

LATERAL DIVERGENT PINNING VERSUS LATERAL PARALLEL PINNING IN MANAGEMENT OF SUPRACONDYLAR FRACTURES OF THE HUMERUS IN CHILDREN

By

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ABSTRACT

Background: Supracondylar humerus fracture in children is a very common elbow injury. The commonly accepted treatment of type II and III supracondylar fractures of humerus in children is closed reduction with percutaneous pinning. Lateral pinning has an advantage of avoiding the possibility of iatrogenic ulnar nerve injury.

Objective: This study was conducted to compare the stability of lateral divergent pinning and lateral parallel pinning in treatment of type II and type III supracondylar humerus.

Patients and Methods: A prospective, randomized, single Centre, study was conducted at the Emergency Department of Al-Azhar university hospitals from March 2019 to November 2019. Thirty children with supracondylar humerus fracture Gartland type IIB and type III were treated with two techniques: lateral divergent (15 patients), and lateral parallel (15 patients). All of them were included for the study and analysis of results regarding functional outcome and graded according to Flynn's criteria and Baumann's angle.

Results: Thirty children were treated for displaced supracondylar fracture of humerus during the study period, 9 females and 21 males, and mean age was 5.1 years. The mean duration from admission to surgery was 17.3 hours; the mean follow-up duration was 3 months. In lateral divergent pinning group, 14 patients with excellent result and one good. In lateral parallel pinning technique 13 patients with excellent and 2 good.

Conclusion: There was no statistically significant difference with regard to functional outcome between the two groups. Both methods produced satisfactory results in all cases.

Keywords: Supracondylar fracture humerus, divergent, parallel, lateral, Kirschner wires.

INTRODUCTION

Supracondylar fractures are the most common pediatric fracture. Humeral fractures are common in the pediatric population and account for almost 70% of elbow fractures. The incidence peaks between the ages of 5 - 8 years (Wilkins,

2010). These fractures are either extension or flexion type with varied mechanism of injury. Extension type fractures account for 96-99% of all supracondylar fractures (Abzug and Herman, 2012). Supracondylar fractures are commonly classified based on the Gartland system of classification, where they are divided into

three types: Type I being non-displaced, type II being displaced but with an intact posterior cortex, and type III being displaced and without any cortical contact (*Leung et al., 2018*).

Although type I is generally treated nonoperatively, type II and type III are generally managed with closed reduction and pinning in order to avoid malunion (*Mulpuri et al., 2012*). Optimal pin configuration and the number of pins required to provide adequate fracture stability to maintain reduction and promote proper union, while minimizing the risk of neurovascular injury remain issues of debate (*Brighton et al., 2016*).

The original technique involved the use of one lateral and one medial pin inserted percutaneously but some authors have reported iatrogenic ulnar nerve injury rates of up to 10% for medial pin placement, and have advocated lateral pin fixation alone to reduce this complication (*Shtarker et al., 2014*).

Although these nerve injuries usually resolve within a year, persistent ulnar nerve palsy has also been reported (*Valencia et al., 2015*). Moreover, authors of retrospective clinical studies have concluded that pin insertion through the lateral condyle alone, which avoids injury to the ulnar nerve, is as clinically effective as crossed-pin insertion through the medial epicondyle and lateral condyle in stabilizing supracondylar humeral fractures (*Woratanarat et al., 2012*).

The aim of this work was to compare the results of the lateral divergent and the lateral parallel pinning in 30 children below 10 years with Gartland types II and III supracondylar humeral fractures.

PATIENTS AND METHODS

This prospective randomized-controlled trial was conducted in Al-Azhar university hospitals during the period from March 2019 to November 2019 including 30 children below 10 years with Gartland types II and III supracondylar humeral fractures, and a follow up period of 3 months. The patients were divided into two equal groups. Patients in group I were managed with lateral divergent pinning, and those in group II were managed with lateral parallel pinning.

Patients scheduled for closed reduction and K wiring of supracondylar fractures of the humerus under general anaesthesia were type II or III supracondylar fractures of the humerus. Patients were below 10 years, and Consent was obtained from the child guardian to participate in the study. The exclusion criteria were open fractures, fractures with vascular injury, fractures with compartmental syndrome, fractures with pre-operative ulnar nerve injury, and refusal to provide an informed consent.

All the children with suspected supracondylar fracture of elbow were seen at the Emergency Department. 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 splint with elbow in 90 to 120 degrees of extension. Elevation and ice compression were advised. Surgery was planned and technique was selected according to random number generated by computer,

and was enveloped securely so as to be opened at surgery time.

