ORIGINAL ARTICLE

To Compare the Outcome of Patients with Supracondylar Fractures of Humerus Treated by Cross K-Wires and Lateral Entry K-Wires in Children

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ABSTRACT

Objective: To compare outcome of patients with supracondylar fractures of humerus treated by cross K-wires and lateral entry K-wires in children.

Patients and methods: It is a randomized controlled trial study, conducted at Department of Orthopedic surgery, Shaikh Zayed Hospital/PGMI Lahore, during period of 8 months (June 2011 to Feb. 2012). *Total* 200 cases were included in the study (divided in two groups A & B). In group A cross k wire fixation and in group B lateral entry k wire fixation performed. Loss of reduction assessed and recorded in the immediate postoperative period and three weeks later at the time of removal of k wires. Range of motion of elbow, in the form of excellent outcome assessed at the end of 12 weeks postoperatively.

Results: Total 200 patients were included in study. Eighty patients (80%) were males and twenty patients (20%) were females in cross k wire fixation, while seventy eight (78%) male and twenty two (22%) were female in lateral entry k wire group. The age ranged from 3 to 10 years. Loss of reduction was found in thirty patients (30%) in group A and in forty one patients (41%) in group B. In group A, seventy two patients (72%) had excellent outcome while twenty eight patients (28%) did not gain the desired range of motion at elbow. In group B, sixty five patients (65%) had excellent outcome while in thirty five patients (35%) the desired range of motion at elbow was not achieved.

Conclusion: Lateral entry k wire fixation is as effective as cross k wire in the treatment of displaced supracondylar fracture of humerus in children keeping and applying the technical aspect of fracture reduction. Excellent outcome in the form of range of motion can be obtained even if the fracture has lost the reduction.

Keywords: Baumann`s angle, Anterior Humeral line, Loss of reduction, Range of motion

INTRODUCTION

Supracondylar fractures of the distal humerus are the most common (60%) of elbow fracture in children.[1] It is fracture that occurs at the supracondylar area or the metaphysis of the distal humerus. Unlike adults, children usually sustain fracture in the upper limb. Of all the fracture in upper limb the supracondylar fracture of humerus is not only the most common injury but can result in serious complications if not treated appropriately. Gartland proposed a useful classification for supracondylar fractures: type I, undisplaced; type II, displaced with intact posterior cortex; and type III, displaced with no cortical contact. Type III fractures are displaced posteromedially or posterolaterally with no cortical contact, and reduction is difficult and maintaining reduction is almost impossible without internal fixation. Type IV fracture is extension type fracture with multidirectional instability determined at the time of operation. The rate of associated neurological injury has been reported to be as high as 49% and the rate of compartment syndrome is estimated to be 0.1% to 0.3%[1, 2].

In general fractures in children are treated conservatively. Operative treatment is reserved for some physeal injuries, fracture associated with neurovascular compromise and open fractures. Type I undisplaced fractures can be satisfactorily treated by closed manipulation. Type II fractures are displaced and treated by closed method or percutaneous kirschner wire fixation. Closed reduction followed by percutaneous k wire fixation is the treatment of choice for type III fractures, either lateral entry k wires or cross k wires. In our set up both of the methods are used, but cross k wires are associated with iatrogenic injury to the ulnar nerve (0% to 5%). Loss of reduction in lateral entry k wires occurred due to technical fault in 14% patients in different studies and 3% in cross k wires [3]. Excellent outcome in the form of range of motion was 91% in lateral entry k wire fixation and 66% in cross k wire fixation[3,4].

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In the past malreduction i.e. cubitus varus or valgus frequently was thought to occur because of the growth arrest of the distal humeral physis rather than malreduction of the fracture. Modern techniques for their treatment have dramatically decreased the rates of their malunion and compartment syndrome. There still remain several controversies with regard to the treatment of these injuries, including the pin placement configuration, whether type II supracondyler fracture should be treated operatively or nonoperatively and the management of dysvascular limb[3,4]. Cubitus varus and loss of range of motion are the most common postoperative sequelaes which occur after loss of reduction and contribute significant morbidity to the child and his family.

