Two Lateral Divergent Wires Versus Crossed Wires in Pediatric Supracondylar Humeral Fractures; Stability and Safety

Mahmoud Ahmed El-Desouky[1], MD; Hassan Magdy El-Barbary[2], MD and Sherif Hamdy Zawam[1], MD

Department of Orthopedics and Traumatology, Faculty of Medicine, Cairo University
1- Lecturer of orthopedic surgery
Department of Orthopedics and Traumatology, Faculty of Medicine, Cairo University
2- Professor of orthopedic surgery
Department of Orthopedics and Traumatology, Faculty of Medicine, Cairo University

Corresponding author: Mahmoud Ahmed El-Desouky
Address: Hadayek El-Ahram - Giza
Tel: 01004223520
Email: madesouky@gmail.com

The Egyptian Orthopedic Journal; 2021 supplement (1), June, 56: 55-59

Abstract

Background:
The standard treatment method in displaced supracondylar fractures in pediatrics is closed reduction and K-wires pinning. Choosing between either lateral divergent pinning or crossed medial and lateral pinning methods is controversial. The aim of this study was to compare both techniques functionally and radiologically.

Patients and methods:
Seventy-three children with supracondylar humeral fractures Gartland type III with intact vascularity were treated with either lateral divergent pinning or crossed medial and lateral pinning techniques. Then they were followed up and assessed for the stability of reduction, healing, range of motion (ROM), and any complications such as pin tract infection, or ulnar nerve injury.

Results:
The average time to union was 4.2 weeks. There were no significant differences between both groups in the average lag period before surgery, loss of reduction, and functional outcome (P = 0.135, 0.736, 0.882 respectively). There was a significantly longer operative time in the Crossed pinning group (P<0.001). No significant difference was noted in the complications rate.

Conclusion:
Both techniques are equally safe and stable when applied properly. The surgeon can choose any of both techniques according to his familiarity with its steps and his preference. Both provide comparable results. However, if the medial wire insertion was not done properly, and following all the precautions, ulnar nerve injury may be encountered.

Level of Evidence: Therapeutic study, level IV

Keywords:
supracondylar fracture, K-wires, lateral pinning, crossed pinning.

Introduction

Supracondylar fractures of the humerus (SCH) represent about 60% of elbow fractures in the pediatric population. The extension type is the most common pattern (95%). According to Gartland, they are classified into 3 types; I (non-displaced fractures), II (hinged fractures), and type III (totally displaced fractures). [1,2]

The standard treatment for Gartland type III fractures is closed reduction and percutaneous pinning [3,4]. Crossed medial and lateral wires as proved by several studies provide better fracture stability. However, this technique may carry a higher risk for ulnar nerve injury. Using two divergent lateral wires for fixation may be less stable but almost abolishes the risk of ulnar neurapraxia [5,6]. Controversy still persists about the best wires configuration that provides the needed stability, faster union, fewer complications, and low or no ulnar or radial nerve injury.

Our randomized controlled trial aimed to compare both techniques in the management of Gartland type III supracondylar humeral fractures regarding the functional outcome, stability of fixation, and complication rate.

Patients and methods

This is a prospective, randomized controlled clinical trial that was conducted from June 2017 to June 2019. Our study included

children with closed Gartland Type III supracondylar humeral fractures, extension type, below the age of 13, presenting to the Emergency Room (ER) in a tertiary trauma center. Children with any associated fractures of the same limb, fractures of flexion type, or neurovascular injury requiring exploration were excluded.

Eighty patients included in our study were randomized by the even/odd numbers technique into 2 groups. Group A; 40 cases (even numbers) were treated by lateral divergent pinning (Lateral pinning group), and Group B; 40 cases (odd numbers) were treated by crossed medial and lateral pinning (Crossed pinning group).

Open reduction was needed in one case in group (A) after unsuccessful trials of closed reduction and this case was excluded from our study. Other 6 cases were excluded because they didn't complete a 6-months follow-up period (4 in group A and 2 cases in group B). At the end of our study, we had 35 cases in group (A) and 38 cases in group (B).

