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Results of crossed and lateral pinning for treatment of supracondylar fracture of humerus in children

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Abstract : Crossed pinning and lateral pinning with 2 to 3 pins for fixation of displaced supracondylar fracture of the humerus in children are the main debate about the stability of fixation and the risk of ulnar nerve injury. The purpose of this study is the comparing of clinical result between crossed, 2 lateral and 3 lateral pinning. We reviewed 31 cases of supracondylar fracture of the humerus in children treated with closed or open reduction and fixation with pins in our hospital. 7 cases were Gartland type Ⅱ and 24 cases were type Ⅲ. The 9 type Ⅲ cases were fixed with 2-3 crossed pins and 22 cases were treated with 2-3 lateral pins. 4 cases required revision. All were type Ⅲ, and successfully revised with lateral pinning. The most of revisions (3 cases) were in 2 lateral pinning group. No varus deformity occurred at the end of treatment and no difference in carrying angle, humeral-ulnar angle and range of motion was observed between the groups. In the cross pinning group, 2 of 9 (22%) had ulnar nerve injury. In conclusion, the result of 3 lateral pinning cases is comparable to cross pinning without the risk of ulnar nerve injury.

Introduction

The most accepted-treatment for type Ⅲ displaced-supracondylar fracture of the humerus in children according to Gartland's classification is closed or open reduction and fixed with pins. Skeletal stabilization with pinning after reduction was also recommended in Gartland type Ⅱ fracture with some characteristics such as marked soft tissue swelling, obliteration of pulse with flexion or medial bone collapse[1]. Two lateral pins usually provide adequate stability for Gartland type Ⅱ fracture[2]. However, for type 3 fracture, two cross pins with lateral and medial entry technique is one standard fixation after reduction and has shown good stability and clinical results[3)4)]. The main problem of crossed pin fixation is iatrogenic ulnar nerve injury due to medial entry pin. The iatrogenic ulnar nerve injury can be avoided if only lateral pin fixation is used. The adequate stability of fixation by only lateral pins in Gartland type Ⅲ is still controversial. Biomechanical studies show that two crossed pin configuration has greater torsion strength than two lateral pins but without significant difference from three lateral pins[5)6)]. Good clinical

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result of two lateral pin fixation comparable with cross pinning has been reported[7)~9)]. The divergent lateral pin configuration can give more stability than parallel pins and convergent or lateral pins crossed at the fracture site had the least stability[10)]. However, three pins can be used for only lateral insertion to increase stability without risk of ulnar nerve injury. We have used the cross pin technique for the fixation of displaced supracondylar fractures of the humerus in our hospital for a long time, but iatrogenic ulnar nerve injury had been found in some cases. Recently, we changed the technique to only lateral pins for fixation, initially with 2 lateral pins and finally with 3 lateral pins for Gartland type 3 fracture. The purpose of this study was to assess the results of each type of fixation in the view of clinical outcome and the risk of iatrogenic ulnar nerve injury.

Methods

Before the year 2004, all displaced supracondylar fractures requiring reduction in our hospital were fixed with standard crossed pinning and iatrogenic ulnar nerve injury occurred in some cases. After a review of the relevant literature, we introduced the method of divergent lateral pinning for fixation of the fractures after reduction to avoid iatrogenic ulnar nerve injury. We also initiated a pilot randomized control study comparing the result of crossed pinning and two lateral pinning for fixation of Gartland type 3 fracture from the year 2004 to 2007. Because of the small number of patients enrolled, only 16 cases were included in that study with similar clinical results found in both groups. From the year 2007 to 2009, we recommended using two lateral divergent pins for all fixations and found some cases that needed revision. After that, we used three lateral pins fixation for all type 3 fractures and some type 2 fractures with uncertain stability after two lateral pins were inserted. In order to compare the result of the different methods of fixation, we started to review all cases treated during the change of treatment strategy.

