17	
Neurovascular Status @			
Pulseless viable hand	4	3	0.261
Median nerve injury	1	0	
Radial nerve injury	2	1	
Primary spintage @			
Yes	25	28	0.7251
No	4	3	
Displacement @			
Posteromedial	24	23	0.403
Posterolateral	3	7	
Posterior	2	1	
Injury-Hospital Duration hr.*	15.6±12.1	20.1±5.7	0.223
Loss of reduction			
Major	0	0	
Mild	3	1	0.083
None	28	30	0.570
Iatrogenic Ulnar nerve injury @	0	3	0.367
Bauman angle loss*(deg)	5.30±5.0	5.96±5.6	0.645
Humerocapitellar angle loss*(deg)	6.1±5.1	6.3±5.4	0.209
Carrying angle loss*(deg)	3.70±4.24	3.57±4.65	0.814
Range of motion*(deg)			
Extension	-4	-3	
Flexion	133	130	0.410
Total motion	129	127	
Flynn grade@			
Excellent	25	24	0.405
Good	3	5	0.699
Fair	1	2	0.606
Poor	0	0	
Superficial Infection@	1	2	0.606
Re-operation@	0	3	0.367
Hospital-Treatment Duration hrs.*	5.6±2.4	6.1±2.1	0.178
Return to function@			
Full	28	29	0.5179
Minor limitation	1	2	0.606
Major limitation	0	0	

*The values are given as the mean and standard deviation. @The values are given as the number of patients

Discussion :

Treatment of displaced extension type III supracondylar fracture of humerus treated by closed reduction and percutaneous pin fixation has consistently given satisfactory result compared to other method of treatment. But controversy still persists regarding the adequate pin fixation technique comparing lateral pin fixation with medial and lateral pin fixation. In this study we found no significant difference between both fixation methods in terms of stability but there is a evidence of iatrogenic ulnar nerve injury (5%) in medial and lateral pin group.

The lateral and medial pin fixation method supposed to have the advantage of better fracture stability, although iatrogenic ulnar injury can occur with this technique. Conversely, lateral pin entry has the advantage of avoiding ulnar nerve injury but this construct has been thought to be biomechanically less stable.

A cadavaric study reported by Lee SS et. al and Ziouts et.al suggested that medial and lateral entry provides greater torsional rigidity than lateral entry pin fixation does[20]. The overall strength of this construct is not only related to pin entry but mainly to divergence of the pins in different column and number of pins. The greater strength seen with the divergence of the pins was related to the location of the interaction of the two pins and the fact that the greater amount of divergence between the two pins allow for some purchase in the medial and the lateral column[19,29]. Bloom et al. reported that three lateral divergent pins were equivalent to cross pin fixation and both of these constructs were stronger than two lateral divergent pins.

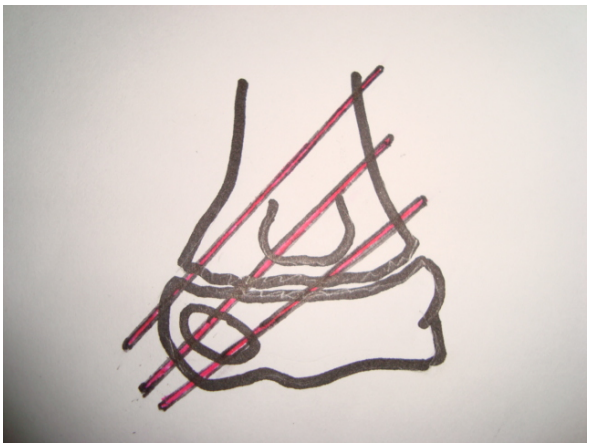

Fig. 1. Three divergent lateral pins are biomechanically equivalent to cross pins

