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TRANSOLECRANON AND LATERAL KIRSCHNER WIRE FIXATION FOR DISPLACED SUPRACONDYLAR HUMERAL FRACTURE IN CHILDREN

By

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ABSTRACT

Background: Supracondylar fractures in children are common, accounting for 65% of all elbow fractures in children. In types II and III displaced supracondylar humeral fractures, closed reduction is difficult to achieve because of the thin bone between the coronoid and olecranon fossae as well as stripping of the periosteum. In addition, hyperflexion for maintenance of fracture reduction leads to swelling, compartment syndrome, and neurovascular compromise.

Objective: To evaluate the clinical and radiological outcome after closed reduction and pinning using a Kirschner wire inserted vertically through the olecranon and another inserted laterally for displaced supracondylar humeral fractures.

Patients and methods: A prospective case series, single Centre study conducted at Al-Azhar University Hospitals from June 2020 to May 2021. It included 20 patients with Gartland type III fracture who undergone for closed reduction and percutaneous pin fixation using two Kirschner wires, the first one was inserted vertically through the olecranon across the fracture into the metaphysis of the humerus and the second wire was inserted from the lateral column across the fracture at 30-40 degree to the opposite cortex of the humerus.

Results: Operative time ranged from 15- 30 minutes with a mean of 19.25 minutes. We counted the operative time after induction of anesthesia (including draping, reduction, wires insertion and splint application). Results were within normal range for all patients. The mean Baumann angle in the patients was 70.57 degree, and standard deviation was 3.01. Postoperatively, anteroposterior and lateral views were done, and wires were removed by 3 weeks if clinical and radiological evidence of early bone union was present and, if not, wires removal was postponded one week later. Thirteen patients (65%) had the wires removed by 3rd week, and 7 patients (35%), the wires were removed by 4th week with a mean of 3.35 week, and standard deviation of 0.49. Few complications occurred and all were tolerable with no effect on final outcome, and these were pin tract infection in 2 patients and loss of reduction.

Conclusion: Transolecranon and lateral Kirschner wires fixation was an effective option for displaced supracondylar humeral fractures in children.

Keywords: Transolecranon, Lateral K-wire fixation, displaced supracondylar humeral fracture.

INTRODUCTION

Supracondylar fractures are considered the second most common type of fracture in children surpassed only by forearm fractures, accounting for 3% of all fractures in children. These fractures are caused by direct or indirect low kinetic energy traumas, such as falls, which make the occurrence of comminution, bone exposure or association with other fractures less frequent *(Al-Algawy et al., 2019).*

Due to the anatomical characteristics of this region and the variations in fractured fragments, immediate complications (vascular-nerve injuries, compartment syndrome) and late complications (vicious consolidation and angular deformities) can arise. The flexion-type fracture, which is caused by falling on a flexed elbow, is a rare occurrence *(Chukwunyerenwa et al., 2016).*

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) *(Mallo et al., 2010).*

Despite the various types of treatment, high morbidity and complications related to this type of fracture make treatment urgent and essential *(Rouede et al., 2010).* Types I and IIA are mainly treated in an above-elbow cast while in Type IIB and type III the preferred most common method is closed reduction and percutaneous pinning, and open reduction is indicated for irreducible fractures, vascular compromise and open injuries *(Kumar and Singh, 2016).*

In types II and III displaced supracondylar humeral fractures, closed reduction is difficult to maintain because of the thin bone between the coronoid and olecranon fossae as well as stripping of the periosteum. In addition, hyperflexion for maintenance of fracture reduction leads to swelling, compartment syndrome. Closed reduction and percutaneous pinning enables the cast to be kept in <90º flexion and thereby reduces the risk of complications *(O'hara et al., 2010)*. The optimal pin configuration for displaced supracondylar fractures in children remains Controversial *(Mulpuri and Wilkins, 2014).*

The most common used configuration of pinning are medial and lateral crossed pinning, and lateral pinning. However, there is still controversy regarding the choice of pinning configuration and based primarily on the surgeons' preference. There are two key factors when comparing these two configurations which are the mechanical stability and the risk of iatrogenic ulnar nerve injury. Cross pinning is more biomechanically stable in fixation but it has higher risk of ulnar nerve injury during insertion of medial pin *(Larson et al., 2012)*. Although, pinning from lateral side has negligible risk of ulnar nerve injury, is considered biomechanically less stable and having theoretical chances of loss of reduction *(Eberhardt et al., 2013).* Lateral K wires with Trans olecranon fossa four cortex purchase technique was described in displaced pediatric supracondylar fractures of humerus. This technique can be successfully employed even in

comminuted and unstable fracture patterns without the fear of loss of reduction *(Kasirajana et al., 2018)*.