After clinical and radiological assessment of patients in the ER, a posterior slab was applied and they were prepared for surgery. Parents of every child enrolled in this study were informed about the procedure and randomization system and signed informed consent before surgery. Surgery was done under general anesthesia in a supine position with the patients' affected arm off the operating table. Tourniquet was applied but not inflated unless open reduction was needed. After sterilization and draping, the reduction was achieved by traction and checked using the image intensifier in the anteroposterior view first. Then the elbow was flexed while maintaining traction and reduction was rechecked in the lateral view. At this stage, reduction may be helped by pronating or supinating the forearm.

After confirming satisfactory reduction, in group (A), 2 K-wires were introduced for fixation with the first one was inserted from a point just lateral to the capitellum aiming superiorly and medially followed by the second wire which was inserted from the same entry point. Wires had to be divergent, and engaging through the medial cortex, with the distance between them on the medial cortex should be more than one-third of the fracture width (Figure-1).

Fig. (1): Intraoperative radiographic view of lateral divergent pinning technique.

In group B, a lateral wire was inserted firstly in the same manner as in group (A). Then, the elbow was extended to 30:45 degrees, and a 1 cm incision was taken directly over the medial epicondyle. Dissection was done until the medial epicondyle was reached and seen. The medial wire was introduced from the medial epicondyle as anteriorly as possible through open Mosquito forceps and directed to the lateral supracondylar ridge (Figure-2).

Fig. (2): Intraoperative radiographic view of crossed pinning technique.

Reduction, stability, and wires position were re-checked by the image intensifier. Vascular status was checked and the wires were bent, and cut with 1 or 2 centimeters protruding from the skin. Betadine-soaked gauze was rolled around the wires. After that, they were left in the posterior slab in 90^{o} elbow flexion and discharged the next day after surgery.

Patients were followed-up clinically and radiologically every week until 6 weeks postoperatively for assessment of healing and early complications (Figure-3,4). The slab was changed after 2 weeks and pins were checked for possible pin tract infection. Slab and wires were removed after healing was confirmed radiologically and range of motion exercises were encouraged. Then follow-up visits were arranged at 3 months for assessment of the stability of reduction using **Skaggs grading** and at 6 months for assessment of functional outcome using **Flynn criteria** and late complications [7,8].

Data were summarized using the mean and standard deviation or count and percentages. Comparisons were done using unpaired t-test or Chi-square *tests. P-values < 0.05 were considered as statistically significant. SPSS 28 was used.

Fig. 3: Post-operative x-rays of lateral divergent wires configuration.

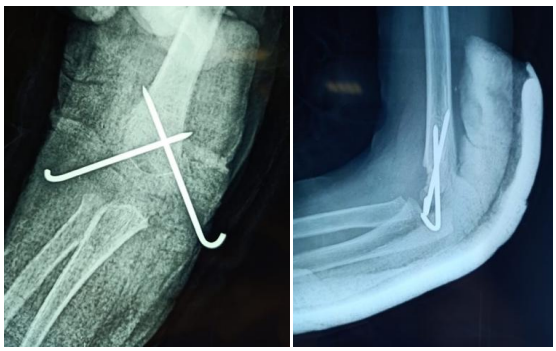

Fig. 4: Post-operative x-rays of crossed wires configuration.

Results

Patients included in our series were 73 cases whose ages ranged from 3 to 13 years old. There were 44 males (60.1%) and 29 females (39.9%). The injury resulted from fall to the ground (FTG) in 66 patients (90.4%), road traffic accidents (RTA) in 6 cases (8.2%), and fall from height (FFH) in one case (1.4%). There was no statistically significant difference in demographic features between both groups (Table-1).

Table (1) Patient Demographics.