The medical records and plain radiographs of all pediatric patients attending our hospital for treatment of supracondylar fracture of the humerus between the year 2004 and 2011 were reviewed. The patients with Gartland type Ⅲ fracture and Gartland type Ⅱ that required reduction and fixation with pins were included in this study. All patients were followed up until union of the fractures with at least one further follow up after pin removal. The demographic data of the patients were reviewed and important data were collected such as preoperative neurovascular status, need of open reduction, techniques and numbers of pins used for fixation, revision of reduction and fixation and iatrogenic ulnar nerve injury. The range of motion and carrying angle compared with the uninjured side recorded on the last follow up were collected. The last plain radiograph was used to measure the humeral-ulnar angle by recording the positive value for the valgus angle and negative value for the varus angle. The patients were categorized into 3 groups : those with crossed pinning, 2 lateral pinning and 3 lateral pinning. The age of the patient and the duration of follow up were compared among groups. The clinical results included range of motion, the difference of the carrying angle to the normal side, and humeral-ulnar angle, compared by Kruskal Wallis test. The rate of revision and iatrogenic ulnar nerve injury were also compared among groups.

Table 1 Comparing ammong the groups about age of patients, difference of carrying angle compared with the normal side (Diff. carrying), Humeral-ulnar angle (H-U angle), follow up time (F/U), range of motion in extension (ROM ext.) and range of motion in flexion (ROMflex.). No difference of all indicators was observed among the groups ($p>0.05$) determine by the Kruskal Wallis test

	crossed pinning (8 cases)		2 lateral pinning (16 cases)		3 lateral pinning (7 cases)		p-value[a]
	Median	min-max	Median	min-max	Median	min-max	
Age (year)	5	3-9	6	2-9	7	3-13	0.540
Diff. carrying	2	0-3	1	0-5	2	0-4	0.899
H-U angle (°)	9.5	6-14	9	5-13	10	6-14	1.000
F/U (week)	12	6-176	12	6-39	8	6-32	0.904
ROM ext. (°)	−2.5	−5-10	−5	−10-10	0	−5-10	0.426
ROMflex. (°)	140	120-145	140	125-145	140	130-140	0.985

[a] : Kruskal Wallis Test

Results

Of the 31 patients included in this study, 20 male and 11 female. 14 cases were right side and 17 cases were left side. The ages of the patients range between 2 and 13 (average 5.97) years. According to Gartland's classification, 24 were type Ⅲ and 7 were type Ⅱ. No preoperative neurovascular compromise was found in all cases. All type Ⅱ fractures were successfully treated with closed reduction, and 5 of 24 type Ⅲ fractures needed open reduction due to unacceptable reduction with closed method. Of 5 cases of open reduction, 2 cases were performed on revision. Initially, 9 cases were fixed with crossed pinning, 7 cases with 2 crossed pinning and 2 cases with 3 crossed pinning (2 pins on lateral and 1 pin on median). Of 18 cases fixed with 2 lateral pinning, 13 cases were classified as type Ⅲ and 5 cases as type Ⅱ. 4 cases were initially fixed with 3 lateral pins, 2 cases were type Ⅲ and 2 cases were type Ⅱ. 4 cases of the patients, all were type Ⅲ, needed revision according to unacceptable alignment. Of 4 cases of revision, 1 case was revised from 2 lateral pinning to 2 lateral pinning, 1 case was revised from 3 crossed pinning to 3 lateral pinning, and 2 cases were revised from 2 lateral pinning to 3 lateral pinning. The revisions resulted in 8 cases remain in the crossed pinning group (a case with 3 crossed pins). 16 cases in the 2 lateral pinning group and 7 cases in the 3 lateral pinning group. The pins were removed between 4 and 6 weeks. Iatrogenic ulnar nerve injury was detected in 2 of 9 cases (22%) initially treated with cross pinning. Both cases had complete recovery at last time follow up, and no ulnar nerve injury was detected in the lateral pinning group.

