Comparative study between crossed and lateral Kirschner wires fixation of supracondylar humerus fractures in pediatrics

Ali Mohammed El-Geuoshy, M.D. Mohammed Abdel-Aziz Hassan, M.D. Mohammed Ahmed Abdullah, M.B.B.CH.

Orthopedic Surgery Department, Faculty of Medicine, Al-Azhar University, Cairo, Egypt

Corresponding author: Ali Mohammed El-Geuoshy, M.D.
Mobile: 01098467102
E-mail: Alygeoushy@gmail.com.

The Egyptian Orthopedic Journal; 2021 supplement (1), June, 56: 81-90

Abstract

Background
Supracondylar humerus fractures of types I and IIA are mainly treated in an above-elbow cast while in type IIB and type III the preferred method is closed reduction and percutaneous pinning. Open reduction is indicated for irreducible fractures, vascular compromise and open injuries. Medial, lateral, posterior and anterior approaches have been used and methods of fixation include lateral divergent or crossed Kirschner wires (K-W).

Aim of the work
The aim of this study was to compare between crossed and lateral Kirschner wires Fixation of supracondylar humerus fractures in pediatrics, their indications, contraindications and complications.

Patients and Methods
A prospective, randomized, single Centre, study was conducted at Benisuef insurance hospital from March 2016 to December 2017. All the children with Gartland type IIB and type III fracture who presented to the orthopedic casualty were included for the study. All the children with suspected supracondylar fracture of elbow were seen at 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 70 to 90 degree of flexion, Elevation and ice compression given. Patients were classified as: Group A (two-crossed wiring technique):10 patients, and Group B (two lateral Divergent-wiring):10 patients.

Results
The mean loss in elbow extension in patients treated with crossed pinning fixation was 2.4 ± 1.1^{O} (range, 0^{O}- 4^{O}), while that in patients treated with lateral pinning fixation was 2.8 ± 1.2 ^{O} (range, 2^{O} -6^{O}). The mean loss in elbow flexion in patients treated with crossed pinning fixation was 3.2 ± 1.2^{O} (range, 2^{O}-6^{O}), while that in patients treated with lateral pinning fixation was 3.1 ± 2.1^{O} (range, 0^{O}-8^{O}). The mean loss in carrying angle in patients treated by crossed pinning was3.4 ± 1.35^{O} (range, 2O-6^{O}), while that in patient treated with lateral pinning was 2.8 ± 1.03^{O} (range, 2^{O}-5^{O}). The mean Baumann angle loss in the crossed pin fixation group was 2.3 ± 1.63^{O} (range, 0^{O}-5^{O}) and in the lateral pin fixation group was 2.8 ±1.68^{O} (range, 0^{O}-5^{O}). According to above mentioned data there was no significant difference between the two groups regarding flexion, extension, Baumann's angle and carrying angle. 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 Bivtracin spray as local antibiotic and oral antibiotic (Amoxicillin-clavulinic acid) lead it to recover at the subsequent follow-up.

Conclusion
To conclude, there was statistically no significant difference between crossed wiring and lateral wiring technique in terms of stability, duration of bone healing, loss of reduction and neuro-vascular injuries. So we conclude that lateral pinning entry, if placed with proper technique, is as stable as crossed pinning entries. However due to small sample size a possibility of Bias error should be taken in consideration and a larger study with enough power is needed for further assessment of these two modules of treatment.

Key words
Supracondylar humerus fractures, lateral divergent, crossed Kirschner wires (K-W).

Introduction

Supracondylar humerus fracture is a very common elbow injury and represents approximately 16.6% of all childhood fractures, accounting for 75% of all pediatric elbow injuries [1]. The peak age range in which most supracondylar fractures occur is 5 to 6 years [2]. Although the incidence of these fractures

generally has been reported to be higher in boys, more recent reports indicate that the frequencies of supracondylar humeral fractures in girls and boys seem to be equal, and some series actually have reported higher rates in girls [3].