Transolecranon and lateral wires is described method for configuration of the pins, using a Kirschner wire inserted vertically through the olecranon and another wire inserted laterally, as an alternative available method for fixation of displaced supracondylar humeral fractures. It has the advantage of being of an easier method, especially in cases with massive elbow swelling where the olecranon process being easily palpable. It also has the advantage of avoiding risk of ulnar nerve injury *(Sharma et al., 2015)*.

The aim of this study was to evaluate the clinical and radiological outcome after closed reduction and pinning using a Kirschner wire inserted vertically through the olecranon and another inserted laterally for displaced supracondylar humeral fractures.

PATIENTS AND METHODS

This was a prospective case series, single Centre study conducted at Al-Azhar University Hospitals (Assiut) from June 2020 to May 2021. It included 20 patients with Gartland type III fracture.

Inclusion criteria: Children aged 2 - 12 years old, and displaced types of supracondylar humerus fractures (Gartland type II & III).

Exclusion criteria: Open fracture, irreducible fracture, vascular injury, patient presented 10 days after fracture, and refusal to provide an informed consent.

Gartland type (classification): All the patients had extension type III supracondylar humeral fractures with complete displacement.

Preoperative evaluation:

Patients were subjected to thorough preoperative evaluation both clinically and radiographically. This was done by a single observer. The medical status of the patients were revised to avoid any complications during anesthesia or surgery caused by medical illness or associated fractures (especially those in ipsilateral forearm), in addition to neurovascular examination and examination for any evidence of compartment syndrome. All the children with displaced supracondylar fractures of humerus were admitted and injured elbow was immobilized in splint with elbow in 90 to 120 degrees of extension, elevation and ice compression were advised.

Standard radiographs were done before and after surgery including an anteroposterior (AP), lateral, oblique views and forearm X-rays were done.

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

Surgical protocol and operative details:

Anesthesia: Surgery was done under general anesthesia, the patient received intravenous antibiotic; first generation cephalosporins whose dose was adjusted according to the weight. (50_100 mg /kg).

Position: All the patients were positioned supine with the fractured elbow was placed over a sterile draped C-arm image intensifier which was adequate for the

surgery due to the small size of the elbow **(Figure 1)**.

Figure (1): The elbow over the plate of image intensifier.

Reduction: Closed reduction was performed and confirmed by C-arm image intensifier. Traction was applied with the elbow flexed at about 20 degrees to avoid the possibility of tethering neurovascular structures over an anteriorly displaced proximal fragment, with the surgeon grasping the forearm with both hands, and the assistant providing counter-traction in the axilla **(Figure 2)**. Next, controlling rotation of the fracture occurred by the medial and lateral humeral epicondyles. The forearm was then pronated as this controlled the medial rotation, and with flexion locked the fracture in place.

This technique was adequate for reduction in all the patients of the study. Reduction acceptability was confirmed by assessment of displacement, angulation, and rotation in the coronal and sagittal planes under image intensifier **(Figures 3 and 4)**.

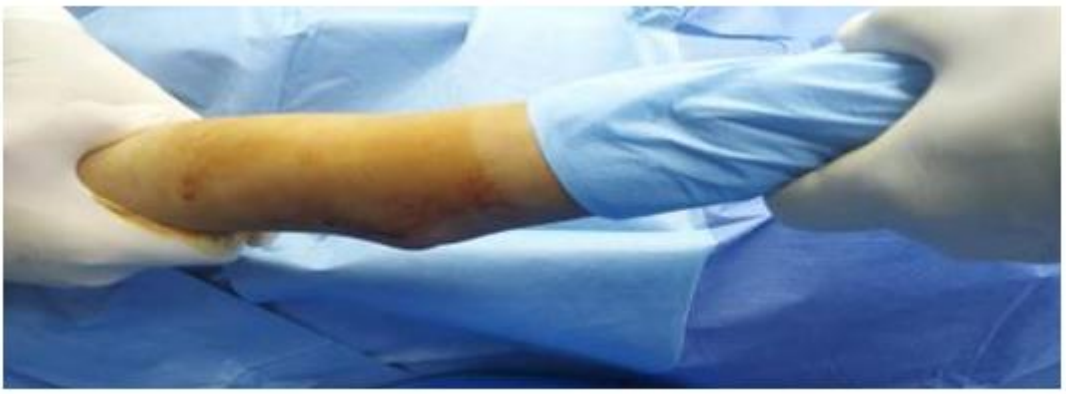

Figure (2): Manual traction of the elbow.