	Group (A) Lateral wires n = 35	Group (B) Crossed wires n = 38	P value
Mean Age (Range)	6.8 (3-11)	7.3 (3-13)	0.726
Sex: Males	19 (54.3%)	25 (65.8%)	0.320
Females	16 (45.7%)	13 (34.2%)	
Side: Right	16 (45.7%)	21 (55.3%)	0.425
Left	19 (54.3%)	17 (44.7%)	
Mode of injury: FTG	32 (91.4%)	34 (89.5%)	0.904
RTA	2 (5.7%)	4 (10.5%)	
FFH	1 (2.9%)	0 (0%)	

Surgery was done after an average time of 1٠.2 ± 8.3 hours for the Lateral pinning group and 9.4 ± 6.2 hours for the Crossed pinning group. There was no significant difference in the lag period between the two techniques (P=0.153). The mean operative time was significantly longer in the Crossed pinning group as it was 38.8 ± 6.1 minutes when compared with the Lateral pinning group 27.0 ± 4.6 minutes (P<0.001). The average time to union was 4.2 weeks (ranging from 3 to 5 weeks).

Regarding loss of reduction which was assessed by **Skaggs grading** (based on the change in Baumann angle measurement between recent postoperative x-rays and those at 3 months follow-up), most of the cases showed no loss of reduction (91.4% in the Lateral pinning group versus 97.5% in the Crossed pinning group) and there was no significant difference between both groups (P=0.736) (Table-2).

According to **Flynn Criteria** (based on measurement of loss motion and loss of carrying angle at 6 months follow-up), there was no significant difference between both groups (P=882).

Table (2): Assessment of loss of reduction by Skaggs grading and functional outcome by Flynn criteria.

		Group (A) Lateral wires n = 35	Group (B) Crossed wires n = 38	P-value
Skaggs grading (Loss of reduction)	No (<6°)	32 (91.4%)	37 (97.4%)	0.736
	Mild (6-12°)	2 (5.7%)	1 (2.6%)	
	Major (>12°)	1 (2.9%)	0 (0%)	
Flynn Criteria (Functional outcome)	Excellent	26 (74.3%)	30 (78.9%)	0.882
	Good	7 (20%)	7 (18.4%)	
	Fair	2 (5.7%)	1 (2.6%)	
	Poor	0 (0%)	0 (0%)	

Pin tract infection was experienced in 6 cases; 3 cases in each group, and it was managed successfully by oral antibiotics and repeated dressing. Two cases in the Crossed pinning group (5.3%) had mild tingling and numbness along the distribution of the ulnar nerve, with no motor deficits, and these symptoms resolved within 2 weeks. There were no cases with iatrogenic vascular injuries or union problems.

Discussion

Pediatric supracondylar fractures of the humerus (SCH) are the most common elbow fractures in children. They represent about 60% of pediatric elbow fractures. Thorough clinical assessment is crucial to exclude associated neurovascular injuries. Closed reduction and percutaneous pinning is the standard method of treatment. Several studies were conducted in order to identify the best pattern of wires placement [1,3,4].

Classically crossed medial and lateral wires are known to have better biomechanical stability. Several studies had adopted this hypothesis. In 11 out of 80 cases (14%) studied by Kallio et al., loss of reduction occurred when two lateral pins had been used [9].

It is believed by others that reduction stability is not related to the configuration of pinning but strongly related to the use of the proper technique. So, lateral pinning may have comparable reduction stability with crossed pinning if performed properly. Wires in the lateral pinning technique must engage the medial cortex with divergence which is more than one-third of the fracture width [10,11]. In a study made by Skaggs et al. on 55 cases fixed by lateral pins, no cases were complicated by loss of reduction [7].

In many previous studies, ulnar nerve injury was encountered especially with the medial and lateral crossed wires technique. Although most of the ulnar nerve injuries were transient with spontaneous recovery, some injuries continued for long durations and required further intervention [12-14].