PATIENTS AND METHODS

It is a randomized controlled trial study, conducted at Department of Orthopedic surgery, Shaikh Zayed Hospital/ PGMI Lahore, during June 2011 to Feb. 2012. Total 200 cases were included in this study (divided in two groups A & B). Radiographs of the elbow were performed to know the fracture type. These patients were divided into group A and group B randomly. In group A cross K wire fixation and in group B lateral entry K wire fixation performed. Patients age 3-10 years having Gartland type II fractures, Gartland type III fractures and fresh supracondylar fractures of humerus within one week of injury were included. Those patients who have supracondylar fractures of humerus with vascular or nerve injury (clinical assessment), supracondylar fractures of humerus with ipsilateral forearm fractures and open supracondylar fractures of humerus were excluded. Vascular and neurological status were assessed. After initial closed reduction, back slab was applied. The patients were placed supine with the injured upper limb at the side of operating table. After thorough scrubbing and then draping of injured elbow, closed manipulative reduction was performed and the reduction was confirmed with image intensifier. If the reduction was acceptable k-wires (0.062mm) were passed under image intensifier, cross k-wires in group A and lateral entry k-wires in group B. When the reduction was not acceptable another one or two more attempts of closed reduction were performed, if still acceptable reduction was not achieved then open reduction and k-wire fixation, cross k-wire (group A) or lateral entry k-wire (group B) was carried out. Wound was closed over drain in cases of open reductions and back slab applied in 90 degrees elbow flexion. Immediate postoperative x rays of operated elbow were taken in true AP and lateral views to document loss of reduction if present, by measuring Bauman´s angle and anterior humeral line. Neurovascular status was assessed again postoperatively. All the patients were followed up at outpatient department. Radiological examinations of operated elbow were performed fortnightly. At 3rd postoperative week k-wires were removed and operated elbow was assessed again by taking x rays in AP and true lateral views. Bauman´s angle and anterior humeral lines were drawn on the x rays taken in the immediate postoperative period and at 3rd week at the time of removal of k-wires, values were recorded and compared. Deviation from the normal values of either the Baumann's angle of anterior humeral line were considered loss of reduction.

After the removal of the back slab gentle range of motion exercises of the operated elbow were started and any loss of range of motion of the elbow were recorded at the end of 12th week postoperatively in the form of excellent outcome according to Flynn's criteria. Loss of reduction assessed and recorded in the immediate postoperative period and three weeks later at the time of removal of k wires. Range of motion of the elbow, in the form of excellent outcome assessed at the end of 12 weeks postoperatively. An initial attempt at closed reduction is indicated for almost all displaced supracondylar fractures that are not open. With the patient under general anesthesia, the fracture is first reduced in the frontal plane with fluoroscopic verification. The elbow is then flexed while the olecranon is pushed anteriorly to correct the sagital deformity and reduce the fracture. Criteria for an acceptable reduction include restoration of the Baumann angle on AP radiograph, intact medial and lateral columns as seen on the oblique radiographs, and the anterior humeral line passing through the middle third of the capitellum on the lateral radiograph[7]. Any rotational malignant is detrimental to fracture stability, so, if it is present, one must be especially careful in assessing the stability of the reduction and probably use a third fixation pin. The fracture reduction is held with two or three Kirschner wires. The elbow is immobilized in 40 to 60 degrees of flexion, depending on the amount of swelling and the vascular status. If there is a considerable gap in the fracture site or the fracture is irreducible with a so-called rubbery feeling on attempted reduction, the median nerve and/or brachial artery may be trapped in the fracture site and one should proceed to an open reduction.