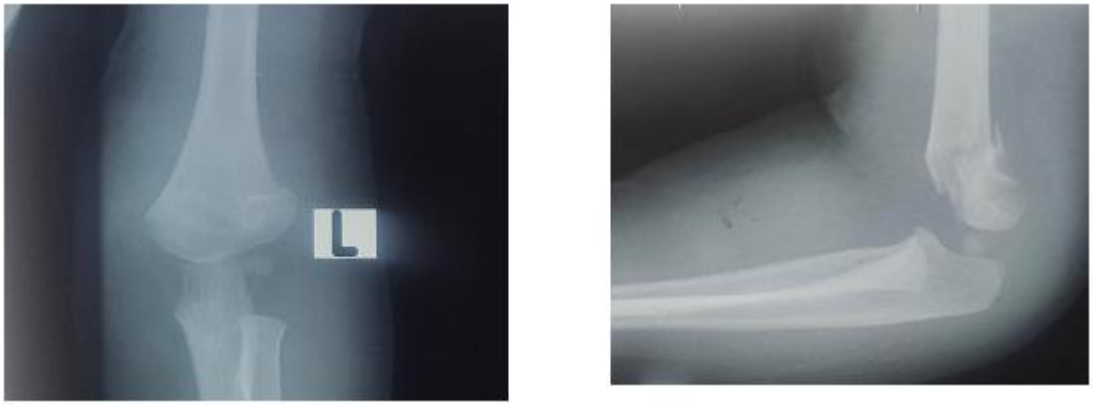

Figure (3): Preoperative x-ray.

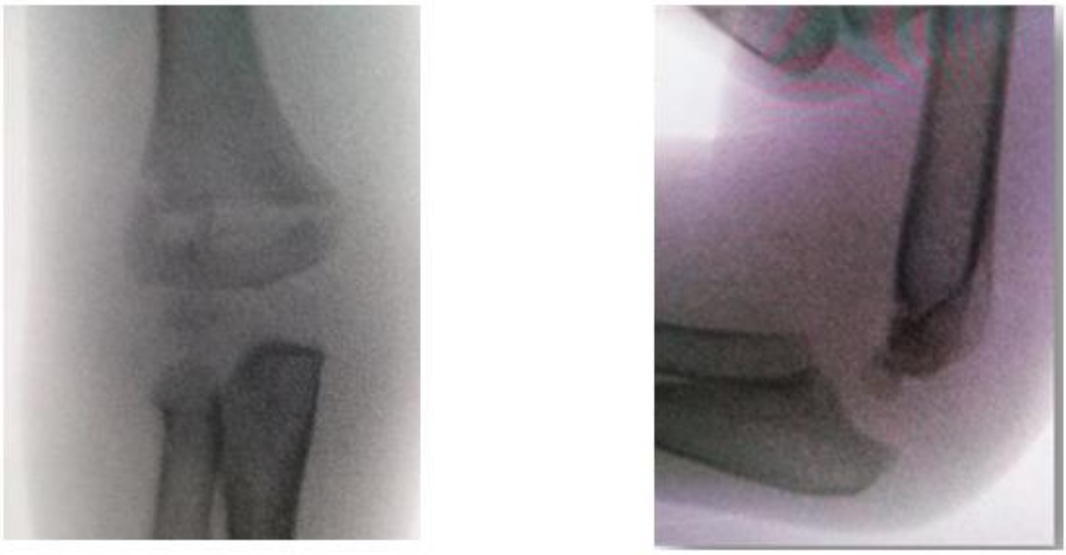

Figure (4): Reduction confirmation under image intensifier.

Pinning technique: Under complete aseptic conditions, two 1.6 mm Kirschner wires were inserted for fixation, with elbow flexion to about 90º the first one was inserted vertically through the olecranon across the fracture into the metaphysis of the humerus directed intramedullary, posterolaterally, posteromedially or posteriorly **(Figures 5-7)**.