The risk increases if the medial wire is taken with the elbow in flexion as the ulnar nerve becomes stretched and may slide over the medial epicondyle. In Skaggs et al series study, no cases were complicated by ulnar nerve injury in the 125 cases treated by lateral pins. But, in the group treated by crossed medial and lateral wires, ulnar nerve injury occurred in 6 cases (4%) out of 149 patients when the pin was applied with the elbow in slight extension, and in 11 cases (15%) out of 71 cases when the elbow was in hyperflexion. One of the 17 cases, had persistent sensory and motor deficit after 2 years [5].

Our study was conducted on 73 patients with Gartland extension type III supracondylar fractures, aged from 3 to 13 years. The mean age in group A (Lateral pinning) was 6.8 years and in group B (Crossed pinning) was 7.3 years. There were 16 female patients and 19 males in the Lateral pinning group, 13 female patients, and 25 male patients in the Crossed pinning group. The average operative time of the Crossed pinning group was significantly longer than in the Lateral pinning group (38.8 versus 27.0 minutes).

According to Skaggs grading for loss of reduction, mild loss was observed in 2 cases (5.7%) in the Lateral pinning group compared to one case (2.6%) in the Crossed pinning group. Major loss was seen in one case only in the Lateral pinning group. According to Flynn grading, excellent outcome was obtained in 26 cases (74.3%) and 30 cases (78.9%) in group A and B respectively. Good outcome was present in 7 cases in each group. Fair outcome was present in 2 cases (5.7%) in group A compared to 1 case (2.6%) in group B.

Pin tract infection was experienced in 3 cases in each group and transient ulnar nerve neurapraxia was seen in 2 cases (5.3%) in the Crossed pinning group.

In a comparative study made by Naik et al, 28 cases were done with lateral wires only (group A) and 29 cases with crossed medial and lateral wires (group B). In group A, the average operative time was 28.3±1.6 minutes compared to 30±3.6 minutes in group B (p value=0.02). According to Flynn criteria, regarding the carrying angle loss, the results were excellent in 22(78.6%) cases, good in 5(17.9%) cases and poor in 1 case (3.5%) in group A. While in group B, 23 (79.3%) cases had excellent results and 6 (20.6%) cases had good results. The range of motion loss was satisfactory in twenty-seven cases (96.4%) in group A compared to 29 cases (100%) in group B. Ulnar nerve injury didn't occur in group A, while 2 cases (6.8%) had ulnar neurapraxia in group B [15].

Fifty-five cases were reviewed prospectively by Foaed et al and followed up for an average period of 8.93 months. According to Flynn grading in the 2 lateral wires group, 22 cases (81.5%) had excellent, 2 cases (7.4%) had good, 1 case (3.7%) had fair and 2 cases (7.4%) had poor results. While in the group treated by medial and lateral crossed wires, 21 cases (75%) had excellent, 4 cases (14.3%) had good, 2 (7.1%) had fair and 1 case (3.6%) had poor results. On the lateral pins group, 2 cases had ulnar nerve injury and 1 case

had radial nerve injury. Ulnar nerve injury occurred in 5 cases in the crossed pinning group. All the differences were not statistically significant [16].

We conducted a prospective series and we included functional and radiographic assessment of cases. These are strength points in this study. The short period of follow-up (6 months) was one of the limitations in this study but we had to deal with the fact that in these pediatric fractures usually there is rapid healing and functional improvement. So, the parents are not interested or compliant with longer-term follow-up. But the results of our series were encouraging and unlike what was previously known that crossed pinning has higher stability of reduction we found no significant difference compared to the lateral pinning configuration if done properly.

Conclusion:

We recommend that both techniques are equally safe and stable when applied properly. The surgeon may choose any of both techniques according to his familiarity with its steps. Both provide comparable results. However, if the medial wire insertion was not done properly, following all the precautions, ulnar nerve injury may be encountered.

