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Percutaneous Lateral Pinning for Pediatric Supracondylar Fracture of Humerus

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ABSTRACT

BACKGROUND: Pediatric supracondylar fractures of humerus are managed with closed reduction and percutaneous pin fixation. The cross pinning technique has advantage of stability over lateral pinning but puts the ulnar nerve in peril. The lateral pinning technique avoids iatrogenic nerve injury while providing comparable stability. In this study, we attempt to analyse the outcome and complications of lateral pinning.

METHODS: We prospectively followed 33 children, with modified Gartland II b and III supracondylar fractures of the humerus, after doing closed reduction and fixation with two to three percutaneous lateral pins. Any displacement of fracture after fixation was assessed with changes in anterior humeral line and serial measurement of Baumann's angle. The pins were removed after 3 weeks and the final outcome was assessed after three months and graded according to Flynn's criteria.

RESULTS: We achieved excellent results in 17(51.51%) patients, good in 10(30.30%), fair in 4 (12.12%) and poor results in 2 (6.06%) patients. The mean age of the patients was 8.36 +/- 2.43 years with type III fractures (81.8%) being the commonest. 13 fractures were stabilized with two lateral pins and 20 fractures with 3 lateral pins. No loss of reduction was seen in fractures fixed with divergent pins. Two patients had cubitus varus deformity. There were no iatrogenic nerve injuries but cases which had been manipulated previously had greater elbow stiffness.

CONCLUSION: Displaced supracondylar fractures can be fixed with divergent lateral pins after successful closed reduction with no risk of iatrogenic nerve injuries.

KEY WORDS: Supracondylar fracture, Cubitus varus, Divergent pins, Iatrogenic nerve injury.

INTRODUCTION

Supracondylar fractures of the humerus comprise 17% of all childhood fractures and also are the commonest elbow injuries in children[1]. These fractures are often complicated by neural and vascular injuries and malunion leading to cubitus varus deformity.[2] The classification of these fractures by Gartland was modified by Wilkins to allow for the rotational deformity: type I (undisplaced), type IIA (angulated, posterior cortex intact, no rotation), type IIB(angulated, posterior cortex intact, rotational deformity), and type III (displaced with no cortical contact)[3].

The challenges in the management of supracondylar humeral fractures are to prevent immediate and late complications and achieve full elbow range of motion. Historically the non-operative management of displaced supracondylar fractures is associated with a high rate of complications including failure to obtain and maintain reduction, vascular compromise, and compartment syndrome. The evolution of methods for obtaining reduction and holding it with percutaneous pin fixation under radiographic control with a variety of pin configurations has markedly reduced the incidence of poor outcomes in the management

of displaced supracondylar humerus fractures.[4] The incidence of iatrogenic nerve injury varies considerably depending both on the pin configuration and the operative technique used for placement of medial pins[5,6]. Avoidance of neurological injury and stability of fracture are the main issues with different percutaneous pinning methods. Biomechanical studies have shown that stability provided by divergent lateral pins is similar to crossed pins in extension, varus and valgus testing while crossed pinning proved more stable in axial rotation testing[7, 8]. The ideal pin configuration continues to be debated. This study was undertaken to assess the stability of the fracture using lateral pins, the complications and overall outcome of treatment.

MATERIALS AND METHODOLOGY

This was a prospective and analytical study undertaken at Civil Service Hospital (CSH) from July 2013 to June 2014.

All consecutive cases of modified Gartland extension type IIb and III supracondylar fractures of distal humerus presenting within 5 days of injury with or without previous failed manipulation attempts were taken up. Forty-two such patients were included in the study. Open fractures and fractures with vascular injury, compartment syndrome, ipsilateral skeletal injuries and fused distal humeral epiphysis were excluded.

Ethical clearance was taken from the CSH ethical clearance committee. All the patients were counseled about the treatment method and follow up and a written consent was taken. The procedure was done by the on-duty orthopedic surgeon under general anaesthesia.