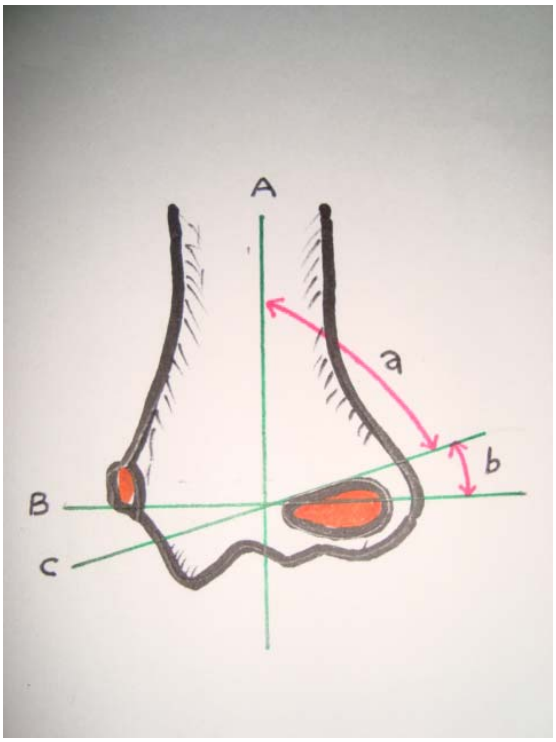

Fig.2 Baumann angle, A, Midline of diaphysis. B. Line perpendicular to midline C. Line through physis of lateral condyle. Angle 'a' is more commonly used currently, Angle 'b' is original Baumann angle

The rate of iatrogenic ulnar nerve injury associated with cross medial and lateral pin has been reported to be from 0% to 6%[14,17,18,22,23,24]. Others have reported that these injuries occur more commonly[24,25]. In 1977 Arino et al. recommended two lateral pins in order to avoid ulnar nerve injury[3]. A recent systemic review of 35 articles comparing lateral pin fixation with lateral and medial pin fixation revealed that iatrogenic ulnar nerve injury occurred in 40 (3.4%) of 1171 cases of medial and lateral fixation group[27]. Although ulnar nerve injury recovered in most of the cases but there are several reports of permanent ulnar nerve injury [14,22,26]. Skaggs et al. reported that even making an incision over the medial epicondyle in an effort to ensure that the ulnar nerve is not directly injured does not guarantee protection of the nerve[14]. In a study by Rasool MN six iatrogenic ulnar nerve injury treated by early operation showed two direct ulnar nerve penetration and three had constriction of cubital tunnel and in one case ulnar nerve was fixed anterior to medial epicondyle[22]. Thus, even if direct injury to the ulnar nerve is avoided, just placing the pin over the medial epicondyle just adjacent to ulnar nerve can cause constriction of cubital tunnel.

Therefore, one obvious undeniable conclusion is that, if medial pin is used, the lateral pin(s) should be used first followed by medial pin fixation with elbow in

extension. But the best way to avoid ulnar nerve injury is not to place medial pin.

Conclusion :

From this prospective study we conclude that there is no significant difference between the stability provided by the medial and lateral pin fixation and two lateral pin fixation method. But the medial and lateral pin fixation group shows three (5%) cases of iatrogenic ulnar nerve injuries which is also shown by many other studies. Therefore, lateral pin fixation method for the treatment of type III supracondylar fracture is a reliably safe method to avoid iatrogenic ulnar nerve injury which also provides adequate stability if proper pin fixation principles are used.

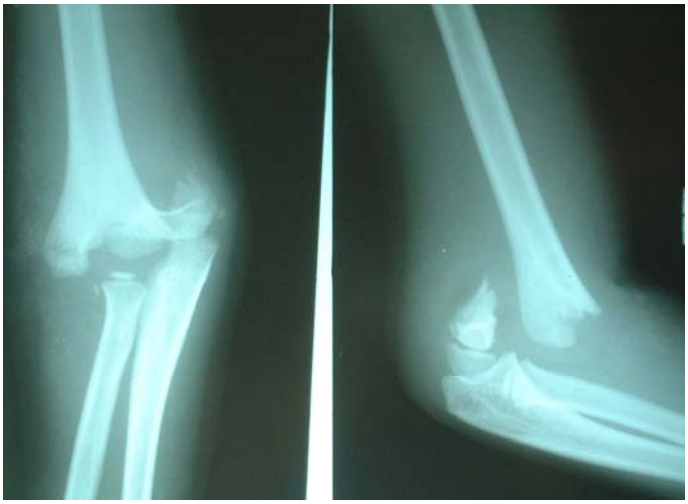

Fig. 3 Type – III supraondylar fracture of humerus

Fig.4 Lateral Pin fixation

Fig. 5 Medial and lateral pin fixation

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