Figure (5): Transolecranon wire insertion clinically.

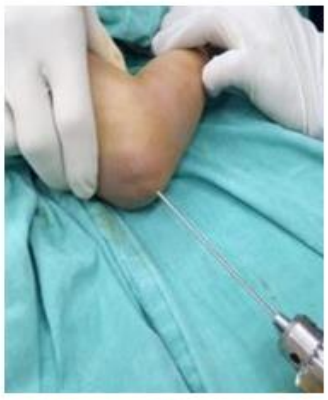

Figure (6): Transolecranon wire clinically.

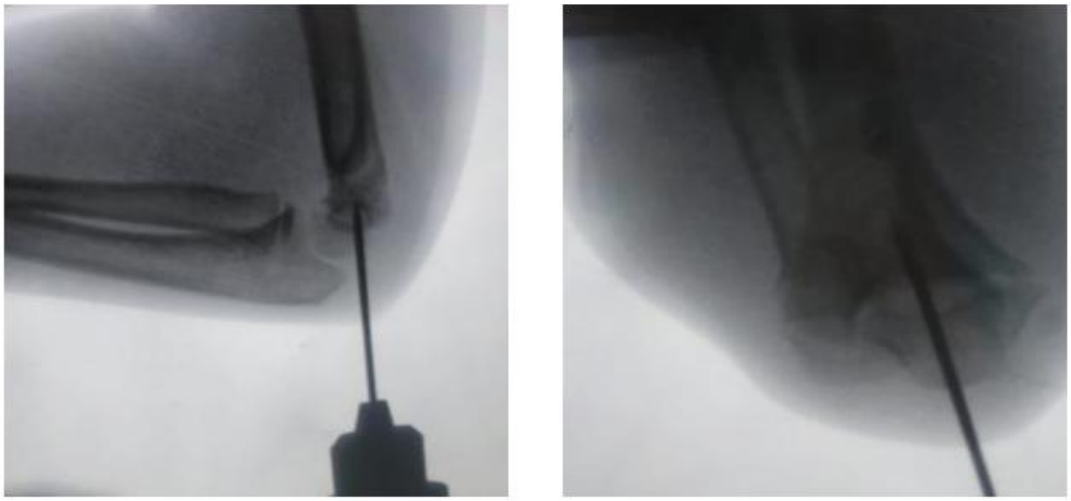

Figure (7): Transolecranon wire insertion under image intensifier

The second wire was inserted from the lateral column across the fracture at 30-40 degree to the opposite cortex of the humerus **(Figure 8)**.

Figure (8): Lateral wire insertion.

Vascular status was assessed and, after assessment of stability, the wires were bent and cut leaving them at least 1 to 2 cm off the skin, to prevent migration of the wires under the skin. A sterile felt square with a slit cut into it was then placed around the wires to protect the skin. Elbow was immobilized in a plaster of Paris back slab in 90º of flexion **(Figures 9 and 10)**.

Figure (9): Wires cut and bent outside the skin.

Figure (10): Above elbow slab.

Postoperative care: All patients were given single dose of broad spectrum intravenous antibiotics; first generation cephalosporins whose dose was adjusted according to the weight (50_100 mg /kg). Followed by oral antibiotics; first generation cephalosporins (30 mg/kg/day) in divided doses every 12 hours for 5 days. Neurovascular observation over the first 24 hours of hospitalization was done. Patients were admitted, and all of them were discharged over 24 hours and all the patients were followed up at the orthopaedic out-patient clinic and reviewed.

Follow-up and outcome measure: All the patients were followed up at the orthopedic out-patient clinic were evaluated clinically and radiographically at one week, three weeks, six weeks and three months and parents were strictly instructed not to remove the slab at home.

Plaster slab and the pins were removed after 3-4 weeks. X-ray evaluation was performed by antero-posterior and lateral views of the elbow.

Range-of-motion exercises were taught to the family, targeting gentle flexion and extension, to be started a few days after slab removal.

The child returned 6 weeks postoperatively for a range of motion check, and radiography at that time.

At the three months follow up children were evaluated for full function according to carrying angle and elbow range of motion using the criteria of Flynn.

The upper arm is not in straight alignment with the forearm, the deviation value 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°–4°), good (5°–9°), fair (10°–15°), poor (>15°) when compared to normal side.