Surgical techniques were standardized in terms of pin location, the pin size (1.6mm to 2mm), stability on table, position of elbow for pins placement and the post-operative course.

General anesthesia was used for all patients, no tourniquet was needed. The reduction was done while maintaining constant traction with varus-valgus

correction controlling rotation of the fracture by the medial and lateral humeral epicondyles. The elbow was then hyperflexed using thumb pressure over the olecranon to reduce the fracture, and the forearm was then fully pronated as this controls the medial rotation and with flexion locks the fracture in place. The fracture was fixed either by the lateral parallel (Fig 1) or the lateral divergent (Fig 2) method according to the randomization.

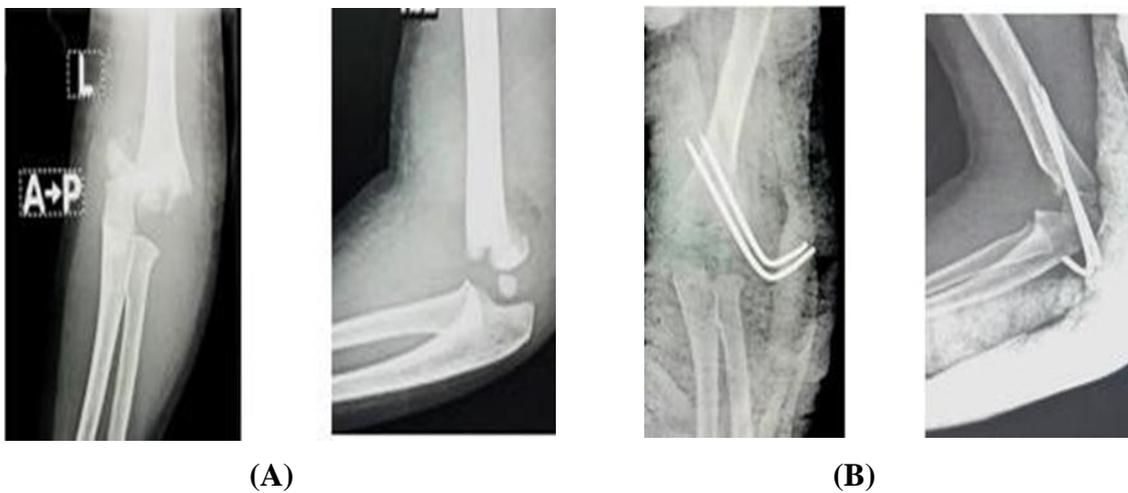


Figure (1): Male patient 3.5 years old with left supracondylar humerus fracture, lateral parallel technique a) preoperative x-ray, b) postoperative x-ray.



Figure (2): Male patient 8 years old with left supracondylar humerus fracture, lateral divergent technique a) preoperative x-ray, b) postoperative x-ray.

Elbow was immobilized with posterior slab with elbow in 90 to 120 degree of flexion depending upon the swelling and neurovascular status. All the patients were followed up at the orthopedic out-patient clinic and reviewed. Plaster slab was usually removed after 4 weeks. Radiographic evaluation was performed by antero-posterior and lateral radiographs of the elbow.

All the patients were evaluated at one week, two weeks, four weeks, six weeks, two months and three months. Neurovascular examination was performed preoperatively and immediate posts operatively and at one week follow

up. In both groups K wires were removed after four weeks. At the three months follow up children were evaluated for full function according to Flynn's criteria for grading involving the evaluation of carrying angle loss (cosmetic), flexion and extension loss. . Carrying-angle loss excellent (0° – 5°), good (5° – 10°), fair (10° – 15°), and poor ($>15^{\circ}$) when compared to normal side. Flexion loss and extension loss values according to Flynn's criteria excellent (0° – 4°), good (5° – 9°), fair (10° – 15°), and poor ($>15^{\circ}$) when compared to normal side. (*Skaggs et al., 2010* -Table 1).

Table (1): Modified Flynn's criteria to evaluate outcome of treatment

Results \ Parameters	Rating	Carrying angle loss	Flexion loss	Extension loss
Satisfactory	Excellent	0-4	0-4	0-4
	Good	5 to 9	5 to 9	5 to 9
	Fair	10 to 14	10 to 14	10 to 14
Unsatisfactory	Poor	>15	>15	>15

Statistical analysis:

Data were statistically described in terms of mean \pm standard deviation (\pm SD). Comparison between the study groups was done using Mann-Whitney test, All data were compiled and

calculated by SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA). Significance of difference was measured by determining P-value, and value less than <0.05 was considered significant.