Extension-type injuries occur in 95% of cases and associated neurovascular injuries are reported in between 5% and 30%. Supracondylar fracture is commonly classified according to Gartland. This system was modified by Wilkins to allow for 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) [4-6].

Diagnosis is usually by x-ray. The fracture can however be difficult to identify and often a joint effusion is used to increase one's suspicion of the presence of a fracture. The existence of an effusion can be determined by the presence of the sail sign. It is a good idea to compare the x-ray of the injured elbow to the opposing side for analysis [7].

Upon examination evaluation of the arm for signs of damage to the nerves and blood vessels, swelling and deformity. This will determine a likely diagnosis [7].

Types I and IIA are mainly treated in an above-elbow cast while in Type IIB and type III the preferred method is closed reduction and percutaneous pinning. Open reduction is indicated for irreducible fractures, vascular compromise and open injuries [8].

Medial, lateral, posterior and anterior approaches have been used and methods of fixation include lateral divergent or crossed Kirschner wires (K-W) [9].

Emergency treatment has been recommended to avoid vascular compromise and compartment syndrome. However, recent studies suggest that delay does not influence outcome [10].

The treatment of supracondylar humeral fracture in children has been of much discussion and dispute for many years. Historically, these fractures were associated with complications such as malunion that resulted in cosmetically and functionally inferior results [11].

Various treatment options has been reported for type III supracondylar fracture as closed reduction and long arm cast or slab, Dunlop skin traction, olecranon traction, but all of these methods had significantly large complication rate [1].

Results have been improved and the frequency of these complications dramatically decreased with the advent of the image intensifier, which facilitates accurate pin placement, Blount's [12], caution against operative management is now of only historic interest.

Controversies about the treatment of supracondylar humeral fractures in children, however, still exist: how long after injury can operative treatment be done safely and effectively, is a crossed-pin configuration better than a lateral-entry configuration, should type II supracondylar fractures be treated operatively or nonoperatively, and when does a pulseless hand require emergent treatment.

Therefore, this prospective study was conducted to compare whether lateral divergent pin construct, can provide the same stability like crossed pin fixation at the same time avoiding the possibility of iatrogenic ulnar nerve injury.

Patients and Methouds

Patients:

A prospective, randomized, single Centre, study was conducted at Benisuef insurance hospital from March 2016 to December 2017. All the children with Gartland type IIB and type III fracture who presented to the orthopaedic casualty were included for the study.

Eligible patients will be selected according to the following inclusion and exclusion criteria:

Inclusion criteria

1) Age between 3-13 years.

2) Both sexes

3) Gartland type II or III supracondylar.

4) Closed fracture.

Exclusion criteria

1) Open fractures.

2) Fractures that required open reduction.

3) Neurovascular injury on presentation.

4) Previous supracondylar fracture.

5) Age above 13.

6) Gartland type I.

- All the protocols and procedures applied in this study were approved by administration department of this institution. 20 children were treated for displaced supracondylar fracture of humerus during the study period.
- All the children with suspected supracondylar

fracture of elbow were seen at 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 70 to 90 degree of flexion, Elevation and ice compression given.

- Patients were classified as:
- Group A (two crossed wiring technique):10 patients.
- Group B (two lateral Divergent-wiring):10 patients.

Methods:

- Surgical techniques were standardized in terms of pin location, the pin size (1.4mm-1.6mm), stability on table, position of elbow for medial and lateral pin placement and the post-operative course.
- Surgery was performed in Benisuef insurance hospitals. After taking a written and informed consent and proper preparation of the patient for the surgery, General anesthesia was used for all patients with the injured upper limb at the side of the table. The injured elbow was placed on the plate of image intensifier which was adequate for the surgery due to the small size of the elbow.
- Closed reduction was done and confirmed by image intensifier. Reduction can be considered a "standard" technique which involved manual traction with the elbow flexed at 20 degrees, controlling rotation of the fracture by the medial and lateral humeral epicondyles. The forearm was then pronated, as this controls the medial rotation, and with flexion locks the fracture in place. This technique was adequate for reduction in all the patients of the study, if acceptable, assistant would clean and drape the limb along with image intensifier and surgeon goes for scrub. Reduction acceptability was confirmed by achievement of normal Baumann angle under image intensifier.
- For the 2 lateral divergent technique the reduction was imaged in anteroposterior, lateral and two oblique planes to observe the medial and lateral columns. After acceptable reduction Two Kirschner wires (1.4-1.6mm) were then inserted from the lateral side. Placement of the divergent wires was crucial for stability and commenced with the most lateral wire into the lateral column at the fracture site.
- The next wire inserted was divergent and entered the medial column with maximal pin separation as was possible at the fracture site. On the lateral intraoperative radiograph the pins incline in the anteroposterior direction in accordance with the normal bony anatomy of the distal humerus. (Figure 1)
- For the two Cross-wiring, the lateral pin was inserted in the center of lateral condyle (capitellum), and then through the distal humeral physis with avoiding the olecranon fossa as possible and come to rest along the far cortex.
- The lateral pin is inserted first to obtain stability while reduction is evaluated to avoid repeated insertion of medial pin if reduction is not adequate.
- The medial pin was passed obliquely through the medial epicondyle just proximal to olecranon fossa, after the lateral was inserted first with hyper flexed elbow to confer stability, once the lateral pin was inserted the elbow flexion was decreased to decrease the ulnar nerve subluxation before placement of medial wire to avoid ulnar nerve injury. (Figure 2)
- The wires were then bent and cut outside the skin. Elbow was immobilized with posterior slab with elbow in 70 to 90 degree of flexion depending upon the swelling and neurovascular status. All patients were given single dose of broad spectrum antibiotics followed by oral antibiotics for five days.
- The child was discharged on post-operative day. 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 anteroposterior and lateral radiographs of the elbow. All the patients were evaluated clinically and radiographically at one week, two weeks, four weeks, six weeks 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.
- Active assisted mobilization started Clinical evaluation was done including passive range of motion, measurement of carrying angle, neurovascular status, superficial and deep infection and necessity to re-operate. Clinical evaluation was graded according to carrying angle and elbow range of motion using the criteria of Flynn et.al. [13].
- Baumann angle was calculated on the immediate radiographs and after three months for any loss of Baumann angle. At the three months follow up child were evaluated for full function and loss of

function.

- Flynn's criteria for grading [13] involving the evaluation of carrying angle loss (cosmetic), flexion and extension loss. Carrying-angle loss mean When the arm is extended, with the palm in supination, the upper arm is not in straight alignment with the forearm, The deviation of the straight line extending from the arm away from the forearm Excellent (0°–5°),Good(5°–10°), Fair(10°–15°), Poor(>15°) when compared to normal side. Flexion loss and Extension loss values according to Flynn's criteria Excellent (0°–5°), Good (5°–10°), Fair (10°–15°), Poor (>15°) when compared to normal side.
- For carrying angle, elbow flexion, elbow extension, Baumann angle, [12] we looked into the value of differences comparing the treated side with the uninjured side. We then compared these values between the 2 groups treated with different method of fixation.

Statistical Analysis:

Data were statistically described in terms of mean, standard deviation (SD). Comparison between the study groups was done using Student t test, all data were compiled and calculated by SPSS (Statistical Package for the Social Science; SPSS Inc., Chicago, IL, USA) version 15 for Microsoft Windows. Significance of difference was measured by determining P-value and value less than <0.05 was considered significant.

Figure 1: Female patient 5.5 years old fixed by (2 Lateral divergent K-wires pinning technique). **A:** Pre-operative x-ray (AP and lateral views). B Post-operative x-ray (AP and lateral views). C: Post-operative (3-month) x-ray (AP and lateral views).

Figure 2: Male patient 8 years old fixed by (2 crossed pinning K-wires technique). **A:** Pre-operative x-ray (AP and lateral views). B: Post-operative x-ray (AP and lateral views). C: Post-operative (3-month) x-ray (AP and lateral views).