Open reduction is indicated in cases of failed closed reduction, a devascular limb, and open fractures. It was reported in a study that 78% (fifty-one) of sixty-five patients treated with open reduction (through either a medial or a lateral approach) had an excellent or good result according to the criteria of

Flynn et al.[8] The posterior approach is generally not recommended because of the high rate of loss of motion and, more importantly, the risk of osteonecrosis secondary to disruption of the posterior end arterial supply to the trochlea of the humerus.[9]

1A 2A 1B

Fig. 1A Type II supracondylar fracture, Fig. 2A: Supracondyler fracture of the humerus Gartland type III
Fig. 1B: Cross k-wire fixation

Fig 2 B: Post operative, Figure 3A:, Figure 3B: Type II supracondylar fracture (a) lateral view (b) after closed reduction 2 lateral k wires were passed, Fig 3C: after the removal of k wires, 3 weeks later

RESULTS

The study was conducted at the Department of Orthopedics Shaikh Zayed Hospital/PGMI Lahore, from June 2011 to Feb 2012 on patients who underwent K wire fixation for displaced supracondylar fracture in children by two different methods i.e., Cross k wire fixation (group A) and Lateral entry k wire fixation (group B). A total of 200 patients were treated, 100 in each group. The mean age of the patients in Cross k wire group A was 6.51±2.26 years and 5.83±1.83 years in lateral entry group B. In group A, 59 patients (59%) were in range of 3 to 6 years and 41 patients (41%) were in range of 7 to 10 years. Similarly in group B, 58patients (58%) were in range of 3 to 6 years and 42 patients (42%) were in range of 7 to 10 years (Table 1).

In group A, 80 patients (80%) were male and 20 patients (20%) female. Male to female ratio was 4.0:1.In group B, 78 patients (78%) was male and 22 patients (22%) were female with male to female ratio of 3.54:1 (Table 2).

The normal Baumann`s angle is between 64 t0 81° (average 72 degrees) on AP radiograph. In group A, in immediate postoperative period 94 (94%) patients has normal Bauman`s and in six patients (6%) it was abnormal. The mean Baumann angle (and standard deviation) was 74.90±6.85°. In group B, in immediate postoperative period 82 patients (82%) had normal Bauman`s angle and 18 patients (18%) had abnormal angle. The mean Baumann angle (and standard deviation) was 77.60±4.40 and P value was 0.12 (Table 3).

Anterior humeral line was intact in 70 patients (70%) and not intact in 30 patients (30%) in group A. Similarly anterior humeral line was intact in 59 patients (59%) and not intact in 41 patients (41%) in group B, in immediate postoperative period. The difference between two groups was 2.64 (Chi-square test) with P value of 0.10 (Table 4). Comparison of Baumann` angle was also done at the time of removal of k wires (3 weeks after the date of operation).In group A, in 90 patients (90%) the Baumann`s angle was normal while in 10 patients (10%) it was abnormal. The mean Baumann`s angle (and standard deviation) was 77.50±5.09. In group B, it was normal in 78 patients (78%) and abnormal in 22 patients (22%) with mean (and standard deviation) of 77.70±6.30 and P value of 0.037 (Table 5)

There was almost no change in the anterior humeral line at the time of union i.e. 3 weeks

postoperatively between groups. Anterior humeral line was intact in 70 patients (70%) and not intact in 30 patients (30%) in group A. Similarly anterior humeral line was intact in 59 patients (59%) and not intact in 41 patients (41%) in group B, 3rd postoperative week. The difference between the two groups was 2.64 (Chi-square test) with P value of 0.10 (Table 6).

So at the end of 3rd postoperative week 30 patients (30%) in group A had loss of reduction of fracture while seventy patients (70%) had no loss with stable reduction. In group B, forty one patients (40%) had loss of reduction and 59 patients (59%) had stable construct of fracture reduction with P value of 0.10 (Table 7). Comparison of range of motion in the form of excellent outcome has also been done between groups. In 72 patients (72%) had excellent outcome while 28 patients (28%) did not gain the desired range of motion at elbow. In group B, 65 patients (65%) had excellent outcome while in 35 patients (35%) the desired range of motion at elbow was not achieved. Chi-square test was 1.13 and P value of 0.28 (Table 8)

Comparison of Baumann angle in the immediate postoperative period and 3 weeks later at the time of removal of k wires performed in group A. The immediate post op Baumann angle`s mean and standard deviation was 74.88 ± 6.79 and after 3 weeks it was 77.50 ± 5.09 with p value of <0.001.