A single dose of Ceftriaxone 50mg/kg was given just before the start of the procedure. Closed manipulation done with traction-counter traction and three closed manipulations were allowed before declaring the fracture as unreducible. Such fractures went for open reduction and were excluded from final analysis. The reduction was assessed using c-arm with elbow in AP, oblique with 10^{o} internal and external rotation and lateral positions. Alignment of pillars and olecranon fossa were observed to note any coronal displacement. The anterior humeral line, which should pass through middle third of capitellar epiphysis, was used to assess sagittal plane displacement. The successful reductions were fixed with two to three lateral K-wires (1.8 or 2mm) to make a divergent construct with wires widely separated at the fracture site. If divergent pin configuration could not be achieved, other pin configuration were also accepted if the surgeon has checked stability under c-arm and deemed stable. Pins were bent and cut outside the skin and above elbow plaster slab applied. After 3 hours of completion of the procedure, neurovascular status was assessed, AP and lateral views of the elbow were taken and patients were discharged. The patients were followed up weekly for first three weeks with check x-rays on each visit. At the end of three weeks all the wires and splint were removed and elbow range of motion exercise begun. The Baumann angle and the position of anterior humeral line were used to monitor any displacement of fracture in coronal and sagittal planes respectively. Both these parameters were noted in each check x-ray and compared. Range of motion of elbow, neurological status and presence of deformity were assessed after 12 weeks of pin removal. X-ray AP view of both the elbows were also taken at that time to compare ulno-humeral angle and the final outcome adjudged according to Flynn et al criteria[9] (Table 1).

Table 1. Flynn et al[9] criteria for grading

Results	Cosmetic factor (Loss of carrying angle in degrees)	Functional factor (Loss of motion in degree)
Excellent	<5	<5
Good	6-10	6-10
Fair	11-15	11-15
Poor	>15	>15

Table 2. Showing the number of pins used, configurations achieved and the final outcome according to the Flynn's criteria.

Number of pins used	Pin configuration	Number of cases	Outcome (Flynn's criteria)			
			Excellent	Good	Fair	Poor
2	Divergent	8	4	4	-	-
	Non-Divergent	5	-	2	1	2
3	Divergent	20	13	4	3	-
Total		33	17	10	4	2

The Student t test was used to determine the significance of any changes in the Baumann angle. The association between outcome and other variables were assessed by using the Chi-square test. Multivariate linear regression analysis was used to determine the effect of different variables on loss of motion. A p-value of 0.05 or less was considered significant.

RESULTS

There were 42 patients who were taken up for the procedure. Four of them were irreducible fractures who underwent open reduction and fixation with K-wires and excluded from study. Of the 38 patients who underwent closed reduction and percutaneous pinning with lateral K-wires 5 patients were lost to follow up. Thirty three patients were followed up for mean period of 4.6 months (range, 3 to 14 months) and were evaluated for fracture stability and final outcome.

The mean age of the patients was 8.36 +/- 2.43 years (range, 3 to 14 years, median 8 years)

Twenty-seven patients (81.8%) were male and only 6 (18.2%) were female. The left elbow was involved in 24 (72.7%) patients. Twenty-seven (81.8%) fractures were of type III and 6 (18.2%) were of type II B variety according to modified Gartland classification. Posterolateral displacement was noticed in only 3 (11.11%) patients whereas the rest of them (24) had posteromedial displacement in type III fracture.

The time interval between injury and operative treatment ranged from 7 hours to 86 hours with a mean value of 32.09 +/- 21.16 hours.

The Baumann angle on the postoperative anteroposterior radiograph was compared with the angle on the radiograph taken at three weeks. The mean Baumann angle was 16.85° ± 3.52° (range: 8° to 26°) immediately after surgery and 14.97° ± 5.30° (range, 2° to 25°) at the time of union. The mean difference was 1.88° ±3.48° (p = 0.004), which is statistically significant. When analysis of Baumann angle was done leaving the 5 cases with non-divergent pins as technical errors, the mean difference was 0.29° ±1.27° (p = 0.245) which was statistically insignificant.