Results

During the period between February 2016 and December 2017, we conducted a prospective study to assess the radiological and functional outcome of two techniques of fixation of supracondylar fracture humerus. 20 patients were involved in the study (10 crossed pinning (50%) and 10 lateral pinning (50%) and followed up in Benisuef insurance hospital.

We found that; the mean follow-up duration was 3 months (range, 2.8-3.2 months). The mean age was 6.47~2.66 years and range 3-12years. The study included both sexes: 7 (35%) were females and 13 (65%) were males.

The study included 2cases of flexion type and 18cases of extension type. The left side was in 12cases and the right side was in 8cases.Gartland grade II was present in 1case and Gartland grade III was present in 19cases.

We also found that; the duration from injury to admission to the hospital ranged from 1 to 6 hours, with a mean of 2.9 hours, hospitalization ranged from 1-2 days with a mean of 1.5days. The duration from admission to operation ranged from 12-24 hours with mean of 17.3 hours.

Regarding carrying angle loss, in lateral group, results were 9 patients excellent (90%), 1 good (10%). In crossed group, 8 were excellent (80%), 2 good (20%).

Regarding Extension loss, in lateral pin group, there were 9 (90%) excellent, 1(10%) good. In crossed pin group, there were 10 (100%) excellent.

Regarding to Flexion loss, in lateral group, there were 9 cases (90%) excellent, 1 case (10%) good. In crossed group, there were 9 cases (90%) excellent, 1 case (10%) good.

The mean loss in elbow extension in patients treated with crossed pinning fixation was 2.4 ± 1.1^{O} (range, 0^{O}- 4^{O}), while that in patients treated with lateral pinning fixation was 2.8 ± 1.2^{O} (range, 2^{O}-6^{O}). (Table 1).

The mean loss in elbow flexion in patients treated with crossed pinning fixation was 3.2 ± 1.2^{O} (range, 2^{O}-6^{O}), while that in patients treated with lateral pinning fixation was 3.1 ± 2.1^{O} (range, 0^{O}-8^{O}). (Table 2).

The mean loss in carrying angle in patient treated by crossed pinning was3.4 ± 1.35^{O} (range, 2O-6^{O}), while that in patient treated with lateral pinning was 2.8 ± 1.03^{O} (range, 2^{O}-5^{O}). (Table 3).

The mean Baumann angle loss in the crossed pin fixation group was 2.3 ± 1.63^{O} (range, 0^{O}-5^{O}) and in the lateral pin fixation group was 2.8 ±1.68^{O} (range, 0^{O}-5^{O}). (Table 4 – Figure 3).

According to above mentioned data there was no significant difference between the two groups regarding flexion, extension, Baumann's angle and carrying angle (Table 5).

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 Bivtracin spray as local antibiotic and oral antibiotic (Amoxicillin-clavulinic acid) lead it to recover at the subsequent follow-up (Table 6).

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.

Table 1: Comparison between lateral and crossed fixation according to extension loss

Extension loss	Lateral fixation group N = 10	Crossed fixation group N = 10	P - value
Range	2 – 6	0 - 4	
Mean ± SD	2.8 ± 1.2	2.4 ± 1.1	0.805
Median	2.5	2.5	

Table 2: Comparison between lateral and crossed fixation according to flexion loss

Flexion loss	Lateral fixation group N = 10	Crossed fixation group N = 10	P – value
Range	0 – 8	2 – 6	
Mean ± SD	3.1 ± 2.1	3.2 ± 1.2	0.723
Median	3	3	

Table 3: Comparison between lateral and crossed fixation according to carrying angle

Carrying angle	Lateral fixation group N = 10	Crossed fixation group N = 10	P – value
Range	2 - 5	2 - 6	
Mean ± SD	2.8 ± 1.03	3.4 ± 1.35	0.284
Median	2.5	3	

Table 4: showing the study group according to difference of Baumann angle by comparison of affected side to contralateral side in each patient

Baumann's angle	Lateral fixation group N = 10	Crossed fixation group N = 10	P – value
Range	0 – 5	0 - 5	
Mean ± SD	2.8 ± 1.68	2.3 ± 1.63	0.417
Median	3	2.5	