RESULTS

The mean age at presentation was about 5.1 years (range: 1.5–9 years). The study included both sexes: 9 (30%) were females and 21 (70%) were males. The mode of trauma was fall to the ground in 19 patients, fall downstairs in 7 patients and fall from height in 4 patients. The

study included 2 cases of flexion type, and 28 cases of extension type. The left side was in 18 cases, and the right side was in 12 cases. Gartland grade II was present in 3 cases, and Gartland grade III was present in 27 cases (**Table 2**).

Table (2): Type, grade and side of fracture of the study group

Type and side of fracture		The study group (No = 30)
Type		
-	Flexion	2(6.67%)
-	Extension	28(93.33%)
Side		
-	Right	12 (40%)
-	Left	18 (60%)
Grade of fracture according to Gartland		
-	Grade II	3 (10%)
-	Grade III	27(90%)

The carrying angle loss in parallel pinning group was in 13 patients excellent (86.67%), and 2 good (13.33%). In divergent pinning group, 14 were excellent (93.33%), and one good (6.67%). The mean loss in carrying angle in patients treated by divergent pinning was 3.4 ± 1.35 O (range: 2O-6O), while that in patients treated with parallel pinning was 2.8 ± 1.03 O (range: 2O-5O).

The extension loss in parallel pinning group was in 14 (93.33%) excellent, and one good (6.67%). In divergent pinning group, there were 15 (100%) excellent. The mean loss in elbow extension in patients treated with divergent pinning fixation was 2.4 ± 1.1 O (range: 0O-4O), while that in patients treated with parallel

pinning fixation was 2.8 ± 1.2 O (range: 2O-6O).

The flexion loss in parallel pinning group was in 14 cases (93.33%) excellent, and one good (6.67%). In divergent pinning group, there were 14 cases (93.33%) excellent, and one case good (6.67 %). The mean loss in elbow flexion in patients treated with divergent pinning fixation was 3.2 ± 1.2 O (range: 2O-6O), while that in patients treated with parallel pinning fixation was 3.1 ± 2.1 O (range: 0O-8O).

The mean Baumann angle loss in the divergent pinning fixation group was 2.3 ± 1.63 O (range: 0O-5O) and in the parallel pinning fixation group was 2.8 ± 1.68 O (range: 0O-5O) (**Table 3**).

Table (3): Statistical analysis of lateral divergent pin fixation and lateral parallel pin fixation

Fixation Parameters	Lateral divergent pinning fixation (Mean \pm SD) (n=15)	lateral parallel pinning fixation (Mean \pm SD) (n=15)	P value (Mann-Whitney test)
Carrying angle loss	3.4 ± 1.35	2.8 ± 1.03	0.452
Elbow extension loss	2.4 ± 1.1	2.8 ± 1.2	0.805
Elbow flexion loss	3.2 ± 1.2	3.1 ± 2.1	0.723
Baumann angle loss	2.3 ± 1.63	2.8 ± 1.68	0.417

Comparing results of both techniques according to Flynn`s criteria following lateral divergent pinning, excellent results were found in 14 cases (93.33%), and good results in 1 case (6.67%). Following

lateral parallel pinning, excellent results were found in 13 cases (86.67%), and good results in 2 cases (13.33%) (**Figure 3**).

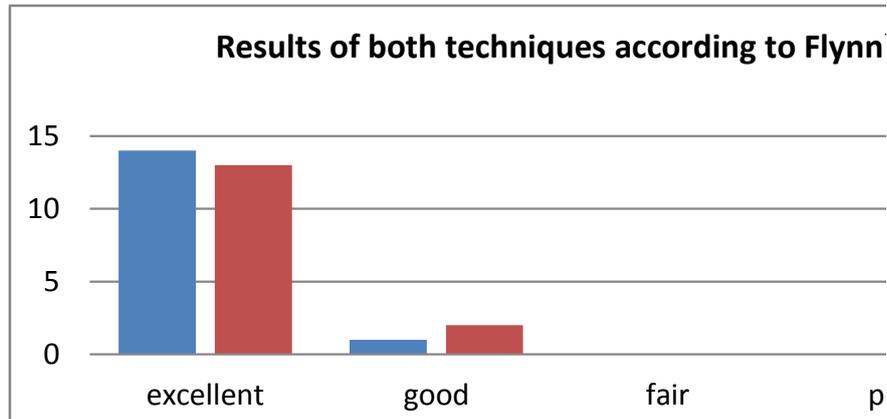


Figure (3): Results of both techniques according to Flynn`s criteria

Pin tract infection was present in one patient and treated by lateral pinning fixation. For this patient, pin site cleaning by removal of crusts, wires and repeated

dressing using Neomycin spray as local antibiotic and oral antibiotic (Amoxicillin-clavulanic acid) lead it to recover at the subsequent follow-up.