There was mean loss of 3.09° ± 6.29° (range, 0° to 31°) of carrying angle. The mean loss of motion was 4.76° ± 5.06° (range, 0° to 15°). Thirteen (39.39%) patients already had one failed manipulation attempt. Multivariate regression analysis showed that the effect of previous failed manipulation attempt on loss of motion was significant (p=0.02) whereas that of injury-surgery time interval (p=0.684) and the time of pin removal (p=0.197) were not significant. The mean duration of pin removal was 25.48±4.88 days (range, 21 to 41 days).

There were 5 (15.15%) cases with nerve palsy. Two each of radial and anterior interosseous nerve palsy and one of median nerve palsy. All of them resolved completely in 3 months.

Cubitus varus deformity developed in two of the cases. Hyperextension of the elbow was seen

in only one who had a cubitus varus deformity of 20°. Superficial pin track infection, noted in one case only, subsided completely with oral antibiotics and dressing. There was no iatrogenic neurovascular injury.

DISCUSSION

Several authors have presented large series documenting the efficacy and advantages of percutaneous pinning over other methods for management of displaced supracondylar humerus fractures[10,11,12]. Nevertheless, the optimal pin configuration continues to be the subject of debate[3,13]. The main debate is the method of holding the fracture in reduced position are crossed medial and lateral entry wires or two to three lateral entry wires alone. A proposed benefit of using crossed wires is increased stability of the fracture fixation but at the increased risk of iatrogenic ulnar nerve injury. Advocates of the lateral wire technique will cite the avoidance of iatrogenic ulnar nerve injury as more satisfactory, even at the expense of a less biomechanically stable construct. Whether the greater stability provided by crossed pins is really required for excellent outcome has also been questioned in the literature[14].

In our study we had 51.51% (17) excellent, 30.30%(10) good, 12.12%(4) fair and 6.06% (2) poor results which corresponds to result of the study reported by Cheng JC and coworkers[11]. They evaluated 82 cases of supracondylar fractures treated with closed reduction and percutaneous K-wire fixation and had 80% of excellent or good outcome. Pirone et al[12] in his study reported 78% excellent, 16% good, 1% fair and 5% poor result in patients treated with percutaneous pinning. The proportion of excellent results in our study is less than those of the studies mentioned above. This is probably because of inability to achieve ideal pin configuration in 5 of the patients who lost the reduction. Two of these had inadequate reduction at the time of fixation. The other reason might be the inclusion of cases with a failed manipulation attempt. Exclusion of these 5 cases as technical errors improves the proportion of excellent results to 60.71% with no poor results.

An another study reported 100% excellent results with the use of two lateral pins in type II and type III fractures[15] .The important technical points for fixation emphasized in this study were maximal separation of pins at fracture site, engagement of medial and lateral column proximal to fracture and use of a third lateral pin if the stability of fracture was doubtful. SolakS et al[16] believes that the most important factor for a good outcome in a patient with supracondylar fracture is adequate reduction rather than fixation. We partly agree with him. The achievement of anatomical alignment in closed manipulation can be extremely difficult at times, forcing the surgeon to accept less than the ideal. And an improper reduction even precludes ideal pin placement.

Kallio et al.[17] reported loss of fixation in 11 of 80 patients in whom only two lateral pins had been used. The loss of fixation was attributed to technical errors, such as failure to engage medial and lateral columns proximal to fracture and narrowly placed pins at the fracture site. The authors concluded that, although the use of two lateral pins eliminates the risk of injury to the ulnar nerve, it is technically very demanding.