Table 5: Analysis of carrying-angle loss, elbow extension loss, elbow flexion loss and Baumann angle loss between the crossed pin fixation and lateral pin fixation by using Student's t test:

Parameter	lateral crossed pin fixation (Mean ± SD)	3 lateral pin fixation (Mean ±SD)	P value (student t test)
carrying angle loss	3.25 ± 1.48	3.87 ± 1.72	0.452
elbow extension loss	3.75 ± 4.36	3.75 ± 4.33	0.999
elbow flexion loss	2.87 ± 1.88	5.12 ± 3.72	0.149
Baumann angle loss	2.62 ± 2.06	2 ± 2.56	0.601

Table 6: Complication of fracture of the study group

Complication of fracture	The study group N = 20
Nil	19 (95%)
Pin tract infection	1 (5%)

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 [13], which has been reported to be as high as 17% [14].

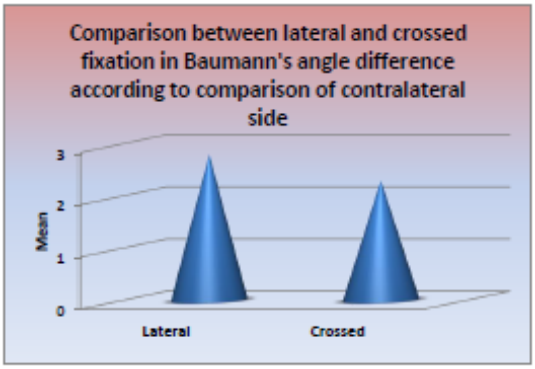

Figure 3: Showing of the study according to Baumann angle.

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 [15]. Open reduction is usually unnecessary, although it sometimes can be required to obtain complete reduction [16] especially in cases in which the fracture cannot be reduced because of the presence of a vascular lesion [16].

In a systemic review [17] PubMed, EMBASE, CINAHL, and The Cochrane Central Register of Controlled Trials were searched to locate 1726 relevant articles published from January 1966 to July 29, 2010. Of these, 44 met criteria for inclusion, On the basis of the results from the systematic review: (1) they [17] suggest closed reduction with pin fixation for patients with displaced (e.g., Wilkins type II and III and displaced flexion) pediatric supracondylar fractures of the humerus. (2) The practitioner might use 2 or 3 laterally introduced pins to stabilize the reduction of displaced pediatric supracondylar fractures of the humerus.

Considerations of potential harm indicate that the physician might avoid the use of a medial pin. (3) The practitioner might perform open reduction for displaced pediatric supracondylar fractures of the humerus after closed reduction if varus or other malposition of the bone occurs.

In a retrospective review [18] that was performed on all children treated for a supracondylar humerus fracture between 2003 and 2010. All the type 3 displaced fractures were placed into 2 groups: lateral-entry pinning and cross-pinning.

The 2 groups were then compared for risk of ulnar nerve injury, and a post hoc power analysis was performed. A total of 381 supracondylar humerus fractures met the inclusion criteria. Cross-pinning technique was used in 187 (49%) of the children with a mean age of 5.8 years (range, 0.92 to 13.92 y). There were 4 ulnar nerve injuries in the entire cohort and 2 sustained as iatrogenic injuries in the cross-pinning group (1.1%). There was no significant difference between 2 groups in regard to risk of ulnar nerve injury (P=0.24). There is a statistically significant lower risk of ulnar nerve injury in lateral cross-pinning technique than previously described techniques (P=0.0028), with a post hoc power analysis of 93% [18].