Statistical analysis:
Categorical variables were described by number and percent (N, %), where continuous variables were described by mean and standard deviation (SD), and median. Chi-square test used to compare between categorical variables. A two-tailed $p < 0.05$ was considered statistically significant. All analyses were performed with the IBM SPSS 26.0 software.

RESULTS

In the period between June 2020 and May 2021 twenty patients with Gartland type III displaced supracondylar humerus fracture were treated and followed up until achieving fracture union, getting functional range of motion and recovering from any complication during the study.

The age ranged from (3 - 8) years with a mean age 4.95 years. Eleven patients (55%) females and 9 patients (45%) males. Eleven patients (55%) had RT side affection and 9 patients (45%) had Lt side affection. The mechanisms of injury were a fall from height on an outstretched hand in 8 patients (40%), a fall to the ground on an outstretched hand in 12 patients (60%). Operative time range from 15- 30 minutes with mean 19.25 minutes, we counted the operative time after induction of anesthesia (including draping, reduction, wires insertion and splint application) **(Table 1)**.

Table (1): Demographic data and operative time

	No. (n=20)	**%**
Gender		
Male	9	45.0
Female	11	55.0
Age		
Range (Min. - Max.)	3 - 8	
Mean±SD	4.95±1.61	
Median	5	
Side		
Lt	9	45.0
Rt	11	55.0
Mode of trauma		
FFH	8	40.0
FTG	12	60.0
Gartland type		
III	20	100.0
Operative time:		
Range (Min. - Max.)	15 – 30	
Mean±SD	19.25±4.38	
Median	20	

*FFH=fall from height, *FTG=fall to the ground

Results were within normal range for all patients. The mean Baumann's angle in the patients was (70.57) degree and standard deviation was (3.01) **(Table 2)**.

Table (2): Baumann's angle (N= 64°- 81°)

	Range (Min. - Max.)	**Mean±SD**	**Median**
Bauman's angle	65.2 - 74.4	70.57±3.01	71.25

Postoperatively, anteroposterior and lateral views were done, and wires were removed by 3 weeks if clinical and radiological evidence of early bone union was present and, if not, wires removal was postponded one week later. Thirteen patients (65%) had the wires removed by 3rd week, and 7 patients (35%) the wires removed by 4th week, with a mean of 3.35 week, and standard deviation of 0.49 **(Table 3)**.

After wires removal, the plaster of Paris splint was retained for 2 weeks postoperatively. Intermittent active flexion extension exercises of the elbow were encouraged and lifting heavy objects by the affected limb was postponded until 12 week postoperatively.

Table (3): Time of wires removal

Wires removal (weeks)	No. (n=20)	%
3	13	65.0
4	7	35.0
Range (Min. - Max.)	3 – 4	
Mean±SD	3.35±0.49	
Median	3	

All patients were available for clinical evaluation and all of them were evaluated at 3 months using the Flynn grading system, based on the difference in carrying angle and range of movement between the injured and uninjured elbow. The mean follow up duration was 3 months (range from 3 – 3.2 months). The mean age was 4.95 years (range from 3-8 years).

All patients are within normal range (5.7-14.7 degree), with mean carrying angle was about (9.38) degree, standard deviation was (2.12) and no one of the patients had excessive deformity of carrying angle that required correction.

There were 11 patients (55%) excellent, 7 patients (35%) good and 2 patient (10%) fair, with mean ROM loss was about (5.76) degree and standard deviation was (3.59) **(Table 4)**.

Table (4): Carrying angle and ROM loss

	Range (Min. - Max.)	Mean±SD	Median
Carrying angle	5.7 - 14.7	9.38±2.12	9.5
Rom loss	0.2 - 14.1	5.76±3.59	5.35
	No.	**%**	**P value**
Degree of ROM loss:			
Excellent	11	55	0.047
Good	7	35	
Fair	2	10	

There were 18 patients (90%) excellent ; 8 patients in the age group 2-4 years and 10 patients in the age group 5-8 years, 1 patients (5%) good ; within age group 5-8 years, 1 patient (5%) fair; this patient was within age group 5-8 years and no poor patients. With mean extension loss was about (3.13) degree and standard deviation was (1.93) **(Table 5)**.