Using the Kruskal Wallis test to compare between the groups (Table 1), no difference ($p=0.54$) was found on the age of the patients in each group with median age of 5 (3-9) years in the crossed pinning group, 6 (2-9) years in the 2 lateral pinning group and 7 (3-13) years in the 3 lateral pinning group. The follow up times were 6-176 (median = 12) weeks in the crossed pinning group, 6-39 (median = 12) weeks in the 2 lateral pinning group and 6-32 (median = 8) weeks in the 3 lateral pinning group without significant difference in each group ($p=0.904$). The median of the differences of carrying angle from normal side were 2° (0-3°) in the crossed pinning group, 1° (0-5°) in the 2 lateral pinning group and 2° (0-4°) in the 3 lateral pinning group without

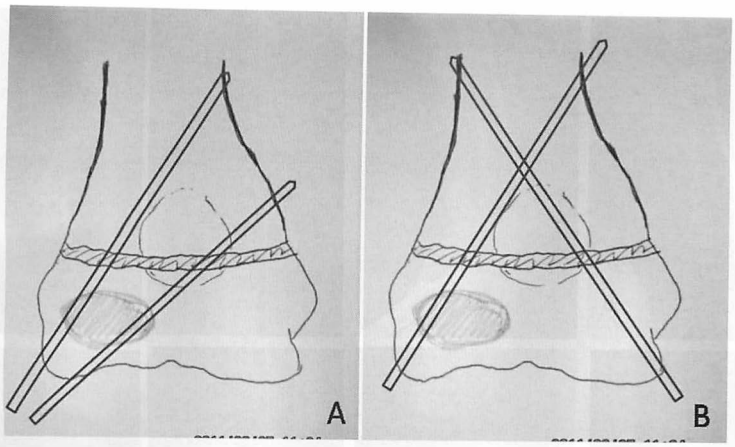

Fig. 1 The proper configurations of the pins (A) 2 lateral pins, each pin should have maximum separation at the fracture site ; the first pin should be inserted in more vertical direction and the second pin should be inserted more distally and penetrate the medial cortex in an adequate distance from the fracture site. (B) 2 crossed pins, each pin should cross each other as much as possible above the fracture site to provide maximum separation at the fracture site

significant differences between each group ($p = 0.899$). The median of the humeral-ulnar angles was 9.5° (6-14°) in the crossed pinning group, 9° (5-13°) in the 2 lateral pinning group and 10° (6-14°) in the 3 lateral pinning group without significant differences among the groups ($p = 1.0$). The range of motion on last follow up in extension had no difference ($p = 0.426$) with the median value of 2.5° (−5-10°) in the crossed pinning group, −5° (−10-10°) in the 2 lateral pinning group and 0° (−5-10°) in the 3 lateral pinning group. No difference were found on range of motion in flexion ($p = 0.985$) with the median value of 140° in all groups, and ranging from 120-145° in the crossed pinning group, 125-145° in the 2 lateral pinning group and 130-140° in the 3 lateral pinning group.

Discussion

The standard stabilization for displaced supracondylar fracture of the humerus in children after reduction is fixation with pins. Crossed pinning has widely been used for a long time because of the evidence supporting its stability. The prevalence of iatrogenic ulnar nerve injury caused by medial entry pin has been reported to vary from 0-20%[2)7)11)12)]. A systematic review by Slobogeoan et al.[13)] suggested iatrogenic ulnar nerve injury occurs in every 28 patients treated with crossed pinning compared with the lateral pinning technique Most of these ulnar nerve injuries had complete recovery, however some cases of persistent ulnar nerve palsy have been reported[7)]. Some authors recommended mini-exploration to identify and protect the ulnar nerve or avoid hyper-flexion during insertion of the medial pin[7)14)15)].