In a prospective study Lee et al. [19] Sixty-one Gartland type II or III supracondylar fracture in children (mean age, 5 years 6 months) treated between 2001 and 2004 according to the following protocol: close reduction and lateral percutaneous pinning using 3 divergent or parallel Kirschner wires. Minimum 2 years' follow-up was done in all 61 patients, of whom 24 (39%) presented with Gartland type II fractures, and the remaining 37 (61%) presented with a type III fracture. A comparison of perioperative and final radiographs shows no loss of reduction of any fracture. There was also no clinically evident cubitus varus, hyperextension, or loss of motion. Eight patients had preoperative nerve palsy. Five of these nerve injuries resolved immediately after surgery, and the other 3 resolved completely within 12 weeks of surgery. After an average of 28 months post operation, 56 (91.8%) patients had achieved an excellent clinical result, and 5 (8.2%) achieved a good result. There were no iatrogenic nerve palsies, and no patient required additional surgery. One patient had a minor pin-track infection. They [19] concluded that only 3 lateral divergent or parallel pin fixations are effective and safe for avoiding iatrogenic ulnar nerve injury.

In a prospective study [20] 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 [20] concluded that manipulative reduction and lateral percutaneous K-wire fixation of supracondylar humerus fractures in children has small wound, is stable and reliable, easy to be operated, safe and effective and low cost. What's more, it can also avoid the complication caused by conservative treatment and operation. It is a good treatment of supracondylar humerus fractures in children.

Lee et al. [21] found that the lateral pinning technique was found to be more beneficial than the medial and lateral crossed pinning technique for supracondylar fractures of the humerus in children, on the basis of current evidences. However, the results were sensitive to the data of ulnar nerve injury. Avoiding the worst clinical scenario (permanent ulnar nerve palsy) might be more important and affordable than obtaining favorable clinical results (stable fixation) at the potential cost of disastrous complications.

Oliver et al. [22] in study on 84 patients with type II and III supracondylar humerus fractures were treated with lateral crossed pin fixation, found that lateral crossed pinning technique gives excellent stability as that achieved with medial and lateral crossed pins while having the advantage of avoiding injury to the ulnar nerve.

Medial pin placement after closed reduction introduces the risk for ulnar nerve damage. Zaltz et al. [12] noted that even when this pin is placed outside ulnar groove, 5.7% to 17.7% of children have ulnar nerve subluxation anteriorly when the elbow is held in the hyperflexed position. Moreover, medial pin placement is made more difficult by elbow swelling, which inhibits ulnar nerve palpation in most displaced and unstable supracondylar fractures. To prevent ulnar nerve palsy during the management of these supracondylar fractures, the lateral configuration, rather than the medial-pin configuration, may be the better option, Pin placement across the olecranon fossa is acceptable, and will add 2 more cortices of fixation [19].

Shannon et al. [9] used Dorgan's percutaneous lateral cross wiring of supracondylar fractures of the humerus on 20 patients ,all children had a full range of the elbow motion compared with their other (normal) side, and the mean carrying angle of the injured elbow was 15 (range 10 -20). There were no intraoperative complications; of note, there were no ulnar nerve injuries. All complications were related to the Kirschner wires. They reported one patient with a minor pin-site infection. In our study, there was 1 patient (13%) of 8 treated with lateral crossed technique with minor pin-site infection that resolved after K-wire removal and oral antibiotics.

Biomechanical studies suggest that crossed wires provide greater torsional stability. [23,24] In lateral wire fixation, divergent wires have been shown to be more stable in extension and varus loading than crossed wires but not in valgus [24]. The strength can be further improved by increasing the number of wires and divergence of the wires in the distal humerus [24]. There are reports of clinical failures of laterally placed wires, thought to be due to poor technique in reduction and fixation [8]. Reports vary as to the loss of reduction using lateral wires.

Dorgan's percutaneous lateral cross-wiring technique secure ulnar nerve from being at risk, unless the proximally inserted wire is driven through the medial condyle [22].

Theoretically [22] the radial nerve could be injured during insertion of the more proximal wire. However, the radial nerve is situated anterior to the lateral intermuscular septum at this level and can be avoided by entering the skin a little posterior to the mid-coronal plane [22].