The mean anterior humeral line in the immediate post op period was 1.30 ±0.46 and after 3 weeks it was 1.30 ±0.45 with p value of 1.0 (Table 9).

Comparison of Baumann angle in the immediate postoperative period and 3 weeks later at the time of removal of k wires performed in group B. The immediate post op Baumann angle`s mean and standard deviation was 77.60±4.40 and after 3 weeks it was 77.70 ± 6.30 with p value of <0.01. The mean anterior humeral line in the immediate post op period was 1.41 ±0.49 and after 3 weeks it was 1.41 ±0.49 with p value of 1.0. (Table 10)

Table 1: Age distribution of patients in both groups (n=200)

Age in years	Group A	Group B
3-6	59(59%)	58(58%)
7-10	41(41%)	42(42%)

Table 2: Sex distribution in both groups

Gender	Group A	Group B
Male	80(80%)	78(78%)
Female	20(20%)	22(22%)

Table 3: Comparison of immediate postoperative Bauman's angle in both groups

Bauman's angle	Group A	Group B
Normal (64-81°)	94(94%)	82(82%)
Abnormal (<64 and >81°)	6(6%)	18(18%)

Table 4: Comparison of immediate postoperative anterior humeral line of patients in both groups

Anterior humeral line	Group A	Group B
Intact	70(70%)	59(59%)
Non intact	30(30%)	41(41%)

P value 0.10

Table 5: Comparison of Bauman's angle after 3rd postoperative week in both groups

Bauman's angle	Group A	Group B
Normal (65 to 82°)	90(90%)	78(78%)
Abnormal (<64 and >81°)	10(10%)	22(22%)

Table 6: Comparison of anterior humeral line after 3rd postoperative week in both groups

Anterior humeral line	Group A	Group B
Intact	70(70%)	59(59%)
Non intact	30(30%)	41(41%)

P value = 1.10

Table 7: Comparison of loss of reduction 3 weeks postoperatively in both groups

Loss of reduction	Group A	Group B
Yes	30(30%)	41(41%)
No	70(70%)	59(59%)

P value 0.10

Table 8: Comparison of excellent outcome (0-5) degree after 12 wks post op. in both groups

Excellent outcome	Group A	Group B
Yes	72(72%)	65(65%)
No	28(28%)	35(35%)

P value 0.28

Table 9: Comparison of Baumann angle and anterior humeral line in the immediate postoperative period and 3 weeks later at the time of removal of K-wire in group A

Baumann Angle: imm. post op Mean ± SD)	Baumann Angle: after 3 weeks (Mean ± SD)	P value
74.88 ± 6.79	77.50 ± 5.09	<0.001
Ant. Humeral line; imm. Postop	**Ant. Humeral line; after 3 weeks**	
1.30 ± 0.46	1.30 ± 0.45	1.0

Table 10: Comparison of Baumann angle and anterior humeral line in the immediate postoperative period and 3 weeks later at the time of removal of K-wire in group B

Baumann Angle: imm. post op (Mean ± SD)	Baumann Angle: after 3 weeks (Mean ± SD)	P value
77.60 ± 4.40	77.70 ± 6.30	< 0.01
Ant. Humeral line; imm post op	**Ant. Humeral line; after 3 weeks**	
1.41 ± 0.49	1.41 ± 0.49	1.0

DISCUSSION

In this study the outcome of cross k wires and lateral entry k wires in the treatment of supracondylar fracture has been compared. 200 cases were studied

with majority of cases were of Gartland type III fractures in both groups. 80% of patients were male involving the dominant upper extremity.