Table (5): Extension loss

Extension loss / Degree	No. (n=20)	%
Excellent	18	90.00
Good	1	5.00
Fair	1	5.00
Range (Min. - Max.)	0 - 7.3	
Mean±SD	3.13±1.93	
Median	2.9	

There were 17 patients (85%) excellent ; 8 patients in the age group 2-4 years and 9 patients in the age group 5-8 years, 2 patients (10%) good; all are within age group 5-8 years, 1 patient (5%) fair; this patient was within age group 5-8 years and no poor patients. With mean flexion loss was about (2.81) degree and standard deviation was (1.95) **(Table 6)**.

Table (6): Flexion loss

Flexion loss / Degree	No. (n=20)	%
Excellent	17	85.00
Good	2	10.00
Fair	1	5.00
Range (Min. - Max.)	0.2 - 6.8	
Mean±SD	2.81±1.95	
Median	2.45	

Few complications occurred and all were tolerable with no effect on final outcome and these were pin tract infection in 2 patients and loss of reduction. One patient (5%) has loss of reduction of the fracture. This complication appeared at 1st week follow up and this was due to slab removal and extension of the elbow by the patient at home against medical advice. The patient brought and X ray was done to evaluate the reduction and patient was put in above elbow cast and instructed to not remove the cast and follow up weekly in the clinic to evaluate the healing and cast state. Then at 4 weeks wire removed and the patient put in a back slab for another 2 weeks. Then at 6 weeks from the operation slab removed and the patient start intermittent active flexion extension of the elbow. 2 patients (10%) had pin tract infection discovered during removal of the wires, for these 2 patients, pin site cleaning by removal of crusts, repeated dressing and oral antibiotic (1st generation cephalosporin) for 1 week and this led them all recover at the subsequent follow-up **(Table 7)**.

Table (7): Post-operative complications

Post-operative complications	No. (n=20)	%
Loss of reduction	1	5.0
Pin tract infection	2	10.0
No	17	85.0

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 hyper flexion and extension of the distal fragment, and thus avoid postoperative deformity *(Lee et al., 2012)*, which has been reported to be as high as 17% *(Solak and Aydn, 2013)*.

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 *(Mazda et al., 2010)*.

Open reduction is usually unnecessary, although it sometimes can be required to obtain complete reduction *(Davis et al., 2010)*, especially in cases in which the fracture cannot be reduced because of the presence of a vascular injury *(Guy et al., 2011)*. There are various methods of fixation for treatment of displaced supracondylar humerus fracture in children which include lateral parallel, lateral divergent or crossed wires, and transolecranon wire configuration have been done in a single center.

This technique has been mentioned by *Sharma et al. (2015)* on Gartland type II & III supracondylar humerus fractures were treated to evaluate the outcome after closed reduction and pinning using a Kirschner wire inserted laterally and another inserted vertically through the olecranon, with mean follow up duration was 13 months. Outcome did not differ significantly between patients operated on within 24 hours of injury and those operated on 2 to 5 days after injury. They concluded that transolecranon vertical and lateral Kirschner wire fixation is a viable option for displaced supracondylar

humeral fractures in children, especially when there is massive swelling.

In the present study, 20 patients with displaced supracondylar humerus fractures were treated to assess the outcome after closed reduction and pinning using transolecranon and lateral Kirschner wires fixation especially in the presence of elbow swelling (made lateral condyle very difficult to palpate), fractures that need more than 2 lateral wires or those need medial wire for fixation. As regards to transolecranon wire trials, we obtained successful wire insertion with small number of trials with a range (1-4 trials), with a mean of 2.1, trial and standard deviation of 1.12. The mean operative time was 19.25 minute. Outcome did not differ significantly between patients operated on within 24 hours of injury or those operated after *(Wu et al., 2014).* We have 2 patients developed superficial pin tract infection, 1 patient has loss of reduction and these complications didn't affect the final outcome.

Although the transolecranon wire limited the flexion and extension of the elbow, this did not affect the final outcome as the elbow was fixed in a plaster of Paris splint for a period of 4 weeks. The elbow had to be maintained in the same degree of flexion, while applying the plaster of Paris splint to avoid the risk of wire bending or breakage, especially the transolecranon wire. No wire backout occurred, probably because the transolecranon transarticular wire was held firmly by fixation into 4 cortices and the metaphyseal cancellous bone of humerus.