Zhao et al. [25] performed a meta-analysis of randomized controlled trials (RCTs) to compare (1) the risk of iatrogenic ulnar nerve injury caused by pin fixation, (2) the quality of fracture reduction in terms of the radiographic outcomes, and (3) function in terms of criteria of Flynn et al. and elbow ROM, and other surgical complications caused by pin fixation. They [25] searched PubMed, Embase, the Cochrane Library, and other unpublished studies without language restriction. Seven RCTs involving 521 patients were included, the pooled RR suggested that iatrogenic ulnar nerve injury was higher with the crossed pinning technique than with the lateral entry technique (RR, 0.30; 95% CI, 0.10-0.89). No publication bias was further detected. There were no statistical differences in radiographic outcomes, function, and other surgical complications. No significant heterogeneity was found in these pooled results. They conclude that the medial and lateral crossed pinning fixation is more at risk for iatrogenic ulnar nerve injury than the lateral pinning technique.

In our study, the fractures that were treated using lateral did not show fixation loss, the mean follow-up duration of the 20 patients was 3 months (range, 2.8 - 3.2 months).above elbow slab were made for all the patients which continued for 4 weeks duration post-operation. 19 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 crossed pin fixation or lateral pin fixation.

There were no patients with a carrying-angle loss of 10^{O} or more compared to the opposite elbow. More than 10 degree 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 [26].

We found No iatrogenic neurovascular injuries during the study in patients treated with crossed pin fixation or the lateral pin fixation. Therefore, there was no statistical difference in the incidence of iatrogenic ulnar nerve injury between the two methods of fixation. This result may be due to the small sample size.

During the process of closed manipulation, acute axial distraction was applied before attempting reduction. The elbow was then hyperflexed to reduce the distal fragment that was usually displaced in extension.

Occasionally, direct pressure on the olecranon process was applied to achieve this objective.

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 slap. None of the patients in our series developed evidence of ischaemic contracture to suggest muscle necrosis at follow-up.

Conclusion

To conclude, there was statistically no significant difference between crossed wiring and lateral wiring technique in terms of stability, duration of bone healing, loss of reduction and neuro-vascular injuries. So we conclude that lateral pinning entry, if placed with proper technique, is as stable as crossed pinning entries. However due to small sample size a possibility of Bias error should be taken in consideration and a larger study with enough power is needed for further assessment of these two modules of treatment.