In our study the mean Baumann's angle with standard deviation was 74.90±6.85 in cross k wires and 77.60±4.40 in lateral entry k wire with p value of 0.12 in the immediate post op period and at the time of k wires removal i.e. fracture healing, the mean Baumann's angle with standard deviation was 77.50±5.09 in cross k wires and 77.70±6.30 in lateral entry k wire with p value of 0..037 (Table 5) while in the study by Baumann E, the Baumann angle on the intraoperative or immediate postoperative AP radiograph was compared with the angle on the radiograph made at the time of fracture union, at approximately three weeks. The mean Baumann angle (and standard deviation) was 17.7°±5.1° (range, 16.7° to 18.5°) immediately after surgery and 17.6±4.9° (range, 16.6° to 18.4°) at the time of union. The mean difference was 0.05°±0.2° (p=0.878). There was no significant difference between the type-2 and type-3 fractures with regard to the Baumann angle at the time of union. The mean Baumann angle measured immediately postoperatively was 17.4°±5.1° (range, 16.2° to 18.7°) in the patients with a type-2 fracture and 17.9°±5.2° (range, 16.5° to 19.4°) in those with a type-3 fracture (p=0.876). The mean Baumann angle at the time of union was 17.4°±4.9° (range, 16.1° to 18.5°) in the patients with a type-2 fracture and 17.8°±5.0° (range, 16.4° to 19.2°) in those with a type-3 fracture (p=0.893). The greatest difference between the perioperative and final Baumann angles was 7°, which was deemed to be not relevant because of the effect that elbow rotation can have on the Baumann angle.

The second parameter for determination of loss of reduction was anterior humeral line. In our study the anterior humeral line was not intact in 30% patient in cross k wire group (A) and it was also not intact in 41% patient in lateral entry group (B), in the immediate postoperative period and at 3 weeks at the time of fracture healing (Tables 4 & 6).In the study of David L. Skaggs, Julia and others, the anterior humeral line was not intact in 4% of patients in lateral entry group and 3% in cross k wire group.

There were many factors responsible for worse result in our study. In our set up procedures were performed by different consultants, some of them not having enough experience in children's fracture reduction. Method of closed reduction also affects the fracture reduction. In some patients the size of k wires was also not appropriate and the last but not the least geometry of fracture especially type V fracture which has greatest difficulty in reduction.

We also followed our patients for 3 months after date of operation to assess the range of motion in the form of excellent outcome according to Flynn criteria. Patients were seen on weekly bases after the wire removal to gain the maximum range of motion of operated elbow. In cross k wire fixation the excellent outcome was 72% in lateral entry k wire fixation it was 65%. We did not gained the desired range of motion i.e. excellent outcome in 28% of patients in cross pinning and 35% patients in lateral entry pin fxation. In the study by Flynn et al, in cross k wire fixation the excellent outcome was 81%.

The reasons for slightly worse results in our study were; a) delay in the removal of k wires due to late presentation b) compliance of the patient and their parents not following protocols for physiotherapy c) technical factors in fixation of the displaced fractures.

We were much more likely to use three lateral-entry pins for type-3 fractures (used for 65% [thirty-six] of fifty-five fractures) than we were for type-2 fractures (used for 38% [twenty-six] of sixty-nine fractures), and we recommend employing three lateral-entry pins if there is any concern about fracture stability or pin position after the first two pins have been placed. Prior to pin placement, the surgeon may use subjective criteria in the decision whether to use three lateral-entry pins. Such criteria may include a severe type-3 fracture, a large patient, and/or an older patient. Instability on stress testing would be an absolute indication for placement of a third lateral pin[10].

A recent biomechanical study demonstrated that two divergent lateral-entry pins offer more stability in extension loading than do two crossed pins. The same study also showed that two divergent lateral-entry pins provide greater stability in varus and valgus loading than do two parallel lateral-entry pins. In that study, the parallel pins were close to each other and engaged only the lateral column, in contrast to the divergent pins, which were more widely separated at the fracture site and engaged both the medial and the lateral column.[8] On the basis of these results and our clinical experience, we believe that the most important factor for biomechanical stability is maximal separation of the pins at the fracture site; we think that whether the pins happen to be parallel or divergent is less important. It has been shown that crossed pins do provide more torsional stability than do two lateral pins but do not offer significantly more torsional stability than do three lateral pins.

This suggests that perhaps three lateral-entry pins should be used more frequently[11]. The opinion that fixation with lateral-entry pins is technically more difficult than cross-pinning has been expressed, but we do not believe that the technical demands are prohibitive.