All patients regained their ROM, only 2 were referred to physiotherapy, and all other 18 patients regained their final satisfactory ROM without any need to specific therapy program. All of them given instruction to actively mobilize their elbows, and the 2 patients that were referred to physiotherapy were reluctant to actively mobilize their elbows.

No radiological evidence of articular damage occurred because smooth pins were used. No infective arthritis occurred despite the Kirschner wire across the joint, probably because of aseptic precautions intra and post-operatively.

The limitations of this study was the lack of a control group for comparison, short duration of follow up and lack of biomechanical study of the stability of the construct.

CONCLUSION

Transolecranon with lateral Kirschner wires fixation was an effective option that provides good stability with little number of trials in management of supracondylar fracture of the humerus in children, and the risk of nerve injury, or fishtail deformity (Dissolution of distal humerus) were avoided.

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علاج الكسور المزاحة بأعلي اللقمتين بعظمة العضد عند الاطفال بالتصليح المغلق والتثبت بواسطة سلك معدني من خلال النتوء الزجي لعظمة الزند واخر من اللقمة الأوحشية لعظمة العضد

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خلفية البحث: الكسور فوق اللقمية عند الأطفال شائعة، وتمثل 65٪ من جميع كسور الكوع عند الأطفال و في النوعين الثاني والثالث من كسور العضد فوق اللقمتين النازحة يصعب تحقيق الرد المغلق بسبب العظم الرقيق بين الحفرة التاجية والحفرة الزهرية بالإضافة إلى تجريد السمحاق. بالإضافة إلى ذلك، يؤدي فرط الثني للحفاظ على الرد لهذا الكسر إلى التورم، ومتلازمة الحجرات، والتسوية الوعائية العصبية.

الهدف من البحث: تقييم النتيجة السريرية والإشعاعية بعد الرد والتثبيت المغلقين باستخدام سلك كيرشنر الذي يتم إدخاله عموديًا من خلال النتوء الزجي, والآخر يتم إدخاله بشكل جانبي لكسور العضد فوق اللقمتين النازحة.

المرضى وطرق البحث: أجريت دراسة مركزية واحدة في مستشفيات جامعة الأزهر من يونيو 2020 إلى مايو 2021. وتشمل 20 مريضًا مصابًا بكسر جارتلاند من النوع الثالث الذين خضعوا لعملية الرد والتثبيت المغلقين باستخدام سلك كيرشنر الذي يتم إدخاله عموديًا من خلال النتوء الزجي, والآخر يتم إدخاله بشكل جانبي.

نتائج البحث: تتراوح المدة الزمنية للعملية من 15 إلى 30 دقيقة بمتوسط 19.25 دقيقة، وقد قمنا بحساب وقت العملية بعد التخدير (بما في ذلك اللف، والتخفيض، وإدخال الأسلاك، ووضع الجبيرة). وقد كانت النتائج ضمن المعدل الطبيعي لجميع المرضى. وبلغ متوسط زاوية باومان عند المرضى 70.57 درجة,

والانحراف المعياري 3.01. وبعد العملية الجراحية، تم عمل مناظر أمامية خلفية وجانبية, وتمت إزالة الأسلاك لمدة 3 أسابيع في حالة وجود دليل سريري وإشعاعي على الاتحاد العظمي المبكر وإذا لم يتم تأجيل إزالة الأسلاك بعد أسبوع واحد. في ثلاثة عشر مريضًا (65٪) قد أزيلت الأسلاك بحلول الأسبوع الثالث، وأزيل 7 مرضى (35٪) الأسلاك بحلول الأسبوع الرابع و بمتوسط 3.35 أسبوعًا وإنحراف معياري 0.49. وقد حدثت مضاعفات قليلة وكلها كانت مقبولة مع عدم وجود تأثير على النتيجة النهائية, وكانت هناك عدوى المسالك الدبوسية في مريضين وفقدان الرد في احدي المرضي.

الاستنتاج: الرد المغلق وتثبيت سلك كيرشنر عن طريق الجلد في علاج كسور فوق اللقمتين في عظم العضد عند الأطفال آمن فيما يتعلق بتجنب مضاعفات الأوعية الدموية، وهو فعال في الحصول على نتائج جيدة، واقتصادي نسبيًا فيما يتعلق بالاستشفاء.

الكلمات الدالة: الكسور المزاحة بأعلي اللقمتين بعظمة العضد, النتوء الزجي لعظمة الزند, سلك من اللقمة الأوحشية لعظمة العضد.