References

1. Herring JA, editor. Fracture about the elbow. In: Tachdjian's Pediatric Orthopaedics. Philadelphia: W.B. Saunders; 2002.3.3. 2:139- 221.
2. Cheng JC, Lam TP, Maffulli N. Epidemiological features of supracondylar fractures of the humerus in Chinese children. J Pediatr Orthop 2001. 10.1:63-67.
3. Houshian S, Mehdi B, Larsen MS. The epidemiology of elbow fracture in children: analysis of 355 fractures, with special reference to supracondylar humerus fractures. J Orthop Sci 2001.6:312-315.
4. Mazda K, Boggione C,Fittoussi F,Pemecot GF. Systemic pinning of displaced extension type supracondylar fractures of the humerus in children. J Bone Joint Surg [Br]. 2001.83(B):888-93
5. Gordon JE, Patton CM, Luhmann SJ, Bassett GS, Schoenecker PL. Fracture stability after pinning of displaced supracondylar distal humerus fractures in children. J Pediatr Orthop. 2001.21.3:313 -318.
6. Pandey S. MS, Shrestha D. MS, MP Sinhg MS. Treatment of Supracondylar fracture of the Humerus (Type IIB, and III) in Children: A Prospective Randomized Controlled Trial Comparing Two Methods. Kathmandu University Medical Journal 2008.6.3.23:310-318.
7. Nicola Maffulli Department of Trauma and Orthopaedic Surgery, Keele University School of Medicine, Thornburrow Drive, Hartshill Stoke-on-Trent ST4 7QB, UK January 2, 2008
8. Skaggs DL, Cluck MW, Mostofi A, et al. Lateral-entry pin fixation in the management of supracondylar fractures in children. J Bone Joint Surg Am 2004.86(A).4:702-707.
9. Shannon FJ, Mohan P, Chacko J, D'Souza LG. Dorgan's percutaneous lateral cross-wiring of supracondylar fractures of the humerus in children. J Pediatr Orthop 2004.24: 376–379.
10. Gupta N, Kay R, Leitch K, et al. Effects of surgical delay on perioperative complications and need for open reduction in supracondylar humerus fractures in children. J Paediatr Orthop 2004.24:245–248.
11. Kocher MS, Kasser JR, Waters PM, et al. 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 2007.89.4:706-712.
12. Wilkins KE: Supracondylar Fracture of the Distal Humerus. In: Rockwood CA, Wilkins KE, Beaty JH. (Editors) Fractures in Children. 7th Ed. Philadelphia, Lippincott - Raven; 2010: 476:481.
13. Russo S.A., Abzug J.M. Supracondylar Humerus Fractures. In: Abzug J., Herman M., Kozin S. (eds) Pediatric Elbow Fractures. Springer (2018), Cham.
14. Solak S, Aydin E. Comparison of two percutaneous pinning methods for the treatment of the pediatric type III supracondylar humerus fractures. J Pediatr Orthop B. 2003.12(B):346:349 .
15. Kasser JR, Beaty JH. Supracondylar fractures of the distal humerus. In: Beaty JH, Kasser JR, eds. Rockwood and Wilkins' Fractures in Children. 6th ed. Philadelphia: Lippincott Williams and Wilkins, 2006:543-589.
16. Reitman RD, Waters P, Millis M.: Open reduction and internal fixation for supracondylar humerus fractures in children. J Pediatr Orthop. 2001.21.2:157:161.
17. Mulpuri K, Wilkins K. The treatment of displaced supracondylar humerus fractures: evidence-based guideline. J Pediatr Orthop. 2012.32.2:143-152.
18. Edmonds EW, RoocroftJH, Mubarak SJ. Treatment of displaced pediatric supracondylarhumerus fracture patterns requiring medial fixation: a reliable and safer cross-pinning technique. J Pediatr Orthop. 2012.32.4:346-351.
19. Lee YH, Lee SK, Kim BS, et al. Three lateral divergent or parallel pin fixations for the treatment of displaced supracondylar humerus fractures in children. J Pediatr Orthop 2008.28.4.:417-422.
20. Lu XZ, Hu CX, Liu BH. Manipulative reduction and lateral percutaneous K-wire fixation for treatment of supracondylar humerus fracture in 128 children. Zhongguo Gu Shang.2012.25.10:872-4.
21. Lee KM, Chung CY, Gwon DK, Sung KH, Kim TW, Choi IH, Cho TJ, Yoo WJ, Park MS. Medial and lateral crossed pinning versus lateral pinning for supracondylar fracture of the humerus in children: decision analysis. J Pediatr Orthop. 2012.32.2:131-138
22. Oliver E, Francisco F, Thomas I, Klaus P .:Cross pinning of supracondylar fractures from a lateral approach. Stabilization achieved with safety J Child Orthop 2007.1:127–133
23. Stephen Paul Guy, Ramakrishna Rao Ponnuru, Sreenadh Gella, and Nirmal Tulwa: Lateral Entry Fixation Using Three Divergent Pins for

Displaced Paediatric Supracondylar Humeral Fractures, ISRN Orthopedics Volume 2011, Article ID 137372, 5 pages.

24. S. S. Lee, A. T. Mahar, D. Miesen, and P. O. Newton, "Displaced pediatric supracondylar humerus fractures: biomechanical analysis of percutaneous pinning techniques," Journal of Pediatric Orthopedics, 2002.22.4:440-443.
25. Jia-Guo Zhao, MD, Jia Wang, MD, PhD, and Peng Zhang: Is Lateral Pin Fixation for Displaced Supracondylar Fractures of the Humerus Better Than Crossed Pins in Children? Clin Orthop Relat Res. 2013 Sep; 471(9): 2942–2953.
26. O'Driscoll SW, Spinner RJ, McKee MD, Kibler WB, Hastings H 2nd, Morrey BF, et al. Tardy posterolateral rotatory instability of the elbow due to cubitus varus. J Bone Joint Surg Am 2001.83(A):1358-69.