Table 4: Complications of the fracture of the study group

Complications of the fracture	The study group N = 30
Nil	29 (96.67%)
Pin tract infection	1 (3.33%)

No neurovascular injury or deficit that required exploration was encountered. There was no case of compartment

syndrome or Volkmann ischemic contracture on the last clinical review.

DISCUSSION

The main goal of surgery in pediatric supracondylar humerus fracture is the safe creation of a construct that is stable enough to prevent axial rotation and hyperflexion and extension of the distal fragment and thus avoid postoperative deformity (*Howard et al., 2012*), which

has been reported to be as high as 17% (*Vallila et al.,2015*).

Closed reduction with percutaneous pin fixation for the management of displaced or angulated supracondylar humeral fractures in children has become widely adopted, but optimal pin configuration remains controversial (*Edmonds et al., 2012* and *Prashant et*

al., 2016). Open reduction is usually unnecessary, although it sometimes can be required to obtain complete reduction especially in cases in which the fracture cannot be reduced because of the presence of a vascular lesion (*Muchow et al.*, 2015).

In our study, the fractures that were treated using both techniques did not show fixation loss, the mean follow-up duration of the 30 patients was 3 months (range: 2.8 - 3.2 months). Above elbow slab were made for all the patients whom continued for 4 weeks duration post-operation. Twenty nine of them regained their full range of elbow motion after removal the slab through one week. One patient achieved full elbow motion after removal above elbow slab through 2 weeks.

Malunion in the coronal plane was assessed both clinically by measuring the carrying angle at last follow-up and radiologically by measuring the Baumann angle at 12 weeks after treatment. Based on these clinical and radiological Parameters, we were not able to find any difference in the change of coronal and sagittal plane alignments of the distal fragment after treatment with the two methods of pin fixation.

Since the enrolment of both groups was randomized, and the standard protocol of reduction was applied for both groups, we considered the change of alignment in any plane at the end of the study period was due to loss of reduction during healing process in the cast. In other words, they reflect the stability of fixation in clinical setting. Therefore, we can consider that there was no difference in the stability of fixation provided by either the lateral divergent pinning or the lateral parallel pinning.

There were no patients with a carrying-angle loss of 10° or more compared to the opposite elbow. More than 10° loss in carrying angle may lead to development of cubitus varus deformity. The cubitus varus may need to be corrected not only for cosmetic appearance, but also to avoid tardy posterolateral rotatory instability of the elbow in future (*Mazda et al.*, 2011). We found No iatrogenic neurovascular injuries during the study in patients treated with both techniques.

All our patients had good nail or pulp perfusion, and in all the patients these findings were maintained throughout the period of traction, manipulation, pin fixation, and in slab. None of the patients in our series developed evidence of ischaemic contracture to suggest muscle necrosis at follow-up.

Lu et al. (2012) in a prospective study from Feb. 2004 to Jun. 2010; 128 cases of supracondylar humerus fractures in children (96 boys and 32 girls) were treated by manipulative reduction and lateral percutaneous K-wire fixation, all these children were followed up from 2 to 36 months (16 months on average). According to Flynn evaluation standard, the result were excellent in 116 children (90.6% of the total patients), good in 11 (8.6%), fair in 1 (0.8%), no infection, no ischemic muscular atrophy and no nerve damage had been found during the treatment. They concluded that manipulative reduction and lateral percutaneous K-wire fixation of supracondylar humerus fractures in children is stable and reliable, easy to be operated, safe and effective and low cost, and it can also avoid the complication caused by conservative treatment and

operation. It is a good treatment of supracondylar humerus fractures in children.

Mulpuri and Wilkins K (2012) showed that crossed pins do provide more torsional stability than do 2 lateral pins but do not offer significantly more torsional stability than do 3 lateral pins.

Chakraborty et al. (2011) reported a retrospective study of 92 children. 56 were fixed by medial and lateral crossing wires and 36 were fixed by 2 lateral wires, there 4 cases of iatrogenic ulnar nerve injury in crossing wires and 4 cases of radial nerve injury in 2 lateral wires. There were 4 cases of cubitus varus in crossing wires and 10 cases of cubitus varus in 2 lateral wires. 4 cases of ulnar nerve injury were explored.