The isolated lateral entry pins can reduce the risk of iatrogenic ulnar nerve injury but the question remains about adequate stability to maintain reduction. A biomechanical study by Zionts et al.[5)] showed that the rotational stability is greatest with two crossed pinning follow by three lateral pinning with the average of 25% less strength. Two lateral pinning in parallel configuration provide an average of 37% less strength. Larson et al.[16)] also found that 3 lateral pin fixation provided stability comparable with crossed pinning except for the torsion strength. Some biomechanical studies in synthetic humeri

Fig. 2 A case of type 3 fracture A & B : before closed reduction, C & D : after closed reduction with 2 lateral pins, the inappropriate insertion points in distal fragment and no penetration of a pin on the medial cortex, E & F after revision with open reduction and fixation with 3 lateral pins, G & H : the fracture healed with appropriate alignment

found that lateral divergent pins have a similar stiffness as two crossed pins with more stiffness in extension and 3 pin configuration had the most stiffness including in mal-reduced specimens[10)17)]. Kocher et al.[11)] held a randomized clinical trial in type 3 fracture and found no difference between lateral pinning and crossed pinning in ability of reduction maintenance and functional result. In that study, the lateral pins configuration were divergent and parallel. Adding a third lateral entry pin will give more stability for the lateral pinning technique. A prospective randomized study in 104 type 3 fractures by Gaston et al.[18)] found no statistical significance for the number of cases had significant change of post operative alignment between the crossed pinning and lateral pinning groups. The configurations of lateral pinning in his study were parallel or divergent. Eight patients in the crossed pinning and 5 patients in the lateral pinning group had to add a third pin due to uncertain stability. The rate of iatrogenic ulnar nerve injury in this study from the cases of our pilot study compared between the crossed pinning and lateral pinning is 22% in only the group initially treated with crossed pinning. No ulnar nerve injury was found in the lateral pinning group. A common problem of 2 lateral pinning is the difficulty to pass the pins in divergent directions. The first pin has to be inserted in a more vertical direction in order to pass the fracture site in the lateral column and penetrate the medial cortex proximally far from the fracture site. The second pin also needs a more distal insertion point to achieve the greatest separation of the pins at the fracture site and penetrate the medial metaphyseal fragment above the fracture site in a distance adequate for stable fixation (Fig. 1). This difficulty will have more effect with an inexperienced orthopedist. From the review on three cases of the lateral pinning group that needed revision, all had an error on fixation technique (Fig. 2). The pin

Fig. 3 A case of type 3 fracture referred from another hospital after closed reduction with 3 crossed pinning A & B : before closed reduction, C & D : after closed reduction and fixation with 3 crossed pins, there had been an extension of the distal fragment because 2 pins penetrated the fracture site at the same point and the third pin passed the fracture site without any fixation on the distal fragment, E & F : revision was done at a week after injury with closed reduction and fixation with 3 lateral pins, G & H : the fracture healed with appropriate alignment

configuration also had an effect on the crossed pinning technique as we had a case that was sent from another hospital because of unacceptable alignment after reduction and fixation with 3 crossed pins (Fig. 3). To achieve maximal stability from the crossed pins, the pins should cross as much as possible above the fracture site to provide the greatest separation of the pins at the fracture site (Fig. 1). If an effective configuration of pins was not achieved, the third pin will increase the stability of fixation[18].

As mentioned previously, we had three cases in the two lateral pinning group requiring revision, successfully revised with two lateral divergent pins in one case and three lateral pins in the other two cases. At present, we decided to use three lateral pins to increase stability without increasing the risk of iatrogenic ulnar nerve injury. After fixation, the stability was checked by moving the elbow in flexion and extension under fluoroscope. If the stability was in question, the configuration of the pins was adjusted. A limitation of this study was that only a small number of cases could be collected and it was not a randomized control study. Further studies are needed before making a clear conclusion. We did not carry out the randomized control study because of our high incidence of ulnar nerve injury from the pilot study, so we abandoned the medial and lateral crossed pinning technique. In our hospital, we recommend using 3 lateral pins for fixation of Gartland type 3 fractures to increase stability. If a surgeon decided to continue using lateral and medial entry crossed pins, the medial pin must be inserted with the elbow in extension and a mini-incision to identify and protect the ulnar nerve

should be performed.

In conclusion, we suggest that three lateral pins for fixation of a supracondylar fracture of the humerus in children provides adequate stability without any risk of iatrogenic nerve injury.

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