To evaluate our results, we chose Flynn's modified overall rating. This is the most rigorous classification since any cubitus varus deformity is considered to be a poor result, whatever the function of the elbow. Our treatment protocol gave excellent

or good results in 96% of cases with 7% of patients lost to follow-up at a mean of 28 months. Comparing the results of our treatment protocol with other published series, we consider it to be a safe method, even when undertaken by less experienced surgeons.

All type-II fractures were classified as having excellent or good results. The four poor results, all in type-III fractures, were considered to be the result of technical errors when the guidelines were not followed, i.e., failure of initial reduction or poor mechanical pinning. This was probably due to the level of experience of the surgeons involved in the primary care; all four mistakes were by junior staff in their first six months.

We did not find one technique of pinning to be superior to other, confirming the experience of Topping et al. Secondary displacement, with a difference of more than 5° in Baumann's angle between the postoperative radiograph and that taken at the time of removal of the wires, occurred in three of the 90 patients treated by lateral percutaneous pinning and in five of the 26 treated by open cross-pinning. All had type-III fractures. In two cases of secondary displacement, poor results were due to technical errors. The displacement in the remaining six patients was less than 10° and of no clinical significance[12].

CONCLUSION

Mechanical stability of cross k wire and lateral entry k wire fixation is same but lateral entry k wire fixation is more technical demanding. Loss of reduction is not the only factor responsible for loss of range of motion. Ulnar nerve injury can be avoided in cross k wire fixation by proper pin placement and sound surgical skills.

REFERENCES

1. Otsuka NY, Kasser JR. Supracondylar fractures of the humerus in children. J Am Acad Orthop Surg 1997; 5:19-26.
2. Dim´eglio A. Growth in pediatric orthopaedics. In: Morrissy RT, Weinstein SL, editors. Lovell and winter's pediatric orthopaedics. Philadelphia: Lippincott Williams and Wilkins; 2005. p. 35-65.
3. Cheng JC, Lam TP, Maffulli N. Epidemiological features of supracondylar fractures of the humerus in Chinese children. J Pediatr Orthop B 2001; 10:63-7.
4. Farnsworth CL, Silva PD, Mubarak SJ. Etiology of supracondylar humerus fractures. J Pediatr Orthop 1998; 18:38-42.
5. Flynn JC, Mattews JG, Benoit RL. Blind pinning of displaced supracondylar fractures of the humerus in children: sixteen years' experience with long-term follow-up. J Bone Joint Surg Am 1974; 56:263-72.
6. Kaewpornsawan K. Comparison between closed reduction with percutaneous pinning and open reduction with pinning in children with closed totally displaced supracondylar humeral fractures: a randomized controlled trial. J Pediatr Orthop B 2001; 10:131-7.
7. Choi PD, Melikian R, Skaggs DL. Management of vascular injuries in pediatric supracondylar humeral fractures. Read at the Annual Meeting of Am Academy of Pediatrics; 2007;27-28.
8. Nacht JL, Ecker ML, Chung SM, Lotke PA, Das M. Supracondylar fractures of the humerus in children treated by closed reduction and percutaneous pinning. Clin Orthop Relat Res 1983;177:203-9.
9. Lyons JP, Ashley E, Hoffer MM. Ulnar nerve palsies after percutaneous cross pinning of supracondylar fractures in children's elbows. J Pediatr Orthop 1998;18:43-5.
10. Cramer KE, Green NE, Devito DP. Incidence of anterior interosseous nerve palsy in supracondylar humerus fractures in children. J Pediatr Orthop 1993;13:502-5.
11. McKee M. Progressive cubitusvarus due to a bony physeal bar in a four yearold girl following supracondylar fracture: a case report. J Orthop Trauma 2006; 20:372.
12. Lee SS, Mahar AT, Miesen D, Newton PO. Displaced pediatric supracondylarhumerus fractures: biomechanical analysis of percutaneous pinning techniques. J Pediatr Orthop 2002; 22:440-3.