Anwar et al. (2011) reported a prospective study of 50 children, 25 were fixed by medial and lateral crossing wires and 25 were fixed by 2 lateral wires, as regard carrying angle loss according to Flynn,s criteria the results were excellent in 72% and good in 28% in both methods, the mean loss of elbow flexion and extension were 8.36 and 7.26 respectively. There was one case of iatrogenic ulnar nerve injury in crossing wires.

Maity et al. (2012) reported a prospective study which was long term study between October 2007 and October 2010 of 160 children, 80 in each group. The follow up duration was 3 months. 30 of 160 children did not complete the follow up visits. Reported that there was no significant difference between the two methods as regard results and complication.

Guy et al. (2011) reported in a prospective study of 25 children were fixed by three lateral divergent wires the mean follow up period was 5 months , as regard Flynn's criteria excellent results was in 21 cases, good in 3 cases, and poor in one case.

Zhao et al. (2013) performed a meta-analysis of randomized controlled trials included 521 patients to compare the risk of iatrogenic ulnar nerve injury caused by pin fixation, the quality of fracture reduction in terms of the radiographic outcomes, and function in terms of criteria of Flynn, and elbow range of movement, and other surgical complications caused by pin fixation, suggested that iatrogenic ulnar nerve injury was higher with the crossed pinning technique than with the lateral entry. There were no statistical differences in radiographic outcomes, function, and other surgical complications. They conclude that the medial and lateral crossed pinning fixation is more at risk for iatrogenic ulnar nerve injury than the lateral pinning technique.

CONCLUSION

There was a statistically insignificant difference between lateral divergent and parallel pinning technique in terms of stability, duration of bone healing, loss of reduction and neuro-vascular injuries. Divergent or parallel pin fixation were effective and safe in avoiding iatrogenic ulnar nerve injury, and were appropriate options for providing stable fixation of displaced or angled supracondylar humeral fractures in children.

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مقارنة بين إستخدام أسلاك معدنية من الجانب الخارجي متباعدة وإستخدام أسلاك معدنية من الجانب الخارجي متوازية في علاج حالات كسور أسفل عظمة العضد في الأطفال

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خلفية البحث: يعد كسر أسفل عظمة العضد عند الأطفال من أكثر الكسور حدوثاً في تلك الفئة العمرية و حول منطقة الكوع. بالنسبة للكسور من النوع الثاني والثالث طبقاً لتقسيم جارتلاند فإن الرد المغلق للكسر والتثبيت بواسطة أسلاك معدنية من خلال الجلد يعتبر الطريقة الأنسب لعلاج هذه الكسور وأن إستخدام الأسلاك من الناحية الخارجية فقط يتميز بتجنب إحتمال إصابة العصب الزندي للطفل.

الهدف من البحث: المقارنة بين إستخدام الأسلاك المعدنية من الناحية الجانبية الخارجية بطريقة متوازية، وطريقة متباعدة لتثبيت كسور أسفل عظمة العضد عند الأطفال من النوع جارتلاند النوع الثاني والثالث.

المرضي وطرق البحث: تم إجراء دراسة مستقبلية ذات عينة عشوائية للمرضي في قسم الطوارئ في مستشفيات الأزهر الجامعي في الفترة من مارس ٢٠١٩ إلى نوفمبر ٢٠١٩، وفيها تم علاج ٣٠ طفل يعانون من كسر أسفل عظمة العضد من النوع جارتلاند (النوع الثاني (ب) والثالث) بتقنيتين: إستخدام أسلاك معدنية متباعدة (١٥ مريضاً)، وإستخدام أسلاك معدنية متوازية (١٥ مريضاً)، وقد تم ضم جميع

المرضي للدراسة و تحليل النتائج الوظيفية والتي تم تصنيفها وفقا لمعايير فلين وزاوية بومان.

نتائج البحث: في خلال فترة الدراسة تم علاج ٣٠ طفلاً يعانون من كسر أسفل عظمة العضد كان منهم ٩ إناث و ٢١ ذكور، وكان متوسط العمر ٥,١ سنة، و متوسط المدة من دخول المستشفى إلى الجراحة هي ١٧,٣ ساعة، و متوسط مدة المتابعة ٣ أشهر، وفي المجموعة التي تم فيها استخدام أسلاك متباعدة كانت نتائج ١٤ مريضاً ممتازة و مريض نتائج جيدة، وفي المجموعة التي تم فيها استخدام أسلاك متوازية كانت نتائج ١٣ مريضاً ممتازة و مريضين نتائج جيدة.

الاستنتاج: لا يوجد فرق إحصائي بين استخدام الطريقتين في تثبيت الكسر أسفل عظمة العضد عند الأطفال، وكلا الطريقتين أعطت نتائج مرضية لكل المرضي.