In our study majority of the patients (60.60%, 20/33) had fixation with three lateral pins. Three pins were more often used in both the type II (66.65%, 4/6) and type III (59.25%,16/27) fractures. All the type II fractures had either excellent or good results. No loss of fixation was noted in patients with 3 pins or two divergent pins, while all the patients (5/33) who had two non-divergent lateral pins lost the fixation as shown by statistically significant changes in the Baumann angle and displacement of anterior humeral line. The added stability given by a third pin and increased chance of making a divergent construct by a third pin may be the reason for no

displacement in fractures fixed with three pins. The increased efficacy and safety of three pin construct has also been cited by Lee YH and co-workers in their series[18].

In our study there were 28 (84.84%) patients with divergent pin configuration. Twenty of them had three lateral pins and 8 had two lateral pins. No loss of fixation was seen was noted in any of these 28 patients either in coronal or sagittal plane, signifying that the stability provided by a divergent pin construct of lateral only pins is good enough to hold the fracture till it unites. It has been shown that crossed pins do provide more torsional stability than do two lateral pins[7,8] but do not offer significantly more torsional stability than do three lateral pins[7]. It has not been proved that the added stability of a medial pin is clinically necessary since, in young children, pin fixation is always augmented with immobilization in a splint or cast[14].

In our study the mean loss of carrying angle was 3.09° ± 6.29°, which does not differ much with the finding in a study by Foead et al[19]. They had observed mean loss of 3.70° of carrying angle in their study. Two patients in our study had cubitus varus deformity. Both of them had inadequate reduction and fixation as the anterior humeral line was not seen intersecting the capitellar epiphysis in the immediate post-operative x-ray and further displacement of the anterior humeral line was seen in both the cases. The cause for cubitus varus deformity was primarily the acceptance of poor reduction. The common reasons for residual cubitus varus deformity mentioned in literature[20] are the inability to interpret roentgenograms and thus acceptance of less than adequate reduction and the loss of reduction after fixation. We believe that the reasons for cubitus varus deformity in two of our cases are the same.

There was no marked loss of motion of elbow in our study as compared to the study by Foead et al[19]. In our study 14 cases (42.42%) had complete range of motion while the majority (19 cases, 57.57%) had some degree of loss of motion ranging from 3° to 15° and the mean loss of motion was 4.75° ± 5.34°. Loss of extension was more frequently observed than loss of flexion. Only 2 cases had limited flexion whereas all the 19 cases with loss of motion had loss of extension. Previous failed manipulation attempt (thirteen or 39.39% cases) had significant effect on loss of motion(p=0.002). The time of pin removal (p= 0.197) and the time interval between injury and surgery (p=0.684) did not have significant effect on loss of motion. Elbow joint stiffness seen in cases with previous failed manipulations is probably because of greater soft tissue injury incurred. Closed reduction and percutaneous pinning was done as late as 86 hours of injury in one of the cases. The outcome was good in this patient however both the cases with poor results had received operative treatment within 12 hours of injury.

There were no cases with iatrogenic ulnar nerve injury in our study. The avoidance of ulnar nerve injury by lateral pins has been cited as the main advantage of lateral pins over crossed pins.[14] The reported incidence of iatrogenic ulnar nerve injury with crossed pinning is between 0% and 8% in several large studies[21-23]. The injured nerve usually recovers spontaneously but permanent ulnar nerve injury has been reported.[24,25] Zhao et al in a meta-analysis found out that medial entry pins put ulnar nerve at risk for iatrogenic injury and has recommended lateral only percutaneous pin fixation of paediatric supracondylar fractures[26].

CONCLUSION

Closed reduction and lateral percutaneous K-wire fixation has been found to be safe and stable for displaced supracondylar fractures of humerus with good to excellent results in most of the cases. Stable fixation can be achieved with two to three lateral pins engaging both medial and lateral columns with maximal separation of pins at fracture site. Insertion of a third pin increases stability and also increases the chance of making an ideal pin construct.

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