References

1. Herring JA (2002) Tachdjian's Pediatric Orthopaedics. 3rd ed. Vol; 3. Philadelphia: W.B. Sanders; Fracture about the elbow; pp.2139-221.
2. Gartland JJ. Management of supracondylar fractures of the humerus in children. *Surg Gynecol Obstet.* 1959;109:145–154.
3. Persiani Pietro, Marica Di Domenica, Michele Gurzi, Lorena Martini, Roberto Lanzone, Ciro Villani (2012) "Adequacy of treatment, bone remodeling, and clinical outcome in pediatric supracondylar humeral fractures." *Journal of pediatric orthopedics. Part B* vol. 21,2: 115-20. Doi:10.1097/BPB.0b013e32834c675e
4. Skaggs, DL (1997) "Elbow Fractures in Children: Diagnosis and Management." *The Journal of the American Academy of Orthopaedic Surgeons* vol. 5,6: 303-312. Doi:10.5435/00124635-199711000-00002
5. Skaggs DL, Hale JM, Bassett J, Kaminsky C, Kay RM, Tolo VT (2001) Operative treatment of supracondylar fractures of the humerus in children. The consequences of pin placement. J Bone Joint Surg Am.; 83:735-40.
6. Gottschalk HP, Sagoo D, Glaser D, et al. (2012) Biomechanical analysis of pin placement for pediatric supracondylar humerus fractures: Does starting point, pin size, and number matter? J Pediatr Orthop. ;32(5):445-451. Doi: 10.1097/BPO.0b013e318257d1cd
7. Skaggs DL, Cluck MW, Mostofi A, Flynn JM, Kay RM (2004) Lateral-entry pin fixation in the management of supracondylar fractures in children. J Bone Joint Surg Am.; 86:702-7. Doi: 10.2106/00004623-200404000-00006
8. Flynn JC, Matthews 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(2): 263-72.
9. Kallio PE, Foster BK, Paterson DC (1992) Difficult supracondylar elbow fractures in children: analysis of percutaneous pinning technique. J Pediatr Orthop.;12:11-5.
10. Lee SS, Mahar AT, Miesen D, Newton PO (2002) Displaced pediatric supracondylar humerus fractures: biomechanical analysis of percutaneous pinning techniques. J Pediatr Orthop;22:440-3. Doi: 10.1097/00004694-200207000-00005
11. Zionts LE, McKellop HA, Hathaway R (1994) Torsional strength of pin configurations used to fix supracondylar fractures of the humerus in children. J Bone Joint Surg Am.; 76:253-6. Doi: 10.2106/00004623-199402000-00013
12. Afaque SF, Singh A, Maharjan R, Ranjan R, Panda AK, Mishra A., (2019) Comparison of clinic-radiological outcome of cross pinning versus lateral pinning for displaced supracondylar fracture of humerus in children: A randomized controlled trial, Journal of Clinical Orthopaedics and Trauma. Doi: 10.1016/j.jcot.2019.01.013
13. Larson L, Firoozbakhsh K, Passarelli R, Bosch P (2006) Biomechanical analysis of pinning techniques for pediatric supracondylar humerus fractures. J Pediatr Orthop. Sep 1;26(5):573e578. Doi: 10.1097/01.bpo.0000230336.26652.1c
14. Kocher MS, Kasser JR, Waters PM, Bae D, Snyder BD, Hresko MT, et al. (2007) Lateral entry compared with medial and lateral entry pin fixation for completely displaced supracondylar humeral fractures in children. A randomized clinical trial. J Bone Joint Surg Am Apr;89(4):706-12. Doi: 10.2106/JBJS.F.00379. PMID: 17403790.
15. Naik LG, Sharma GM, Badgire KS, Qureshi F, Waghchoure C, Jain V (2017) Cross Pinning Versus Lateral Pinning in the Management of Type III Supracondylar Humerus Fractures in Children. J Clin Diagn Res. ;11(8): RC01-RC03. Doi:10.7860/JCDR/2017/28481.10351
16. Foead A, Penafort R, Saw A, Sengupta S (2004) Comparison of two methods of percutaneous pin fixation in displaced supracondylar fractures of the humerus in children. J Orthop Surg (Hong Kong); 12:76-82. Doi: 10.1177/230949900401200114